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Forensic Science of Ballistic Weapons

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ABSTRACT

Forensic science plays a critical role in the investigation and analysis of ballistic weapons, encompassing firearms, ammunition, and related evidence. This abstract explores the important components of forensic ballistic analysis, including firearm identification, trajectory analysis, and gunshot residue examination. The examination of ballistic evidence involves a combination of laboratory techniques, including microscopy, chemical analysis, and computational simulations. By applying principles of physics, materials science, and forensic chemistry, forensic experts can reconstruct shooting incidents, determine the type of weapon used, and establish connections between firearms and crime scenes. This abstract highlights the significance of forensic ballistic analysis in criminal investigations, its role in courtroom proceedings, and ongoing advancements in forensic technology and methodology.

Keywords: *Forensic Science, Ballistic Weapons.*

I. INTRODUCTION

Forensic ballistics is the examination of weapons, cartridges and bullets.[3] Ballistic weapons which are used for crimes of violence can be categories into main types; smooth bore and rifled firearms. Between the two types there are various types of ballistic weapons, but suffice it to say here that a smooth bore firearm is the ordinary type of shotgun or shot-pistol, and the bullet used is the shot which consists of small lead balls or pellets.[4]

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[3] M.C. Sarkar, S.C. Sarkar, *et. al*., *Sarkar's Law of Evidence* 877 (Wadhwa and Company Law Publishers, Nagpur 1999).

[4] V. Mitter, *Law of Identification* 95 (Law Publishers, Allahabad, 1961).

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elapsed since the time of firing etc.[5]

II. INVESTIGATION OF FIREARMS CASES

A genuine investigator has several challenges, the most common of which are:

1. Identifying the crime's location.
2. Go to the area & collect tangible evidence from the scene of the offense.
3. Identification of the weapon used in the incident.
4. Finding information from inputs.
5. Providing one or more missing links in an investigative process.
6. Strengthening a weak link or connections in a collection of evidence.
7. Clarification of ambiguities at the first investigation stage and it may not even be significant later on. [6]

III. FIREARM EVIDENTIARY CLUES

The scene is the most important place for evidentiary clues. The investigating officer must locate, document (image, sketch and describe) and collect:

1. Remains of fired magazine casings, bullets, & explosives. The projectile may be implanted in equipment, buildings, and so on, emitting the smell of a burning power charge.[7]
2. Considering the scene's location and the ways of entrance & door, he draws the scene to measure & prepares a documentary of the incident, capturing all elements of the scene, the period of appearance, the status of entrances, spaces, ventilators, taps, and so on.
3. The identity of the victim, suspicions, eyewitnesses, assistants, etc., the proof gathered, the package & the collecting watchers, packaging, sealing, etc. [8]
4. Handle the ballistic weapon in such a way that even if it goes off it does not injure anybody by ensuring that nobody faces the muzzle of the ballistic weapon. Consider the weapon safe only when can see through the barrel and the magazine, if any is detached,

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[5] Rukmani Krishnamurthy, *Forensic Science in Crime Investigation* 327(Selective & Scientific Books, New Delhi, 2011).

[6] Anoompam Modak, *Scientific Techniques in Criminal Investigation* 2 (Universal Law Publishing an imprint of Lexis Nexis, Gurgaon, 2016).

[7] B.R. Sharma, *Scientific Criminal Investigation* 247 (Universal Law Publishing Co. Pvt. Ltd., New Delhi, 2012).

[8] B.R. Sharma, *Firearms in Criminal Investigation & Trials* 116 (Universal Law Publishing Co. Pvt. Ltd., New Delhi, 2012).

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and avoid touching the inside of the barrel. The presence or absence of rust, fouling, dust, skin, flesh, blood and other materials can lead to important conclusions. If anything is introduced in the barrel, the evidence is contaminated or lost.

5. The barrel should, therefore, be capped, check the breech face of the ballistic weapon. It may bear marks in dust or grease. They are imaged. The breech face may carry enamel or paint from the cartridge fired through ballistic weapon. The materials help in the identification of the cartridge. Avoid carrying the firearm in a pocket or in a dirty or dusty container. It is likely to introduce dust or dirt in the barrel which can mislead the expert. [9]

6. Put identification marks (case number, initials with date) and get signatures of the witnesses on the firearm. The signatures are put at prominent part like barrel, action block or stock and not on interchangeable part. The detailed particulars are scratched on the ballistic weapon, at a place where there is no other evidence.[10]

7. Types of ballistic weapon, these weapon prohibited and prohibited ammunition or not, and arrest of person by police officer.

IV. MECHANISM OF FIREARMS

Two key elements comprise the ballistic weapon: (1) the barrels & (2) the automated system that contains the chamber, tightening pin, extractor, ejection device & activate. There are two kinds of barrels: (1) smooth bore and (2) smooth grooves.

All barrels are made of boiled solid steel parts. The solid steel pieces are subjected to the drilling process from one end to the other with a uniform diameter. The inner side of the barrel will later bore with a reamer to produce a smooth surface. One of the scientific significance of barrel is that due to the drilling process, the inner surface of the barrel gets various scratches and scars which supplies the individually to that barrel. These scratches and scars give distinct marks on the bullets that fired through that barrel, which are considered in forensic firearms as individual characteristics. On the other hand, rifles contain various grooves and lands artificially created for firing accuracy, rotation of bullets, firing to a long distance etc. Barrel grooves are of two types: (1) grooves twist towards that left hand side and (2) grooves twist towards the right hand side.[11]

Ballistic weapon examiners may be called upon to determine if weapons are operating properly

9 *Ibid.*
10 *Ibid.*
11 Rinker R.A., *Understanding Firearm Ballistics* 128 (Mulberry House Publishing, Clarksville, 2004).

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or to conduct firearm powder shot pattern tests. In addition, examinations of questioned ammunition case may be assisting in ascertaining the type of firearm used in a crime. The bomb expert can analyze fragments of bombs to determine their original composition and possible sources of raw materials. The barrel is the metal tube in which the charge is placed ready for firing and in which it is exploded. This tube compresses the gases developed during combustion and gives the missile its proper direction. Now-a-days the barrel is always made of steel: formerly we find it constructed of iron and even bronze, copper, brass, and other metals.

The stock is that part by which the firearm is held and which supports the barrel. It not only enables us to hold and manipulate the arm, but to it also fixed the lock plate and revolvers it may be of horn, ivory, vulcanite, and even metal. When trigger is pulled, it further pulls the firing pin, a hard steel rod that is holding inside the hole drilled through the breech assembly. The firing pins have a nose with different shapes, which is also manufactured after subjecting to different filing steps. The microscopic imperfections are also visible on the firing pin due to the filing process.[12]

V. GENERAL CHARACTERISTICS OF FIREARMS

The following class characteristics are common to large numbers of firearms: [13]

1. Manufacture is indicated by the name or initial stamped on the head in the case or by initial or trade-mark in the case of .22 calibers.
2. The shape can be divided first into rim or rimless and second into straight, tapered, or necked.
3. Caliber is stamped on center fire case generally. Composition may be brass, nickel-plated, copper, plated steel, or paper.[14]

The concept that buck-shots and pellets can be linked to the weapon which fired them is recent. It is of a great importance in forensic firearm. A shotgun is firearm of choice with the criminals in India; firstly, because the firearm and the weapon of choice with the criminals in India; firstly, because the ballistic weapons and the bullets, cartridges are easily available. Secondly, the ballistic weapon can be easily homemade. The surface characteristics of the weapon which scratches the marks on a pellet are like the barrel of a rifled weapon which scratches its thumbprint on a cartridge. The identification of marks on the buckshot is possible

[12] V.R. Dinkar, *Scientific Expert Evidence* 294 (Eastern Law House, Kolkata, 2016).
[13] Charles E. O' Hara, *Fundamentals of Criminal Investigation* 604 (Charles C. Thomas Publishers, USA, 1956).
[14] *Ibid*.

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because: (i) the projectile charge of a firearm cartridge, ordinarily, move in the form of a compact cylinder during their passage through the barrel. Even if there is few turning movement of the projectile inside the barrel, the extent is practically insignificant. If the movement were appreciable, the marks on the projectile would not be sum-total of the given segment.[15]

(A) Time of Fire

It may often be required to determine the time of fire when a ballistic weapon is involved in a crime. If the barrel of the suspected ballistic weapon is examined, there may be growth of cobweb in it indicating that the firearm was not used for a long time. If the firearm is used recently, then trapped gases may be present in the barrel. The concentration of gases can be estimated which will approximate the time of fire. The presence of gaseous products in the bullet cases may also specify the approximate time of fire.

(B) Direction of Fire

During the passage of a cartridge through the rifled barrel and through a defective and roughened bore, small fragments of metal are cut and propelled in the direction in which the projectiles are ejected. Since these, particles are heavier than the powder grains; they are expected to travel up to a certain distance beyond the maximum distance to which powder grains are ejected. From the presence and pattern of these particles, it is possible to ascertain with accuracy the muzzle to target distance up to some feet beyond the powder range.[16]

(C) Fired Bullet identification

The tip of all bullets[17] is pointed for penetrating the air as well as the target. For best penetration, the lead bullets will be covered with a copper alloy partial jacket. There are high and low velocity bullets. High velocity bullets are fully jacketed for deep penetration. Low velocity bullets will cause additional damage to the target. Apart from these types, mushrooming or expanding bullets are available for transferring maximum energy to the target and also for heavy destruction of the target. In forensic firearms the construction and the composition of bullets are very important since it is useful for determining the bullets collected from the crime scenes and the target. The other important part is the propellant. The role of propellant is to help the bullet to move towards the target. In the earlier days black powder was used as propellant and

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15 *M.P.* v. *Paltan Mallah*, 2005 Cr. LJ 918 SC.

16 Gonzales, *Legal Medicine, Pathology and Toxicology* 287(Appleton Century Crofts, Inc, New York, 1990).

17 Types of Bullets: Unjacketted bullets, Jacketted Bullets, Wire-Patch Bullets, Armour Piercing Bullet, Tracer Bullet, Incediary Bullet, Dum-Dum Bullets, Hollow Point Bullet, Aluminium-Tipped Bullet, Split Nose Bullets etc.

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it was substituted later by smokeless firearm powder.[18]

Forensic test for identification of a ballistic weapon also follow the method of examining a fired bullet, if extracted from the victim's body or otherwise obtained at the scene of crime. For the rifling of the barrel may print some mark or engraving on the discharged bullet which can be microscopically examined to ascertain the extent, form and nature of the engraving. A peculiar sort of engraving may be caused by one barrel, while the characteristics of a different type of barrel may implant another shape of engraving on another bullet of the same make.[19]

Bullets are readily identifiable if a suspect firearm is available so that a comparison bullet may be fired. The firearm expert can from his examination of a bullet, may be fired. As the investigator gains experience, he will learn just what type of evidence should be submitted to the laboratory and also just what to expect from an examination of such evidence. As he becomes more familiar with the work of the laboratory, the investigator will learn the different kinds of examinations, the evidence most suited to the various kinds, what he can expect from each. Microscopic examinations are now in common use, particularly in the identification of fired bullets.[20]

(D) Illegal Weapons/Improvised Firearms

The improvised weapons are also recognized as country-made weapons, home-made weapons, pipe weapons, zip weapons etc. these weapons are made by ordinary blacksmiths to no particulars specifications, nor any standard raw material is used. These firearms have short span of life and most of them are extremely dangerous.[21] These may be country made firearms called 'Desi-Kattas' or factory-made firearms smuggled across the international border[22] and Punishment for illegal weapons. Home-made weapons are usually made of raw materials such as steel or iron tubes, water pipes, screws, scrap steel or automotive iron, etc.

Iron tubing of different size, sanitary pipes, bicycle frames are used for manufacture of barrels, metal strips for action body and frame, wood pieces for butts, metallic wires, nut-bolts and cheap quality of nails, and at times, jute or cotton threads are used for assembly. The entire manufacturing process is done in indigenous work-shops of a blacksmith with the assistance of

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[18] B.J. Heard, *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence* 76 (John Wiley and Sons, England, 1997).

[19] A.N. Gaur, *Firearms, Forensic Ballistics, Forensic Chemistry and Criminal Jurisprudence* 33 (Law Publishers, Allahabad, 1962).

[20] Paul B. Weston (eds.), *Handbook of Criminal Investigation* 196 (Arco Publishing Company, Inc., New York, 1977).

[21] *Id*. at 273.

[22] Thejaswi HT, Kumar A, *et. al*., "Desi-Katta (Country-Made Firearm) and Wound Ballistics A Review" 35 *JIAFM* (2013), *available at*: http://medind.nic.in/jal/t13/i2/jalt13i2p165.pdf (last visited on September 13, 2016).

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ordinary instruments. The barrels are made from cheap quality iron tubing which is never tested for the desired strength. There is no special fabrication of chamber, nor there do any chamber cone. The chamber and other parts of the barrel are in one continuation. There is hardly any polishing or lapping of the bore. The firearms generally are chambered for those cartridges which are easily available. Popular bore/calibers are 12 bore, 0.41 bore, 0.303 rifle, 0.32/7.65 mm pistol, 9 mm pistol/sten gun, 0.38 revolver and 0.22 rim fire cartridge.[23]

The improvised weapons are: (i) the weapons become increasingly dangerous with each subsequent shot due to poor craftsmanship, (ii) they are effective at short ranges only as the combustion of propellants is often incomplete and the extent of combustion varies from shot to shot, (iii) the generalizations made from the cartridges, bullet by the manufacturer, for standard weapons, do not hold good. Even results of experiments with the same weapons are only rough approximations, (vi) they do not permit accurate or even approximate estimates of range from the spread of pellets or direction of injury. The direction may have suffered change due to some abnormality in the internal surface of the bore near the muzzle end. Such abnormalities give variations in different shots with the same weapons, (v) the marks imprinted on the projectiles or shells fired from improvised weapons are numerous and characteristic, which facilitate the identification of the fired bullets, cartridges and (vi) it is, therefore, essential that the required information in respect of a country-made firearms could be ascertained with a degree of reliability and certainty only by experimenting with the firearm and the cartridge, bullet combination. [24]

(E) **Evidence Collection**

The evidence available on ballistic weapons should be collected systematically: (i) Search and collect all the extraneous evidence like bloodstains, skin, flesh hair, paint or dust. Detach and pack them in separate small cellophane/plastic pouches, after drying, before the ballistic weapon is processed to fingerprints, (ii) Hold the ballistic weapons from place like the sling, ring, trigger guard or the corrugated surface on the butt where the possibility of fingerprints does not exist, (iii) Check the breech face for enamel or paint left by the bullet fired through the ballistic weapon. They help in the identification of the ammunition; (iv) Put the identification particulars (FIR No, with the date and name of the police-station) and the initials with the date of recovery of the firearm at the prominent parts like barrel, action block or stock of the ballistic weapon, (v) The position of the fired and live cartridges in the cylinder when revolver is involved, and

[23] *Ibid.*
[24] *Ibid.*

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(vi) The nature, quality and the quantity of the extraneous evidence, if any, observed and collected from the ballistic weapon.

VI. METHODS/TECHNIQUES OF EXAMINATION OF BALLISTIC WEAPONS

The bullets and the cartridges are cleaned before they are examined and compared. Dust and dirt is removed with a cotton-wool swab. The greasy surface is cleaned with petroleum either. Dilute acetic and dilute hydrochloric acid are also used to clean dull surfaces.

(A) Visual Examination

Visual examination allows quick eliminations and thus save a lot of time in case involving a large number of ballistic weapons. It gives the position, size and depth of the firing pin, breech face, extractor, ejector and chamber marks. Few times there may be gross characteristics indentations which permit quick identification or elimination of a suspected ballistic weapon in respect of a bullet case. Visual examination of cartridge indicates the caliber, the number of lands and grooves, their depth, width, direction and twist. Few ballistic weapons are easily eliminated by the visual examinations though positive identifications are rare through visual examinations. [25]

(B) Comparison Microscopy

Stereomicroscopy is a simple, inexpensive and an extremely useful method. The test and the crime cartridges are placed side by side. They are properly illuminated by spot light. The light falls on the two bullet cases at the same angle. The examination of the cases is started with the lowest magnification of the microscope and progressively increased. At higher magnification, the bullets are examined in turn because photographs from both bullets are not seen in the field simultaneously. The relevant surface are examined through 360^0 and titled, if necessary. [26]

VII. METHODS OF EXAMINATION OF BALLISTIC WEAPONS

A number of approaches are used to gather gunshot remnants. The following are significant methods:

(A) Dry Method

Gunshot Residues from hands are collected using molten wax with a sufficient melting point. It is carefully rubbed over the hands until it is thick enough. It is permitted to set. If the wax has

[25] B.C. Jauhary and S.N. Gaur (eds.), *Fire Arms, Forensic Ballistics, Forensic Chemistry And Criminal Jurisprudence* 6 (Delhi Law House, Delhi, 2009).

[26] B.R. Sharma, *Forensic Science in Criminal Investigation and Trials* 464 (Universal Law Publishing Co. Pvt. Ltd., New Delhi, 2014).

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hardened, it is scrubbed off. It collects the residues of Gunshot particles from the hand. On location with gunshot remnants a solution of cellulose is administered. It is taken off when it has dried. The cast collects the remains of the gunshot. On the spot with the powder markings, the solution is sprayed. The created film is enhanced by nylon strands. The reinforced film that collects the powder remains is pulled off and desiccated. [27]

(B) Wet Methods

Diluted acetic acid moistens a filter paper. It is pushed against the place suspected of carrying traces of firearms. The filter paper collects them. A cotton cloth or cotton swab is wetted with diluted hydrochloric acid (10 per cent) and with nitric acid (5 per cent) and this piece of cloth is swabbed on the spot containing firearm residues. It collects the residue of firearms. The swabs are taken individually from various areas of the hand. [28]

The hands are washed thoroughly in a plastic bag with diluted nitric acid (50 milliliter of one molar nitric acid are used). The solution obtained is freeze & ready for testing. The remnants in the barrels are recovered with warm distilled water by cleaning the barrel. The washings are checked for the residual components.

(C) Scanning Electron Microscopy (SEM)

SEM is the most impressive and effective technique to evaluate the gunshot residues: (i) it images the powder residue particles at site. The specific shapes of the lead particles indicate firearm shot residue, (ii) it provides elemental analysis of the elements in the powder residues, (iii) the analysis is non-destructive in nature, and (iv) it gives the number of the particles per unit area.

(D) Dermal Nitrate Test

The dermal nitrates test was used often to identify the gunman before 1950. The test is straightforward. The nitrates are collected on a paraffin wax cast, as previously reported. Diphenylamine dissolves the remains of the cast in strong sulfuric acid. The development of blue dots shows nitrates. In turn, the existence of the gunshot remnants is suggestive. The technique is no longer utilized as several common materials had a positive reply to the aforementioned tests.

(E) Paraffin Test

The method of detecting gunpowder residues in the hands of a suspect in a case of shooting is

[27] *Ibid.*
[28] *Ibid.*

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known as paraffin test and depends upon the fact that when a poorly constructed weapon is fired, the burnt/unburnt gunpowder residue escape through the rear and get deposited on the firing hand. If the hand is examined before it is washed, the products of combustion of propellant will be detected therein. [29]

(F) National Integrated Ballistic Information Network (NIBIN)

NIBIN system is a sort of fingerprint bureau for the 'thumbprint' of ballistic weapons. The identifying data from all the licensed factory-made ballistic weapons, if generated and stored in the computers of the NIBIN before they are sold, they are sold, can be used to identify the offending ballistic weapons abused in a crime. The fired bullet, cartridges left at the scene can identify the ballistic weapon from the corresponding recorded data kept in the National Integrated Ballistic Information Network. The NIBIN system has much importance: (i) Comparison takes less time, (ii) Comparison and verification can be done at any designated match point place where the facilities for the work are installed, and (iii) the hurdle presented by the deformation of bullets is taken care of by the NIBIN system. [30]

VIII. CONCLUSION

The forensic science of ballistic weapons is a crucial aspect of modern criminal investigations, providing valuable evidence to law enforcement agencies, prosecutors, and courts. Through meticulous examination and analysis, forensic experts can determine vital information about shooting incidents, including the type of firearm used the trajectory of bullets, and the presence of gunshot residue. This information aids investigators in reconstructing crime scenes, identifying suspects, and establishing connections between firearms and criminal activities. The conclusion drawn from the examination of ballistic evidence can have significant implications in legal proceedings, influencing the outcome of criminal trials and ensuring justice is served. However, it is essential to recognize the limitations and challenges associated with forensic ballistic analysis, including the need for specialized expertise, the potential for human error, and the evolving nature of forensic technology.

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[29] Charles R. Swanson, Jr., Neil C. Chamelin, *et. al.*, *Criminal Investigation* 180 (Goodyear Publishing Company, Inc., California 1942).
[30] *Ibid.*

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