AMIR

G3 UNIT - DOCUMENTS FROM UNAMIR

9-29 MAR 1994

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UNAMIR 29 . 08:44

TO : COMMCEN NYK

FROM : COMMCEN UNAMIR KIGALI

GRATEFUL IF YOU COULD RELAY THE FOLLOWING THROUGH TTY QUOTE:

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TKS A LOT.

UNAMIR 29 . 08

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1. To be filed in your section.
2. ACs to be informed about the presence of this paper
3. To be studied by MID/OPS personnel.

24/03

COM.6 (2–78)

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ASSISTANCE MISSION FOR RWANDA — MISSION POUR L'ASSISTANCE AU RWANDA

UNAMIR - MINUAR

Inter-office Memorandum

To: ALL COMMANDERS (CMC UNOMUR) File: 1000.7(DFC)/G/7

From: FORCE HQ

Info: COO
MIO

Date: 9th MARCH 1994

Subject: CRATER ANALYSIS AND FRAGMENT IDENTIFICATION

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1. The attached document on crater analysis and fragment identification is to be reproduced and distributed to all UNMO teams as SOPs and part of their packages. It is believed portions of it can meet the Force Component requirements during investigations. It is also useful to the troops who operate in the field.

2. Training would be required to ensure they understand the package.

3. This document is provisional. An amended copy will be forwarded when received.

GK ZOWONOO
Lt Commander
For Force Commander

10081-1 (FAS)

Field Artillery School
Canadian Forces Base Gagetown
Oromocto, New Brunswick
E0G 2P0

18 February 1994

BGen R.A. Dallaire
Force Commander, UNAMIR
KIGALI, RWANDA

CRATER ANALYSIS AND FRAGMENT IDENTIFICATION

Reference: Fax dated 14 Feb 94

1. The Field Artillery School received your Fax requesting information on Crater Analysis. This is certainly a subject that all UN personnel should be familiar with.

2. My staff has put together the information that we hold in our Locating Artillery wing (enclosed). The information was drawn from Annexes from 307(1) Locating Artillery Employment, and Appendix A from FM 6-121 Target Acquisition (American). I hope this information will help in your efforts to observe the cease fire violations in the Demilitarized Zones. If additional information is required please do not hesitate to call/fax. Our fax number is 506-422-2794.

3. Ubique.

BW MacLeod

B.W. MacLeod
Lieutenant-Colonel
Commandant

Enclosure: 1

Romeo

I hope this will help. FD ARTY SCHOOL is REDOING the package and will forward better copy when ready.

Ubique

Bryan
Comd CTC.

CRATER ANALYSIS

1. One of the most positive methods of obtaining information about enemy weapon locations and new types of ammunition is the examination of craters and projectile fragments. This information assists in the development of countermeasures, ie, CB.

2. An examination of projectile and mortar craters may permit the identification of:

a. the bearing to the HB;

b. the position of the area being shelled;

c. determination of the angle of descent and hence the possible range of mortar rounds; and

d. collection of fragments for identification, see Annex E.

3. Crater analysis is unlikely to be viable during fluid mobile operations, but in static operations may provide useful information on enemy artillery and thus all arms should be made aware of the value of the information which may be determined.

4. The initial step in crater analysis is to locate a suitable crater for use in determining the direction to the HB. The crater should be clearly defined on the ground and should be reasonably fresh. Since the crater is the beginning point for plotting the direction to the enemy weapon, the grid coordinates of the crater should be determined as precisely as time and the method used will allow. The direction of the firing weapon must be determined (using one of the methods described below) and projectile fragments must be collected for use in identifying the type and calibre of the weapon.

5. Fuze Quick Craters (Artillery). The detonation of a projectile causes an inner crater. The burst and momentum of the projectile carry the effect forward and to the sides, forming an arrow which points to the rear (toward the weapon from which the round was fired). The fuze continues along the line of flight, creating a fuze furrow. There are two methods of obtaining a direction of a hostile weapon from this type of crater. The best results are obtained by using both methods:

a. Fuze Tunnel and Centre of Crater Method. In the fuze tunnel and centre of crater method, one stake is placed in the centre of the crater and another is placed in the furrow at the point where the fuze was blown forward to the front of the crater, see Figure F-1. A direction measuring instrument is set up in line with the two stakes and the direction measured to the hostile weapon. A variation of this method is to place a stake where the projectile entered the ground, instead of in the centre of the crater, and determine the direction in the same manner. This is rarely possible, however, since indications of the point of entry are usually destroyed by the explosion of the projectile. The five steps of the fuze tunnel and centre of crater method are –

(1) place a stake in the centre of the crater,

(2) place a second stake in the fuze furrow,

(3) set up a direction measuring instrument in line with the stakes and away from fragments,

(4) orient the instrument, and

(5) measure the direction to the HB.

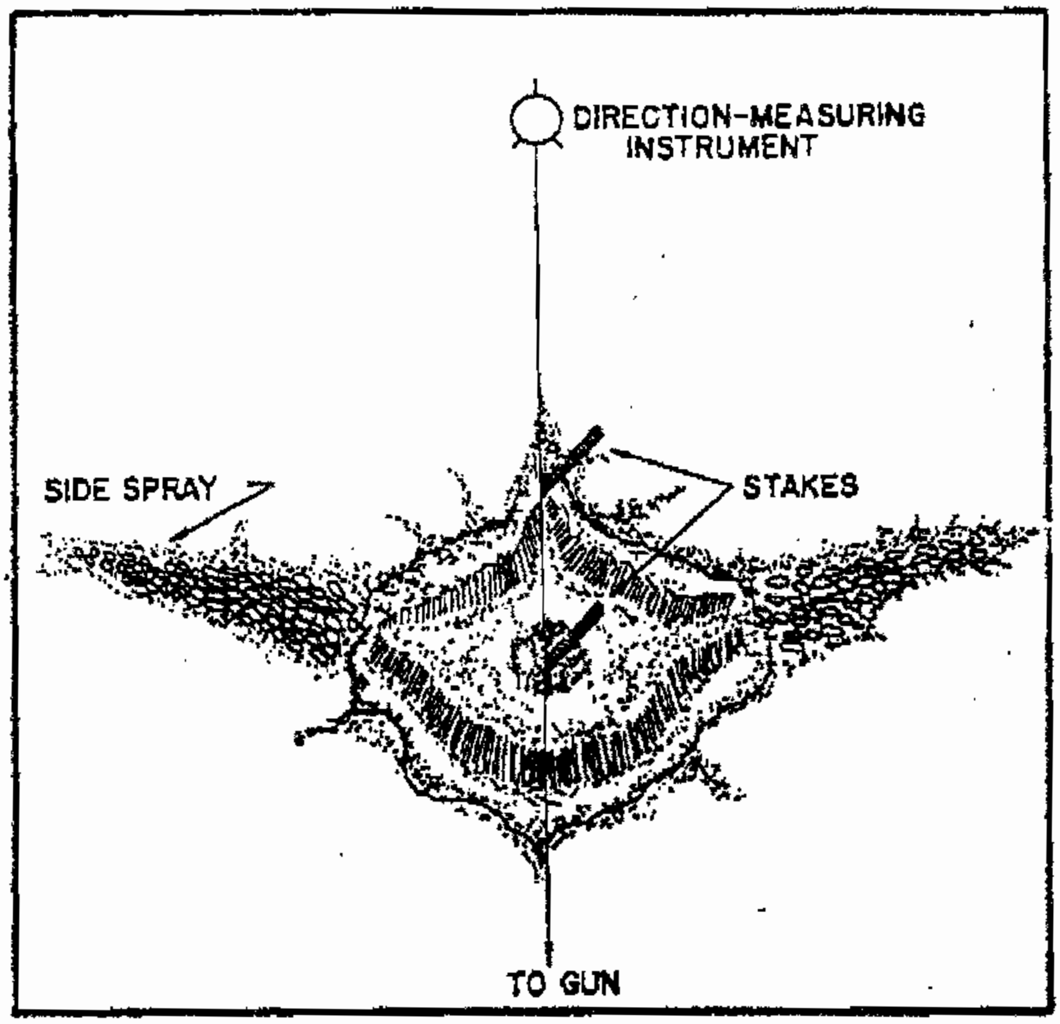

Figure F-1 Fuze Tunnel and Center of Crater Method.

b. Side Spray Method. Another method used to measure the direction to a hostile weapon is to bisect the angle formed by the lines of side spray by striking an arc, see Figure F-2. The five steps in measuring the direction of a fuze quick crater by the side spray method are -

(1) place a stake in the center of the crater,

(2) place two stakes, one at the end of each line of side spray, equidistant from the centre stake,

(3) hold a length of wire to each side spray, stake and strike an arc forward of the fuze furrow,

(4) place a stake where these arcs intersect,

(5) set up a direction measuring instrument in line with the stake and the center stake,

(6) orient the instrument, and

(7) measure the direction to the HB.

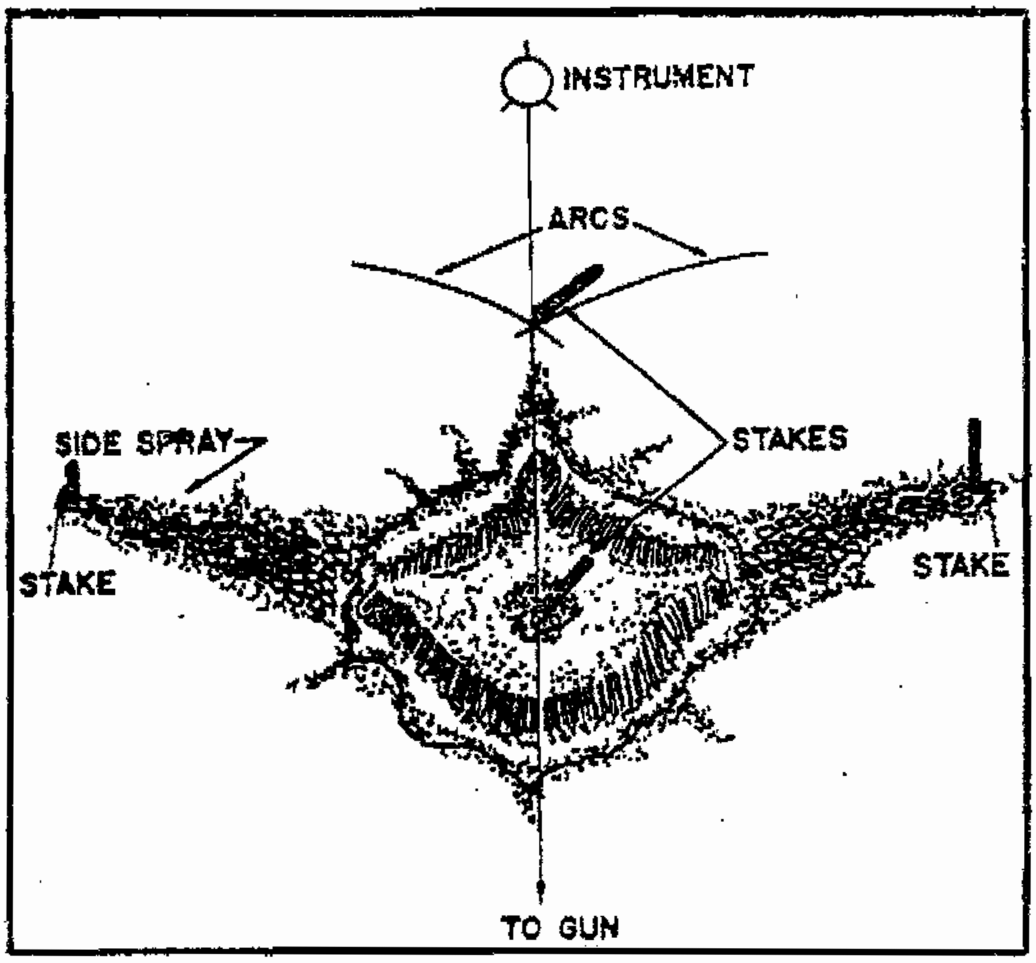

Figure F-2 Side Spray Method

SIDE SPRAY METHOD - COMPASS OPTION

1. A SECOND METHOD AVAL FOR DETERMINING THE BEARING TO THE HOSTILE WPN IS TO EMPLOY A COMPASS. FIGURE F-1A HIGHLIGHTS THE PROCEDURE. THE FOL STEPS ARE TO BE FOL:

a. BEARINGS ARE TAKEN FROM B TO A AND FROM B TO C ALONG THE SIDE SPRAY OR WINGS, AND THE FOL CALCULATIONS ARE CARRIED OUT;

(1) MAG BEARING B TO A ... 900 MILS

(2) MAG BEARING B TO C ... 4900 MILS

(3) ANGLE ABC (1-2 + 6400 MILS IF REQR) ... 2400 MILS

(4) MAG BEARING LINE OF FIRE = 4900 + 2400/2 ... 6100 MILS

(5) MAG BEARING TO HOSTILE BTY
6100 +/- 3200 ... 2900 MILS

(6) **GRID BEARING TO HB 2900 + MV AND COMPASS ERROR**

2. THIS METHOD CAN BE EMPLOYED WHEN TIME IS SHORT OR THE TACTICAL SITUATION WILL NOT PERMIT THE MORE DELIBERATE SIDE SPRAY METHOD OUTLINED ON PAGE F-3 AND FIG F-1.

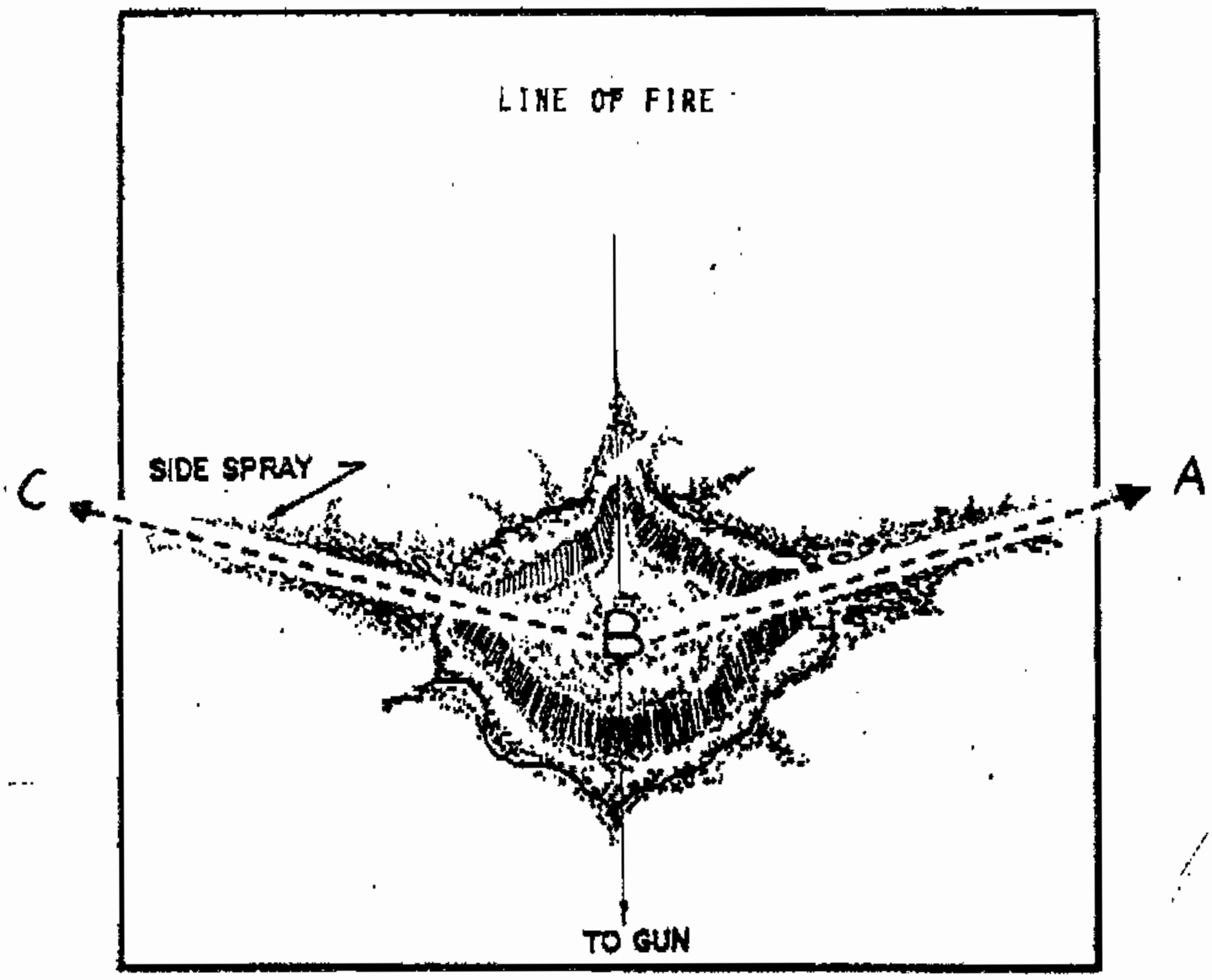

FIGURE 1-A

6. Fuze Delay Craters (Artillery). There are two types of fuze delay craters - ricochet and mine action:

a. Ricochet. The projectile enters the ground in a line following the trajectory and continues in a straight line for a few feet, causing a ricochet furrow. The projectile normally deflects upward and at the same time, changes direction. The change of direction usually is to the right as the result of the rotation of the projectile. The effect of the airburst can be noted on the ground, see Figure F-3. Directions obtained from ricochet craters are considerd to be most reliable. The five steps required to determine direction from a ricochet furrow are -

(1) clean out the furrow,

(2) place stakes at each end of a useable straight section of the furrow,

(3) set up an instrument in line with the stakes and away from fragments,

(4) orient the instrument, and

(5) measure the direction to the HB.

b. Mine Action. Mine action occurs when a projectile bursts beneath the ground. Occasionally, such a burst will leave a furrow which can be analyzed in the same manner as the ricochet furrow. A mine action crater which does not have a furrow cannot be used to determine the direction to the weapon.

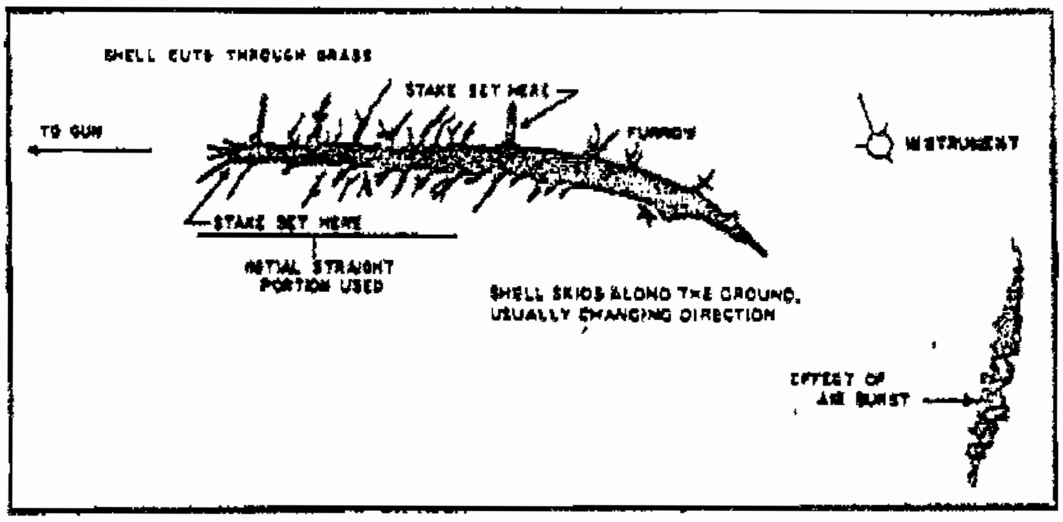

Figure F-3 Ricochet Furrow Method

7. Mortar Shell Craters. In a typical mortar crater, the turf at the forward edge (the direction away from the hostile mortar) is undercut. The rear edge of the crater is shorn of vegetation and grooved by splinters, see Figure F-4. When fresh, the crater is covered with loose earth which must be carefully removed to disclose the firm, burnt inner crater. The ground surrounding the crater is streaked by splinter grooves which radiate from the point of detonation. The ends of the splinter grooves on the rearward side are on an approximately straight line. This line is perpendicular to the line of flight when on level ground or on slopes with contours perpendicular to the plane of fire, see Figure F-5. A fuze tunnel is caused by the fuze burying itself at the bottom of the inner crater in front of the point of detonation. Three methods may be used to determine direction from a mortar shell crater - main axis, splinter grove and fuze tunnel:

a. Main Axis Method. The four steps used to determine direction by the main axis method when a definite and regular crater is formed are, see Figure F-4 -

(1) lay a stake along the main axis of the crater, dividing the crater into symmetrical halves - the stake points in the direction of the mortar,

(2) set up an instrument in line with the stake and away from fragments,

(3) orient the instrument, and

(4) measure the direction to the HB.

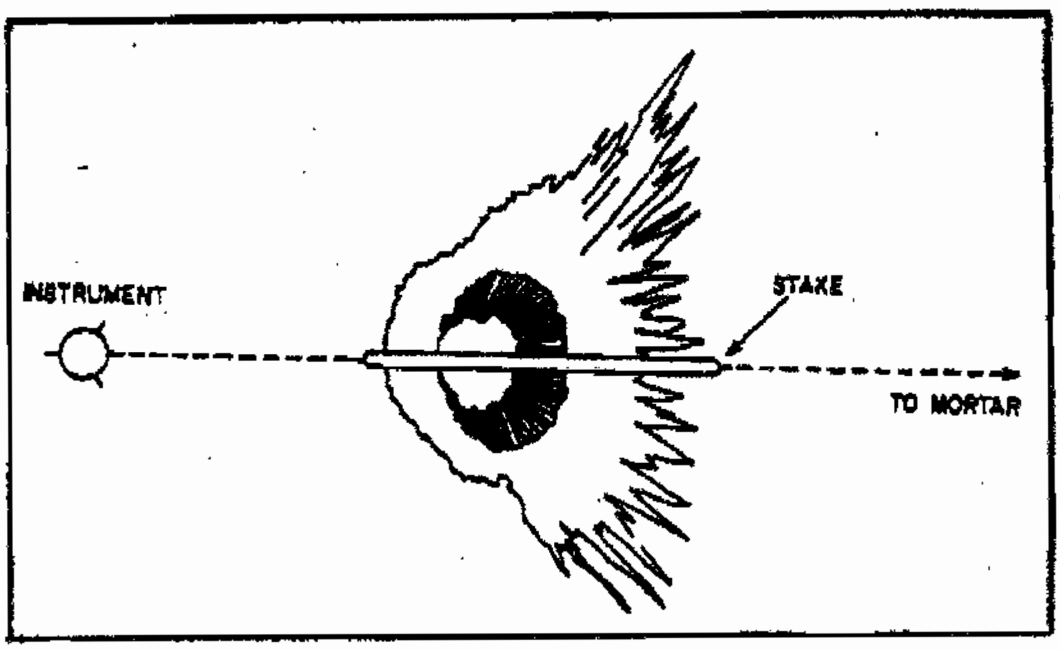

Figure F-4 Main Axis Method 9/22

b. Splinter Groove Method. The five steps used to determine direction by the splinter groove method are, see Figure F-5 -

(1) lay a stake along the ends of the splinter grooves which extend from the crater,

(2) lay a second stake perpendicular to the first stake through the axis of the fuze tunnel,

(3) set up an instrument in line with the second stake and away from fragments,

(4) orient the instrument, and

(5) measure the direction of the HB.

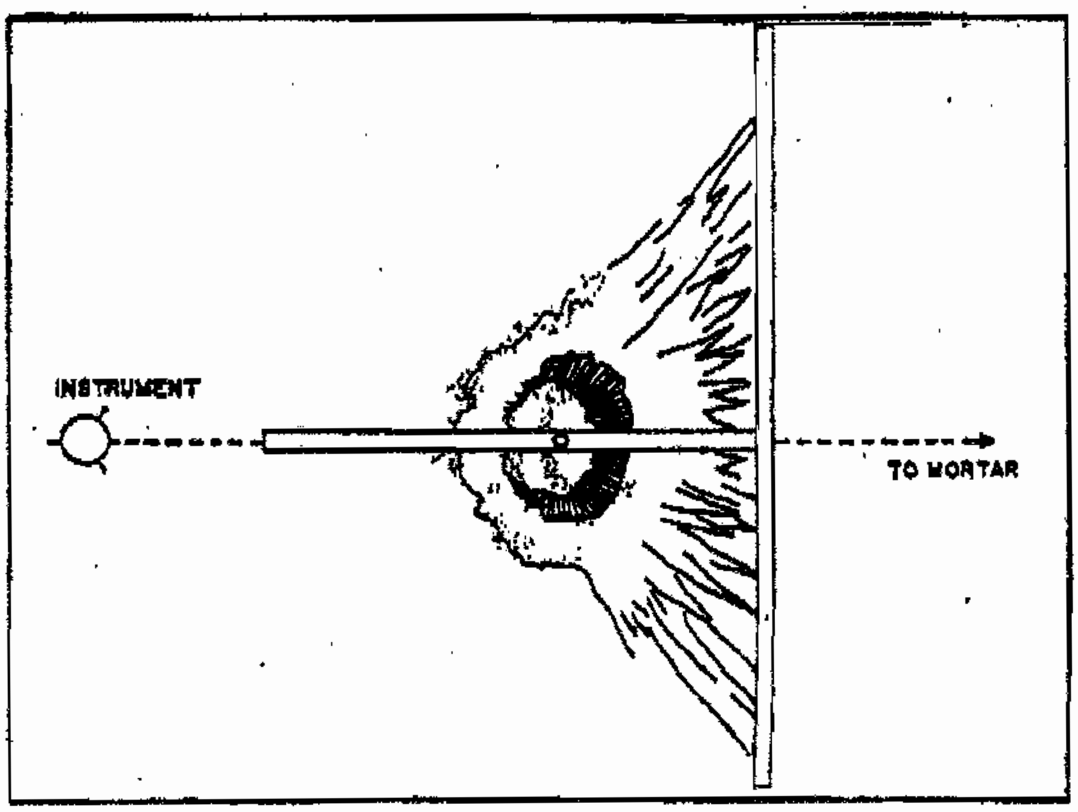

Figure F-5 Splinter Groove Method

c. <u>Fuze Tunnel Method</u>. The four steps used to determine direction by the fuze tunnel method are, see Figure F-6

(1) place a stake in the fuze tunnel,

(2) set up an instrument in line with the stake and away from fragments,

(3) orient the instrument, and

(4) measure the direction to the HB.

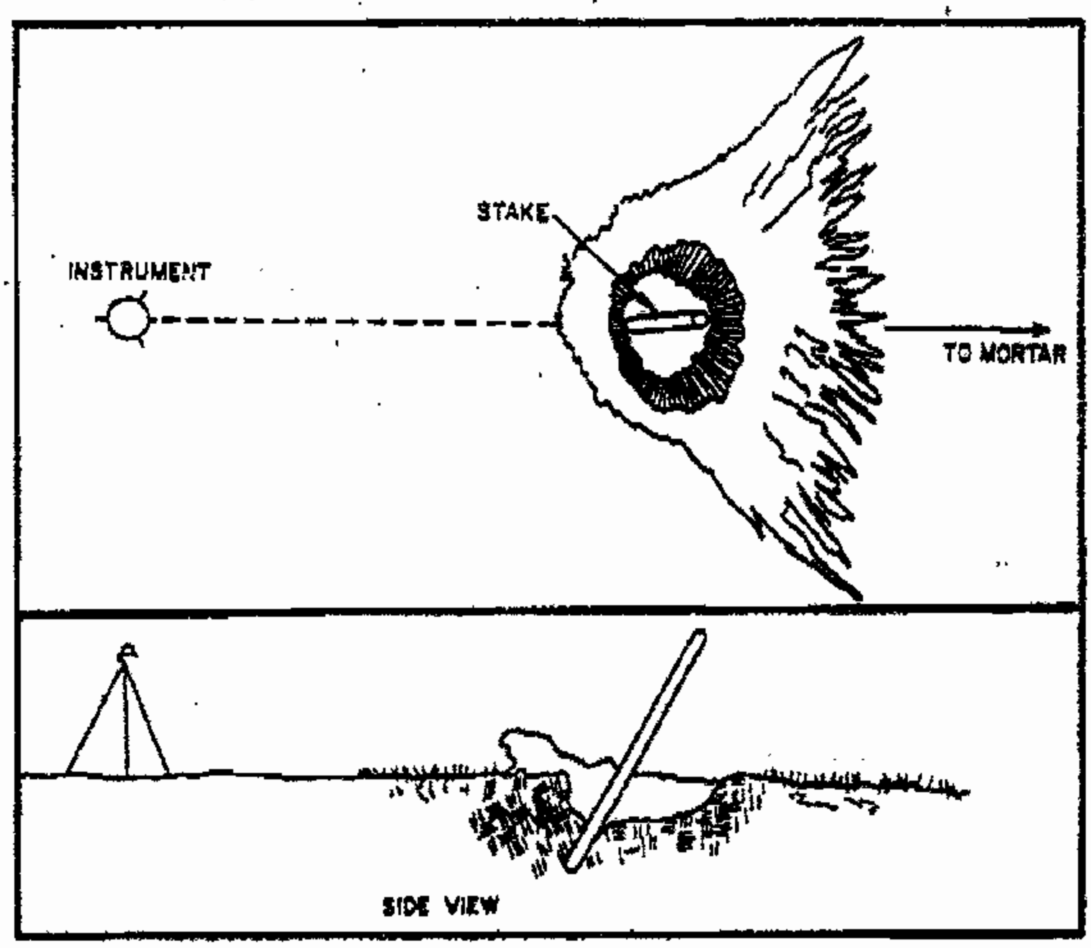

Figure F-6 Fuze Tunnel Method.

6. When examing craters, no attempt should be made to remove fragments until the bearing has been determined. Bearings and other information should be reported by the quickest means to the artillery intelligence office using the BOMBREP/MORTREP/SHELREP format.

1. **MOR BOMB CRATERS - ANGLE OF DESCENT.** THE FOLLOWING DETAILS WILL ASSIST WITH DETERMINING THE ANGLE OF DESCENT:

a. IF THE ANGLE OF DESCENT IS VERY STEEP, THE SPLINTER PATTERN GIVES LITTLE INDICATION OF THE BEARING OF FIRE, AND THE CRATER WILL BE ALMOST ROUND. IF THE ANGLE OF DESCENT IS COMPARATIVELY SMALL THE CRATER WILL BE PEAR SHAPED, AND AN INDCIATION OF THE DIRECTION OF THE MORTAR IS GIVEN BY THE LONGEST AXIS OF THE CRATER.

b. AN ANGLE OF DESCENT MAY BE OBTAINED FROM A MORTAR BOMB CRATER DUE TO THE FACT THAT FUZE AND FINS FOL EA OTHER INTO THE EARTH AT THE FRONT END OF THE CRATER, FORMING A TUNNEL OF WHICH THE AXIS IS IDENTICAL WITH THE TRAJECTORY AT THE MOMENT OF IMPACT. THIS IS ILLUSTATRATED BY THE SIDE VIEW OF A CRATER SHOWN IN FIG F-6. THE FOL PTS SHOULD BE NOTED;

(1) THE EDGE FARTHEST FROM THE MORTAR HAS TURF UNDERCUT, WHILE THE NEARER EDGE IS SHORN OF GROWTH, AND VERY MUCH SERRATED BY SPLINTER GROOVES.

(2) WHEN FRESH, THE CRATER IS COVERED WITH LOOSE EARTH WHICH, WHEN CLEARED, DISCLOSES THE FIRM INNER CRATER **A**. THIS SHOWS SIGNS OF BURNING.

(3) THE FINS AND FUZE ARE BURIED IN THE TUNNEL **B**, OFTEN AT A CONSIDERABLE DEPTH. THE TUNNEL IS FULL OF SOFT EARTH, BUT ITS SIDES CAN EASILY BE FELT WHEN REMOVING THE SOFT EARTH BY HAND.

(4) TO FIND THE ANGLE OF DESCENT, A PEG IS DRIVEN INTO THE CENTRE OF THE FIRM INNER CRATER **A** UNTIL THE TOP OF THE PEG REPRESENTS THE PT OF DETONATION. THE ENTRANCE TO THE TUNNEL IS CAREFULLY CLEARED OF LOOSE EARTH AND A STICK INSERTED IN THE CENTRE OF THE TUNNEL AS IN FIG F-7. THE ANGLE OF DESCENT IS MEASURED WITH A PROTRACTOR AND PLUMB BOB. IN SOME CASES THE INNER CRATER MAY BE DIFFICULT TO IDENTIFY. IF THIS IS SO THE STICK SHOULD BE INSERTED AS ACCURATELY AS POSSIBLE DOWN THE AXIS OF THE TUNNEL. THE BEARING OF THIS STICK WILL ALSO GIVE AN INDICATION OF THE DIRECTION OF THE MORTAR.

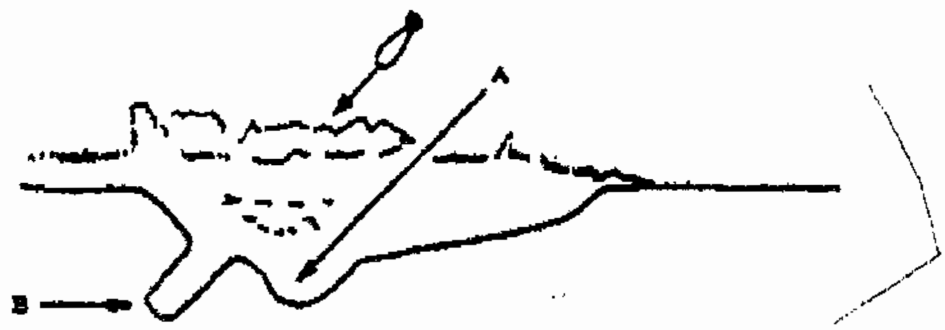

FIGURE F-6

Finding Angle of Descent

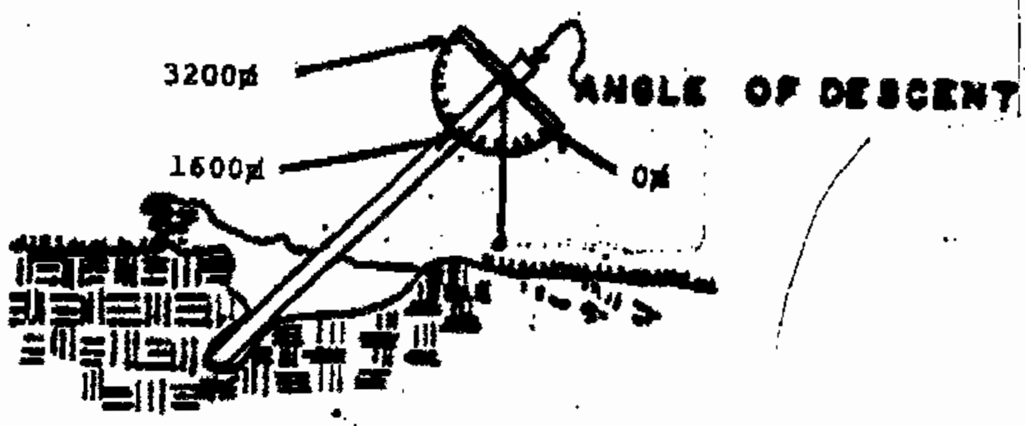

FIGURE F-7

FRAGMENT IDENTIFICATION

1. In conjunction with crater analysis, when possible, fragment identification is carried out to determine the calibre of the projectile and, hence, often the equipment from which it came. This can be determined from a visual or dimensional analysis of the fragment. Artillery intelligence staffs may identify the calibre of the projectile from any fragment displaying an undistorted segment of the circumference of the round. This segment should be at least 2 centimetres in size for the analysis to be accurate.

2. Generally speaking, the easiest method to identify projectile fragments is by examining or measuring the rotating band, or rotating band seat, however, other portions from between the bourrelet and band are acceptable if large enough. Such fragments are generally available only after low order burst, ie, explosive filler not completely detonating. Fragments from high order bursts are generally small and useless, unless they include a portion of the rotating band or rotating band seat. These sections will positively identify the projectile, as each projectile has its own distinctive band markings, see Figure 1.

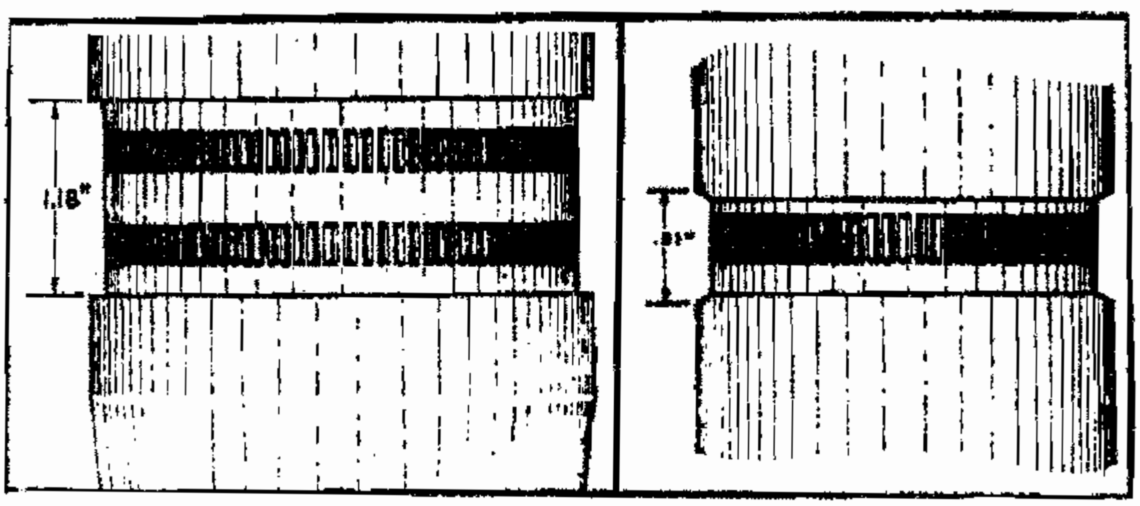

Figure E-1 Soviet 122mm (Left) and 152mm (Right) Rotating Band Markings

3. Undistorted fragments can be measured with reasonable accuracy using a template. This is a sheet of thin metal or other material having arcs of a known radius cut in it. The various projectile fragments are presented to the cut areas to determine which fits. Actual size templates are shown at Figures E-2 and E-3.

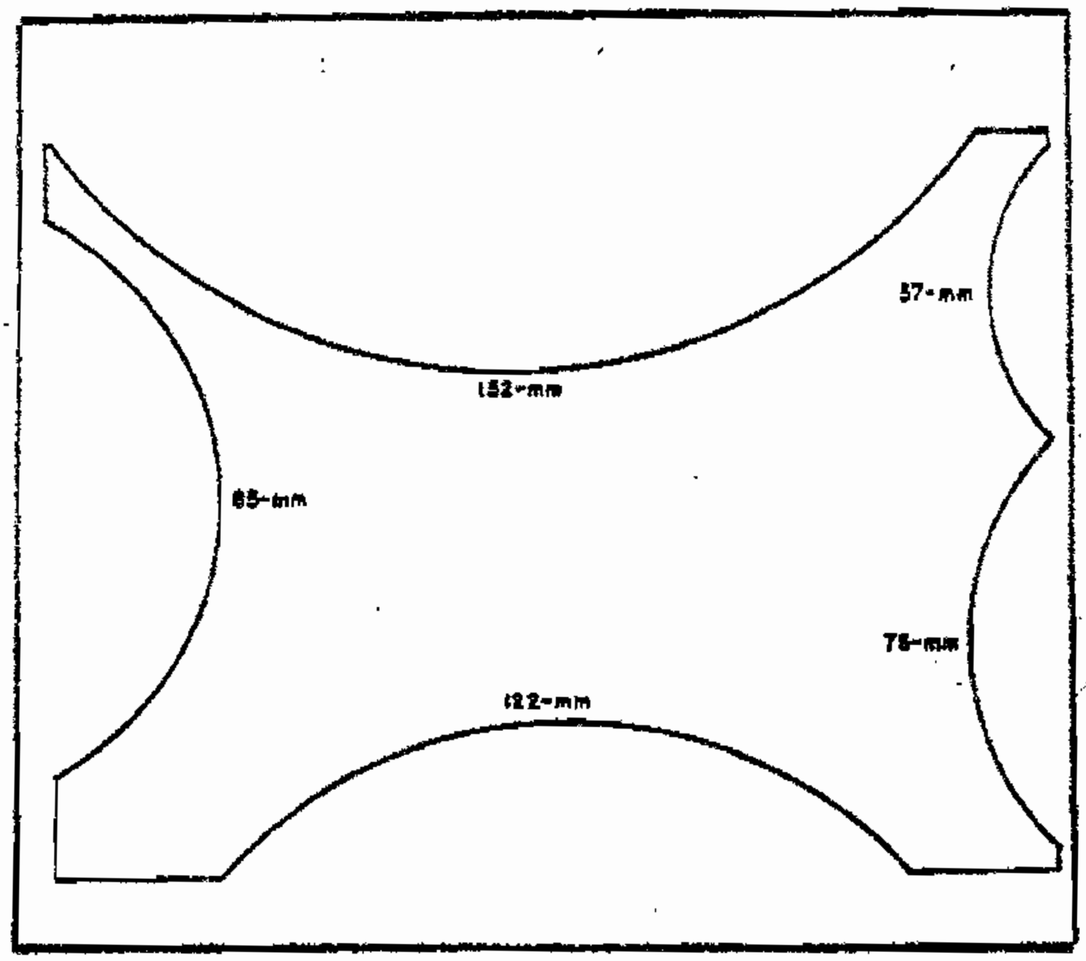

Figure E-2 Curvature Template Soviet Equipments

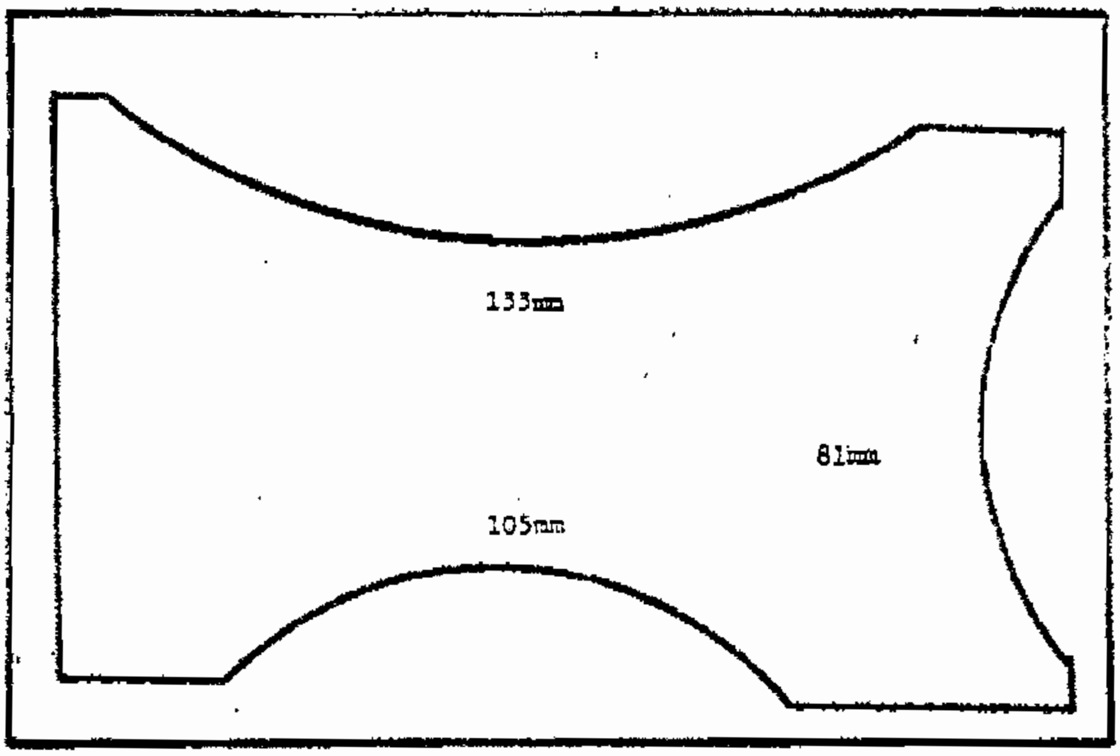

Figure E-3 Curvature Template NATO Equipments

4. In certain instances it may be possible to measure fragments directly to determine calibre of the projectile:

a. The tail fins of mortar rounds may be measured to determine the calibre of the mortar.

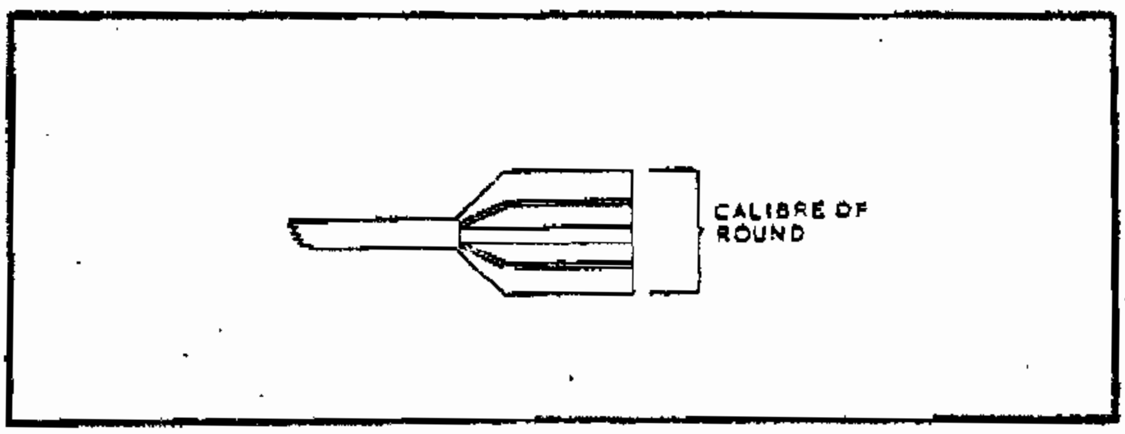

Figure E-4 Mortar Calibre by Measurement of Tail Fins

b. The diameter (calibre) of the projectile may be measured if very large fragments are found.

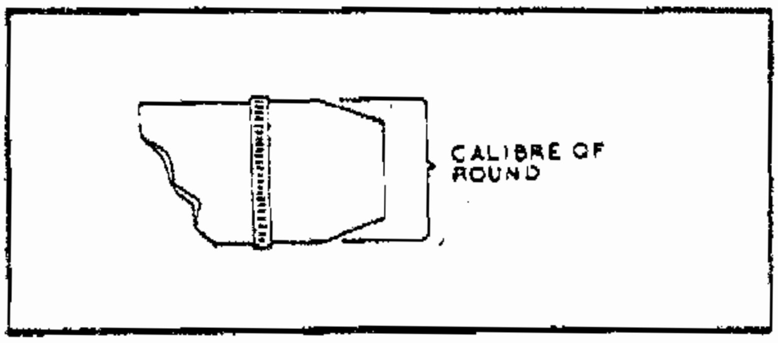

Figure E-5 Determination of Calibre by Measurement

5. Fragments showing 5 centimetres of the undistorted circumference of a projectile can be measured by geometric construction. This method requires careful draughtmanship and is normally attempted only if a suitable template is not available:

a. Select and mark three points on the projectile. They are labelled A, B and C and must be on a straight line around the circumference of the projectile, see Figure E-6.

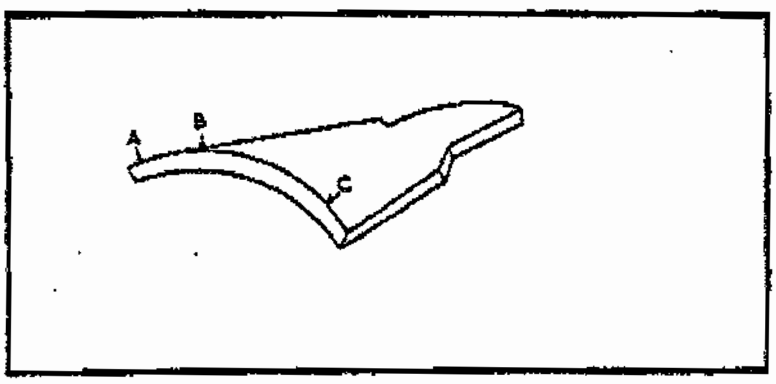

Figure E-6 Fragment Showing Points A, B and C

b. The triangle ABC is now constructed -

(1) Measure the distance AC with a compass and transfer it to a piece of paper, marking A and C.

(2) Measure the distance AB and strike an arc from A on the paper at the distance, see Figure E-7.

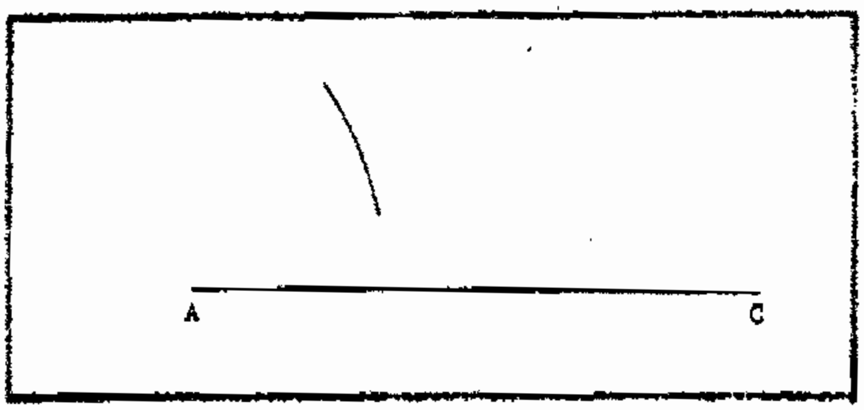

Figure E-7 Line AC and Arc of Radius AB

(3) Measure the distance BC with a compass and strike an arc from C, intersecting the arc of radius AB, see Figure E-8.

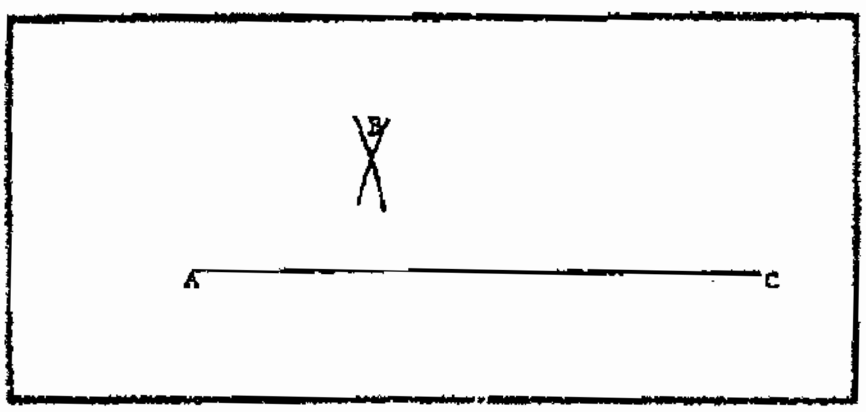

Figure E-8 Arc of Radius BC

(4) The point of intersection of arcs is B. Join AB and BC to form triangle ABC, see Figure E-9.

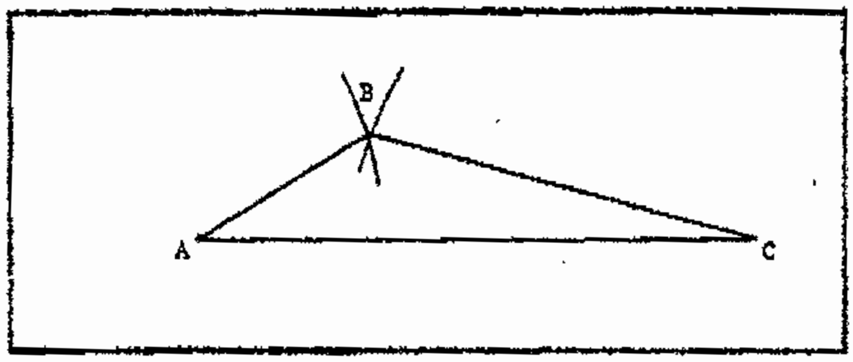

Figure E-9 Triangle ABC

c. The right bisector of AC is constructed -

(1) With the compass at A and a distance of approximately 3/4 of AC, an arc is struck above and below line AC, see Figure E-10.

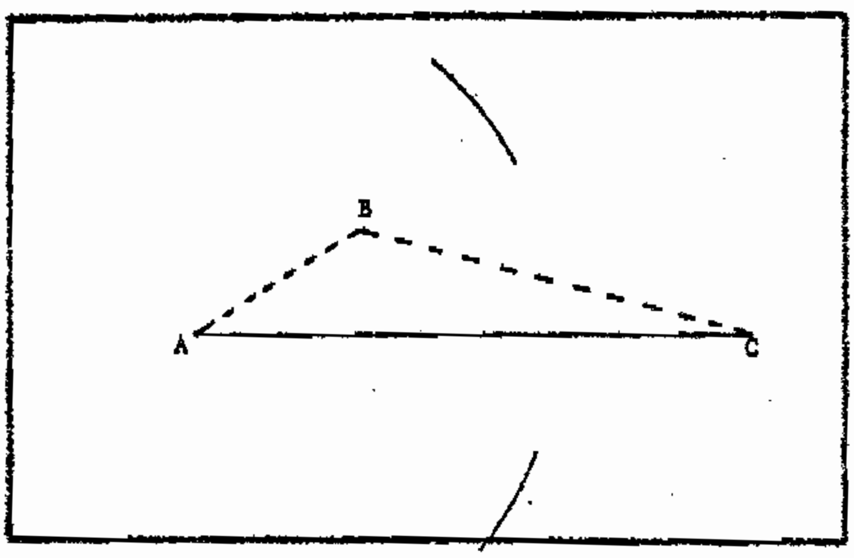

Figure E-10 Arcs with Centre A

(2) With the compass at C and the same radius, draw arcs cutting arcs from A, see Figure E-11

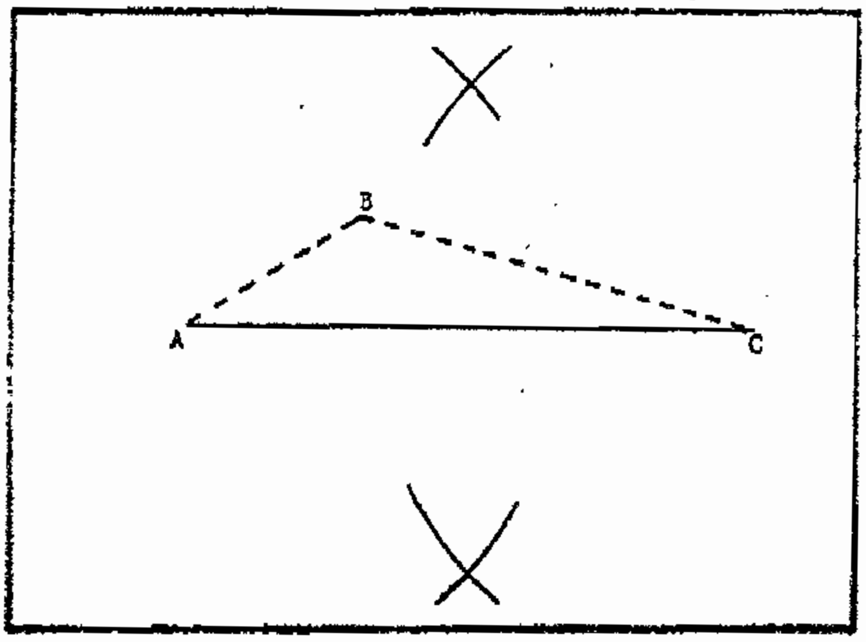

Figure E-11 Arcs with Centre C

(3) Join the intersections to construct the right bisector of AC, see Figure E-12

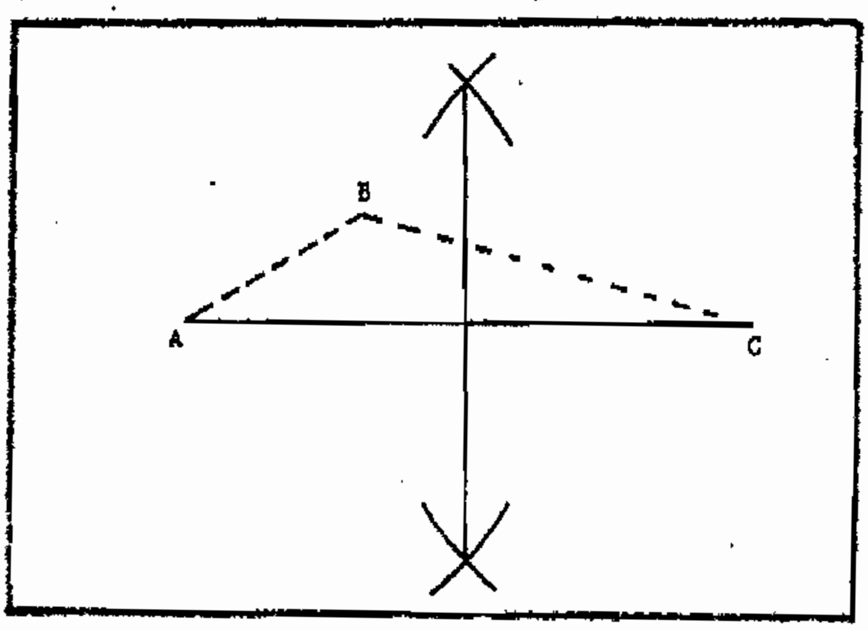

Figure E-12 Right Bisector of AC

d. Construct the right bisector of AB and BC in the same manner. They will all pass through the same point. Label this point P, see Figure E-13.

e. Measure the distance in millimetres from P to A, B and C. These distances should be the same, if not, mean them. This distance equals 1/2 the calibre of the projectile.

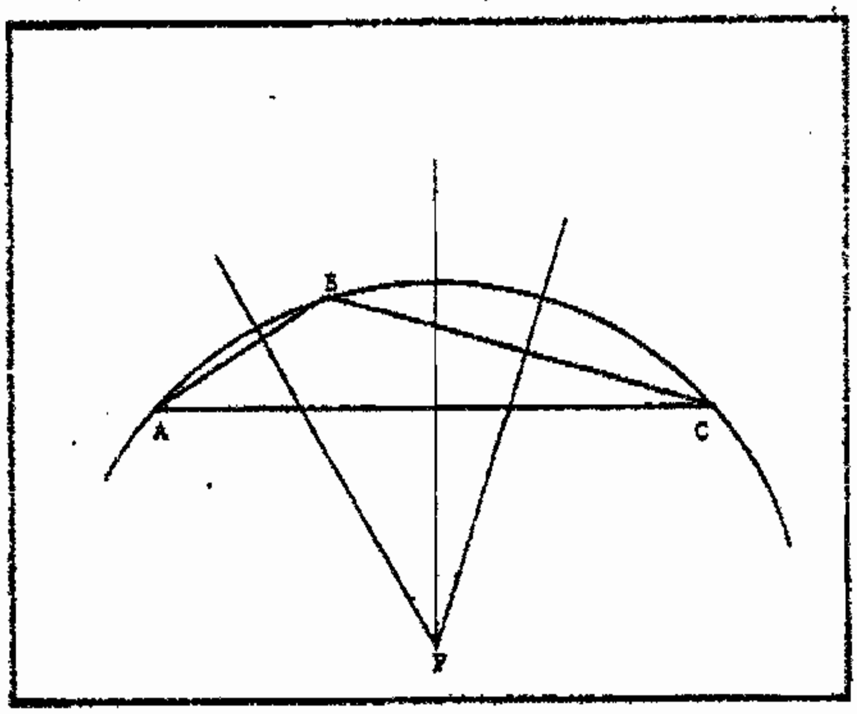

Figure E-13 Right Bisector of Sides AB, AC and BC Forming Point P

6. A useful handbook for visual fragment identification is: PROJECTILE FRAGMENT IDENTIFICATION GUIDE - FOREIGN
Prepard by: US ARMY, ARMY MATERIAL DEVELOPMENT AND READINESS COMMAND, FOREIGN SCIENCE AND TECHNOLOGY CENTRE
Code: DST-1160G-209-80

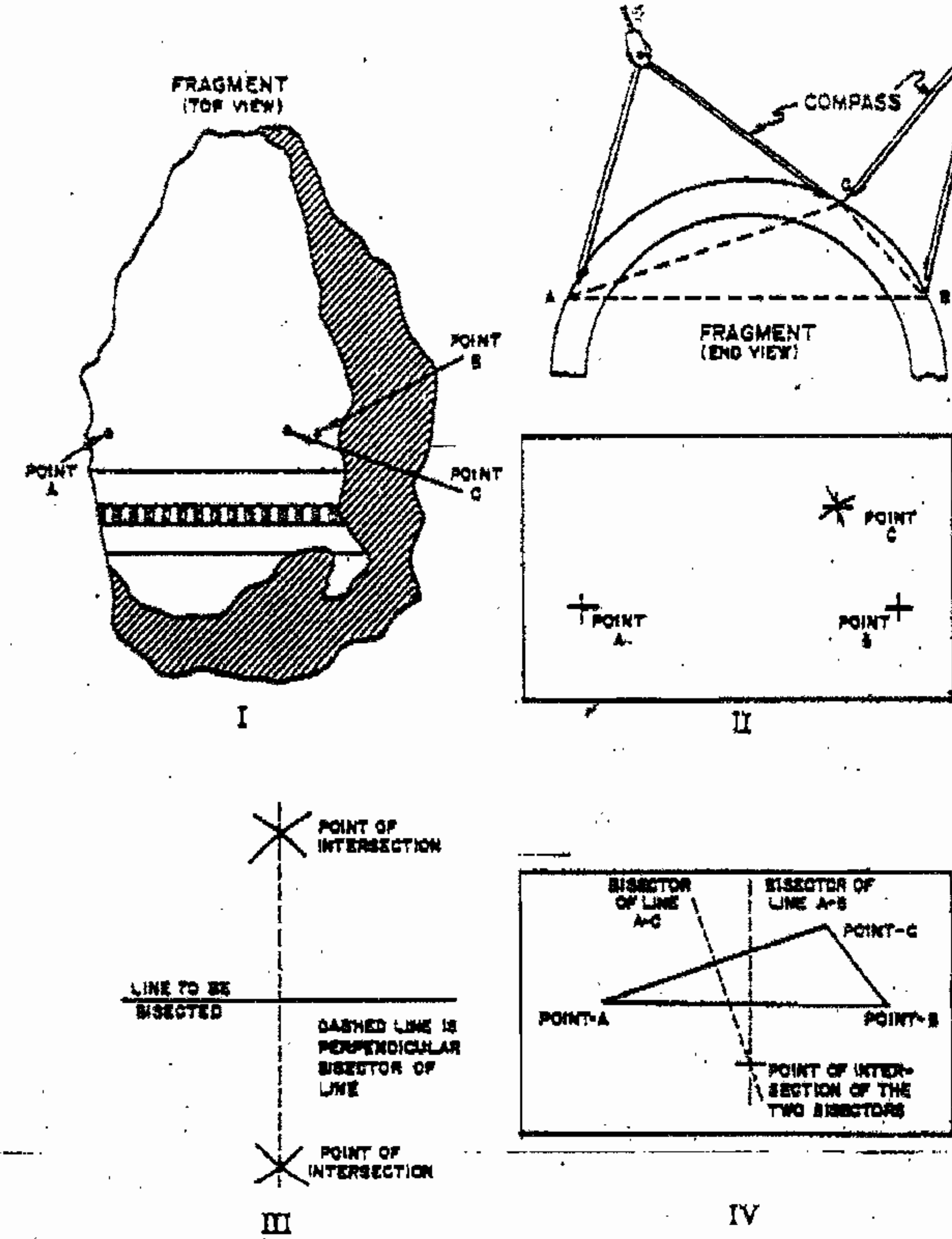

Figure 15. Determination of projectile caliber by geometric analysis of a fragment

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