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BALLISTIC COEFFICIENT OF WADDING BY HIGH SPEED MOTION PICTURE PHOTOGRAPHY

Prediction of lethal range of wadding components has forensic significance. Jauhari et al.(1) approximated the ballistic coefficient of shotgun wadding components on the basis of theoretical considerations. The theoretically derived values of ballistic coefficient when used in nomal equations of motion lead to maximum range figures which show only a limited measure of agreement with the experimentally observed values. Earlier studies (1,2) could not pinpoint the source of this discrepancy although several possibilities were considered. In the present note, the possibility of deriving an experimental estimate of ballistic coefficient of wadding components has been examined by having recourse to high speed motion picture photographic analysis. Attention has been paid only to the air-cushion wad which is the heaviest of the wadding components and which also attains the maximum range.

When a shotgun is fired, the shot charge along with the wadding column emerges from the muzzle with more or less the same velocity. The remaining velocity of wadding components and the shots at various ranges of firing depend upon their ballistic coefficients. The wadding and the shots can be photographed at some distance from the muzzle and their remaining velocities can be computed by analysing the frames of the high speed photographic film. Since the ballistic coefficient of round lead shots is known from literature (3), an estimate of the muzzle velocity of the shot can be made on the basis of remaining velocity figure with the help of appropriate ballistic table. This estimate of muzzle velocity can also be deemed to be the muzzle velocity of the wadding components. Therefore, it can be used in conjunction with the remaining velocity of the components calculated earlier to estimate the ballistic coefficient of the components by again having recourse to the ballistic tables. This approach has been taken care here. The shot charge of a 12 bore 2 1/2" K.F. cartridge was removed and it was loaded with a single lead ball weighing 28.13 gms and measuring 0.658" in diameter. A single projectile was preferred to small shots for convenience in photographic measurements. The cartridge was fired through a 12 bore shotgun and a high speed motion picture photo-

★ Accepted for presentation in the 3rd Indo Pacific Congress on Legal Medicine and Forensic Sciences, Madras, Sept. 1989.
graph of the ejecta was taken by the NAC 16HD high speed motion picture camera across the line of firing at a distance of 3.25 ft from the muzzle. This distance was chosen so that the ejecta could clear itself from the muzzle blast. The photographic parameters are recorded in Table 1 and the high speed photograph is given vide Fig. 1.

| TABLE—1 |
|-----------------|------------------|
| Focal length (mm) | 50               |
| Shutter constant | 40               |
| Framing speed (1/sec) | 6900            |
| Distance from lens to shot path (inch) | 37.25 |
| Distance from muzzle to mid-portion of view-field (ft) | 3.25 |

Using 160 B Film motion analyser, the remaining velocities of the lead ball and the air-cushion wad at a distance of 3.25 ft from the muzzle were estimated to be 1175 ft/s and 1072 ft/s respectively. The ballistic coefficient of lead ball works out to be 0.06214 as per Inglis ballistic table (3). Using space functions of the Inglis table (4), the muzzle velocity of the lead ball was estimated to be 1182 ft/sec.

Since the muzzle velocity of the lead ball and the air-cushion wad can be deemed to be equal, this muzzle velocity and the remaining velocity of 1072 ft/sec as determined from the analysis of high speed photographs was used to compute the ballistic coefficient of the air cushion wad. A recourse to space functions of the Inglis table yields a value of 0.0029645 which is quite close to the theoretical estimate furnished by Jauhari et al. (1).
(High speed frames of single shot projectile and wadding components)

1. Direction of movement of projectile/wadding is from right to left as indicated by arrow.

2. Frame numbers have been indicated by figures on left side of the photograph.


4. Exposure time of each frame is 0.0001449 seconds.
References.

M. Jauhari
National Test House, Alipore, Calcutta-700 027
and
M. S. Rao, S. M. Chatterjee, A. Sen and A. Pal
Central Forensic Science Lab., Calcutta-700 014.

DISTRIBUTION OF NUVAN (DDVP) IN AUTOPSY TISSUES & FLUIDS IN A FATAL POISONING CASE

Dichlorvos, which has the commercial name DDVP is a very volatile insecticide (Vapour pressure 1.2 X 10^-9 mm Hg at 20°C) which gives rapid knockdown and kill of houseflies. It has been widely used in dry or liquid bait or in resin strands for fly control and is also used on livestock to control flies. Dichlorvos is a colourless to amber liquid which is miscible with or soluble in most organic solvents and soluble in water to 1 per cent. It has an acute oral LD₅₀ in rats of 56—80 mg/kg (1).

Dichlorvos is rapidly inactivated by mammalian liver enzymes and patients with hepatic insufficiency may be less tolerant to its toxic effects. It directly affects on chlorinesterase enzyme (2).

DDVP is widely available in India and other countries with the different names as Dedevap, Mafu Nerkol, Oko, Nagos and Vaponent etc.

Since, we could not come across a reference of DDVP poisoning & its distribution in the autopsy tissues on literature survey. It is therefore, worthwhile to report the interesting data obtained regarding the distribution of dichlorvos in various body tissues & fluids.

Case History:
A 24 years male was found dead in his room. A bottle of Nuvan (DDVP) was lying near to body, circumstantial evidences were suggestive of poisoning.
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An international journal dedicated to the applications of science to the administration of justice
A SCHEME FOR THE COMPUTERIZATION OF RIFLING SPECIFICATIONS OF FIREARMS

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Central Forensic Science Laboratory, 30-Gorachand Road, Calcutta-700 014 (India)

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(Revision received March 23rd, 1987)
(Accepted March 30th, 1987)

Summary

A scheme for the computerization of rifling specifications of firearms has been proposed to automate the search for the probable make and model of the firearm responsible for discharging a crime bullet. The practical feasibility of the scheme has been demonstrated by computerizing the rifling specification data reported by Mathews (Firearms Identification, Vol. III, University of Wisconsin Press, 1973, pp. 4–66) using the BDP-100 computer facility of the Central Forensic Science Laboratory, Calcutta. The system lends itself to future enlargement possibilities as more and more rifling specification data become available. A programme flow chart has been presented and the logic of the programme flow has been explained.

Key words: Computer; Rifling specification; Make/model of a firearm

Introduction

When a bullet is discharged through a rifled firearm, the characteristics of the barrel are impressed on the bullet. The lands and grooves of the barrel produce corresponding marks on the bullet. The direction (right or left) and the rate of twist of rifling determine the slant of the lands/grooves on the bullet surface vis-à-vis its longitudinal axis. Thus, from an examination of the bullet, the following parameters of rifling can be gauged: (a) No. of lands and grooves; (b) Angle of rifling/direction of twist; (c) Rate of twist; (d) Width of lands/grooves; (e) Depth of groove. In addition, a measurement of bullet weight/diameter can give an idea of caliber and the constructional features of the bullet provide a clue to the type of weapon (pistol, revolver, rifle).

It is known that the rifling specifications of firearms of different type, caliber, make and model vary considerably although the possibility of some overlap cannot be discounted. This opens up the possibility of determining the firearm responsible for firing a crime bullet on the basis of the observable characteristics mentioned above. Such an evaluation can prove to be invaluable to an investigating officer in the initial phase of investigation when only a fired bullet is recovered. It can help in cutting short the arduous process of
search of the crime weapon and it was this premise which prompted the firearms experts to set up comprehensive collections of the rifling specifications of firearms. The comprehensiveness of collections is obviously related to the reliability of the results. Munhall [1] initiated the work on such a compilation as early as the early sixties. Mathews [2] developed special instruments and techniques to measure the rifling specifications of a large number of firearms and presented the data in a book form. Individual laboratories have generated and compiled their own data. In spite of all such efforts, data on rifling specifications remains scanty and elusively scattered in literature.

With the appearance of instruments like the MP6A Projector, which can measure the rifling specifications rapidly, and the opening up of the storage and fast retrieval of data via a computer, interest in the compilation of rifling specification data has received a boost. The Federal Bureau of Investigation has developed such a computerized system for rifling specifications of firearms and the data from this collection can be had as a hard copy and probably in disc format also. However, such systems have yet to be taken up elsewhere in many other countries, especially in our part of the world. The need for the development of indigenous systems conditioned by the availability of computers of restricted capacity and catering to the needs of a particular country/region cannot be overemphasized. Keeping this in mind, the CFSL, Calcutta has developed a computerized data base of rifling specifications to determine the probable make and model of a firearm responsible for discharging a crime bullet. In the present paper, a computerized scheme for the storage of rifling specification data is presented. This data base has been used to determine the probable make/model of the firearm on the basis of rifling characteristics measured on a crime bullet. The scheme has been worked out on the BDP-100 computer using BASIC language. The system has built-in flexibility for future expansion.

Computer Configuration

BDP-100 is a business machine for EDP applications built around an 8-bit microcomputer. It is small, compact and inexpensive and is designed to meet the requirements of a variety of applications. The system is built around the LSI, N-channel, Si-gate, MOS single chip processor. The chip interfaces with Memory and Input/Output through an 8-line data bus and a 16-line address bus. The micro-computer has an 8-bit Data word length and a Multiple word instruction format. It has a machine of 2 $\mu$s and can directly address up to 64 Kbytes of core memory or any standard combination of semi conductor RAM/ROM. It has 256 input ports and 256 output ports through which it communicates with various standard peripherals. The standard system software includes a Basic Assembler on On-line Debugging system, a variety of Utility packages, basic language, ECObAL and Algebraic language processor. The system available in the CFSL, Calcutta is provided with four floppy disk
drives, a CRT terminal and a 132 column dot matrix printer. A separate data entry machine is also available.

**Rifling Specification Parameters and Creation of Data Files**

When a bullet fired through a rifled firearm is received, it is generally possible to ascertain the type and caliber of the firearm responsible for firing. Computerized systems for evaluating the caliber from bullet weight and diameter [3] have already been developed. Constructional features of the bullet generally provide a clue to the weapon category, i.e. pistol, revolver or rifle. A visual examination of the bullet enables a firearms expert to count the number of lands/grooves and ascertain the direction of twist (right/left). Using a measuring instrument, it is possible to determine the width of bullet groove which corresponds to the width of the land in the firearm. Although the rate of twist of rifling can be deduced by measuring the angle of rifling, such measurements are not considered to be reliable on account of the approximation involved in determining the bullet axis. Similarly, measurement of the width of the bullet land and the depth of groove on the bullet are also not considered to be reliable. In view of this, the parameters which can be reliably measured consist of caliber, number of lands/grooves, direction of twist and the width of groove. Attention was, therefore, confined to these parameters alone.

Mathews [4] has classified the rifling specification data according to the type of weapon and within each type by the caliber. For computerization, this data was recast. All firearms of a particular type, caliber, number of lands/grooves and direction of twist were grouped together for the purpose of creating a sequential file. This arrangement was adopted to cut down the time of search which is generally more in a sequential file than with a random access file because each data item is to be checked serially. Thus if a 0.38 caliber bullet fired through a revolver with 4 lands/grooves and right twist is recovered, only firearms with these class characteristics need be checked by opening the specific file. It was not possible to open random access files because of the

**TABLE I**

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<th>File nomenclature</th>
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<td>303RIF.4L</td>
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<td>.45 Rifles, 3 lands/grooves, right twist</td>
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<td>.22 Rifles, 4 lands/grooves, right twist</td>
<td>22RIF.4R</td>
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<td>.38 Revolvers, 5 lands/grooves, right twist</td>
<td>38REV.5R</td>
</tr>
<tr>
<td>.30 Revolvers, 6 lands/grooves, right twist</td>
<td>30REV.6R</td>
</tr>
<tr>
<td>.32 Revolvers, 6 lands/grooves, right twist</td>
<td>32REV.6R</td>
</tr>
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</table>
EXTRACT OF DATA IMAGE IN FILE (45PIS.6L)

Fig. 1. Typical data entries in a firearms data file.

possibility of overlap of the groove width parameter in respect of different firearms. The nomenclature adopted was such that it was descriptive of the class characteristics which formed the basis for the creation of the file. In the example cited above, the file name would be 380 REV.4R. Here the first three numerals give the caliber, the next three letters indicate the type of weapon (revolver abbreviated as REV), the numeral 4 stands for the number of lands/grooves and the letter R stands for the right direction of twist. Table 1 gives some of the file names adopted. The entries in each file consisted of the bullet groove width (corresponding to the land width of the firearm), rate of twist (wherever available), make/model of the firearm and the source from which the data were obtained. The data were stored on floppy diskettes. An extract of the data image on one of the floppy diskettes is given in Fig. 1. The flow chart for creating the sequential files is given in Fig. 2.

Fig. 2. Flow chart for creating firearms data file.
Search Programme

A search programme based on the width of the bullet groove was developed. The flow chart of the search programme is given in Fig. 3. After the type of weapon, caliber, number of lands/grooves and direction of twist are entered, the computer opens the specific file whose firearms data correspond to these characteristics. At this point, the measured bullet groove width is entered. To take into account the errors in the measurement of groove width, ± error limits are specified so that all the firearms within the measured groove width ± specified error limits are covered. The limits are kept floating and left floating.
to the choice of the firearms expert. All the firearms are then checked serially. If any match is found, the same is relayed to the video screen and a print out is simultaneously obtained. After all the items are checked in the file, the file is closed. In case no match is found, a "No Match" message is relayed on the video screen. A typical print out for a search is given in Fig. 4.

**Practical Application**

It is important that firearms rifling specification data are continually enlarged and updated to make this determination reliable. Data need to be collected from literature and it is to be generated in the individual laboratories. Exchange of data between the laboratories is most desirable. It would be a good and desirable practice to fire a test bullet whenever a rifled firearm is received in the laboratory and measurements made of the rifling specifications. The stored data should then be checked against these measurements. If the computer response includes the firearm in question, the data may be ignored, otherwise they can be entered. In this way, a continuous updating of the file is ensured. A system developed on the above lines is at present working satisfactorily in the CFSL, Calcutta and is being usefully put to practical use.

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EFFECT OF RANGE WIND ON THE TRAJECTORY OF SHOTGUN WADDING

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(Received November 4th, 1986)
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Summary

The mathematical formalism proposed previously in Forensic Sci. Int. (22 (1983) 123–130) to study the undisturbed trajectory of shotgun wadding components has been modified to take into account the effect of wind on the range. The modified equations have been used to gauge the effect of range wind on the ballistic elements of the trajectory of shotgun wadding components.

Key words: Shotgun wadding; Trajectory; Range wind.

Introduction

In an earlier paper [1], a mathematical formalism was proposed within the frame work of which it was possible to evaluate the approximate trajectory of shotgun wadding components. The solution of the normal equations of motion which formed the basis of computations was derived for "NO WIND" condition. This appears to be a deficiency in as much as the trajectory of light wadding components might be affected by the presence of wind. It will, therefore, be desirable to introduce the effect of wind to make the formalism more realistic and acceptable. This has been attempted in the present paper.

Range Wind Correction

A range wind, i.e., the one blowing in or against the direction of fire is most effective in changing the trajectory parameters such as the residual velocity, range, angle of attack, etc. As a first step towards introducing the effect of wind in general, that of range wind has been considered. McShane et al. [2] have discussed the theoretical considerations governing the introduction of wind in the solution of the normal equations of motion. According to them, it is difficult to find the effect of varying wind when the Siacci method is used. It is, however, not difficult to introduce the correction due to constant wind. Since the trajectories of wadding components cover a short span and do not attain any considerable height, the consideration of constant wind should be sufficient for forensic purposes.
In Fig. 1, OX, OY and OZ are the three mutually perpendicular axes forming an orthogonal system. OX is taken as horizontal in the direction of firing. OY points vertically upwards. If now a gun at the origin O is fired in the direction OX with velocity $V_o$ the projectile will trace a trajectory in the vertical plane. The range of the projectile in the direction of firing at any time ($t$) will be represented by the $X$-coordinate and its fall below the line of firing by the $Y$-coordinate of the trajectory. If there is a constant range wind ($W_x$), i.e. a wind blowing along the $X$-axis, then the $(X, Y)$ coordinates of the trajectory at any time ($t$) will be functions of $V_o$, $t$ and $W_x$. Therefore, the coordinates of the projectile $(X, Y)$ at any time ($t$) can be written as

$$X = X(t, W_x, V_o)$$  \hspace{1cm} (1)
$$Y = Y(t, W_x, V_o)$$  \hspace{1cm} (2)

From simple considerations of relative velocity, McShane et al. [2] have established the following identities:

$$X(t, W_x, V_o) = X[t, o, (V_o - W_x)] + tW_x$$  \hspace{1cm} (3)
$$Y(t, W_x, V_o) = Y[t, o, (V_o - W_x)]$$  \hspace{1cm} (4)

These enable one to obtain the solution of the equations of motion when range
wind is present by modifying that obtained for 'NO WIND' condition. From Eqn. (3), it is obvious that the correction for range wind can be introduced into the expression for \( X \) (for 'NO WIND' condition) by replacing \( V_o \) by \((V_o - W_x)\) and adding a term \( tW_x \) and in case of \( Y \) by merely replacing \( V_o \) by \((V_o - W_y)\). From these, the corresponding expressions for the rest of the trajectory parameters can be easily derived by modifying the solution of normal equations of motion obtained earlier [1] for a horizontal firing without any wind. For this purpose, it is convenient to first write the solution as a function of time and then make use of the identities (3) and (4). The solution incorporating the range wind \((W_x)\) correction can be shown to be embodied in the following equations, where the drop \( D \) is the same as \( Y \). The symbol \( D \) has been used in conformity with the notation used earlier [1].

\[
X = \frac{C}{A} \ln \left[ 1 + \frac{At}{C} (V_o - W_x) \right] + tW_x \tag{5}
\]

\[
D = -\frac{gt^2}{4} - \frac{Cgt}{2A(V_o - W_x)} + \frac{gC^2}{2A^2(V_o - W_x)^2} \ln \left[ 1 + \frac{At}{C} (V_o - W_x) \right] \tag{6}
\]

\[
V_{RX} = W_x + \frac{(V_o - W_x)}{1 + \frac{tA}{C} (V_o - W_x)} \tag{7}
\]

\[
V_{RD} = -\frac{gt}{2} - \frac{Cg}{2A(V_o - W_x)} + \frac{Cg}{2A(V_o - W_x)} \left[ 1 + \frac{At}{C} (V_o - W_x) \right] \tag{8}
\]

\[
\tan \theta_A = \frac{V_{RD}}{V_{RX}} \tag{9}
\]

where \( V_o \) is initial velocity of projectile in the horizontal direction of firing (ft/s); \( V_{RX} \) is component of remaining velocity of projectile in the horizontal direction of firing (ft/s); \( V_{RD} \) is component of remaining velocity of projectile in the vertical direction (ft/s); \( X \) is distance travelled by projectile in the horizontal direction of firing (ft); \( t \) is time of flight of the projectile (s); \( D \) is drop of projectile below the line of firing (ft); \( C \) is ballistic coefficient of the projectile; \( \theta_A \) is angle of attack of projectile at the target (radian); \( W_x \) is wind velocity in the direction of firing (ft); \( g \) is acceleration due to gravity (32 ft/s²).

**Effect of Range Wind on Wadding Trajectory**

The above equations can be used to study the effect of range wind on the trajectory of shotgun wadding. For this purpose, experimental data reported earlier [1] were used and the equations were programmed on the BDP-100 computer available in the laboratory.

A range wind could be of a variable velocity from hardly appreciable to strong. It will, therefore, be useful to examine effect over a range of velocities
<table>
<thead>
<tr>
<th>Range wind (ft/s)</th>
<th>Distance travelled (ft) (angle of attack, degree) at a drop of</th>
<th>Horizontal component of remaining velocity (ft/s) at a drop of</th>
<th>Total remaining energy (ft-lb) at a drop of</th>
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<tr>
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TABLE 3
TRAJECTORY OF AIR CUSHION WAD
Weight = 1.426 g; Ballistic coefficient = 0.002054; Initial velocity = 1059 ft/s; Initial energy = 54.9736 ft-lb.

<table>
<thead>
<tr>
<th>Range wind (ft/s)</th>
<th>Distance travelled (ft) (angle of attack, degree) at a drop of</th>
<th>Horizontal component of remaining velocity (ft/s) at a drop of</th>
<th>Total remaining energy (ft-lb) at a drop of</th>
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<td>Total remaining energy (ft-lb) at a drop of</td>
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to cover any eventuality. Accordingly, range wind in and against the direction of firing varying from 0 to 30 ft/s at steps of 10 ft/s have been considered for computing the trajectory of wadding components. The results are indicated in Tables I–IV, where figures have been given for distance travelled by the wadding components, horizontal component of remaining velocity and the remaining energy for drops of 1, 2 and 4 ft below the line of firing. The angle of attack has been given in the parenthesis along with figures for the distance travelled by the wadding components.

Discussion

The ballistic parameters of interest are the distance travelled by the wadding components in the horizontal plane, the horizontal component of remaining velocity and the total remaining energy. The distance travelled in the horizontal plane enables one to ascertain the probable position of the shooter. The other two parameters are intimately connected with the penetrating capability and the wounding power of the wadding components. In addition, the angle of attack which in the present investigation is also the angle through which the tangent to the trajectory turns enables one to examine the validity of the Siacci assumption of a flat trajectory at various ranges of firing. The Siacci assumption is at the heart of all the computations and the reliability becomes less and less as the validity of this assumption begins to be questioned. The wind velocities used, 10 ft/s represents a gentle pleasant breeze; 20 ft/s, quite a strong breeze and 30 ft/s, a very strong wind. Range winds have been assigned positive or negative values depending on whether or not they are with or against the firing direction.

The angle of attack figures in Tables I–IV clearly show that a positive wind has an effect of straightening the trajectory and a negative wind has the effect of making it more curved. The change in the curvature is dependent on the magnitude of the wind. For example, the angle of attack at a drop of 2 ft in case of the closing disc (Table I) is found to be $-14.0^\circ$ in the absence of wind. As the wind velocity increases to 30 ft/s, the angle of attack increases in magnitude to $-7.3^\circ$. For a negative wind of the same magnitude, the angle of attack decreases to $-74.9^\circ$. The same pattern is repeated in cases of other components of wadding.

It is observed from Tables I–IV that the distance travelled by the different wadding components at a particular drop is dependent on the wind velocity. A wind in the direction of firing enables the wadding to be carried to a longer distance, with a corresponding reduction with a contrary wind. At a velocity of 30 ft/s in the direction of firing, the increase in range at a drop of 4 ft as compared with 'NO WIND' conditions is found to be 32.7% in case of the closing disc, 17.5% in case of the air cushion wad, 24.8% in case of the undershot card and 17.6% in case of the overpowder card. For a negative wind velocity of the same magnitude, the results are not reliable with respect to the closing disc and the undershot card because the angle of attack values
(-122.6° and -77.0°, respectively) suggest a steep departure from the Siacci assumption of a flat trajectory. In the case of the air cushion wad and the overpowder card, the decreases in range are found to be 17.6% and 17.7% respectively.

In the earlier paper [1], an attempt was made to compare the theoretical computation figures with those reported by Sinha et al. [3]. Only some measure of agreement could be found and the discrepancy was ascribed to various factors. Sinha et al. conducted the firings at wind speeds of 10–15 knots, i.e., between 17–25 ft/s approx. with an average velocity of 21 ft/s. We may now compare our calculations for the distance travelled by the wadding for 20 ft/s range wind with those of Sinha et al. (Table V). The figures taken from Sinha's experiments relate to those firings in which the wadding components were recovered intact. The figures in Table V once again show that there is only some measure of agreement. Other factors contributing to the discrepancy may be the accuracy of the determination of wind velocity by Sinha et al., variation in wind velocity and uncertainty in their final location of the wadding components.

When a projectile strikes a vertical target, the horizontal component of the projectile velocity is consumed in penetration. The threshold velocity required for skin penetration has been reported to be 125 – 170 ft/s [4]. A review of velocities in Table I–IV shows that except for the air cushion wad and the overpowder card and that too at a drop of 1 ft with a range wind of 30 ft/s, the other figures are well below the threshold.

Since the horizontal component of projectile velocity will continuously decrease due to air resistance, a situation can arise with a negative range wind when this component may become negative. This would mean that the projectile will reverse its course and begin to move towards the shooter. Table I shows that for a drop of 4 ft, the horizontal component of the remaining velocity of the closing disc has indeed become negative leading to the reversal of the

**TABLE 5**

<table>
<thead>
<tr>
<th>Wadding component</th>
<th>Horizontal distance travelled (ft)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean Range Wind (ft/s)</td>
</tr>
<tr>
<td>Closing disc</td>
<td>+21</td>
</tr>
<tr>
<td>Air cushion wad</td>
<td>110–150</td>
</tr>
<tr>
<td>Undershoot card</td>
<td>35–60</td>
</tr>
<tr>
<td>Overpowder card</td>
<td>70</td>
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</table>

*Angles of attack found to be -76.3° and -42.0°.
projectile path. Such an occurrence has also been reported [3] where split closing disc was found to be blown even behind the point of discharge when firing against a wind of 10–15 knots. However, it cannot be ignored that the computations are of doubtful value when the angle of attack is such that it is difficult to justify the assumption of a flat trajectory. This is so in the instance cited above.

The remaining energy figures in Tables I–IV seem to be totally insignificant in the light of 58 ft-lb criterion. Thus none of the wadding components can be wounding agents of any consequence at the ranges corresponding to the drops of 1, 2 and 4 ft.

It is evident from the discussion presented above about the distance travelled by the wadding components that the discrepancy observed between the theoretical and experimental results cannot at this stage be ascribed unequivocally to the deficiencies in the proposed formalism. The best solution to test the formalism will be to conduct fresh experiments under controlled conditions and then compare the theoretical and the experimental results. Such a comparison might be expected to provide a firmer basis for isolating the factors responsible for the discrepancy. This will help in improving the formalism, thereby making it more useful for practical work. Work on these lines is in progress in addition to high speed photography suggested earlier [1].

References

4 J. Beyer (Ed.), Wound Ballistics, Office of the Surgeon General, Department of Army, Washington, D.C.
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Introduction of High Speed Motion Photography in Forensic Science

M. JAUHARI, M. S. RAO, S. M. CHATTERJEE AND A. SEN

Central Forensic Science Laboratory, Government of India
CALCUTTA

A high speed motion picture facility with film analyzing equipment has been set up in the CFSL, Calcutta. The facility, first of its kind in the forensic set up of the country, is expected to open new avenues of research in the field of forensic science. After giving a brief resume of the equipment and its capabilities, a preliminary trial made employing the facility has been described.

INTRODUCTION:

The use of High Speed Motion Picture Photography is of comparatively recent origin and is still not very common in the field of forensic science. This specialized technique registered an enormous growth after the second world war in view of the research demands in the field of armament technology. Coupled with the advances made in the field of electronics, one can say that by now almost all the requirements of a user can be met for recording using this, otherwise, intricate technique. While the uses of this technique for military use are many and varied, the peaceful uses of the technique have also been explored. One of the areas of peaceful research using this technology is forensic science and it is being increasingly employed in this field for problems such as those relating to the study of ballistic phenomena connected with small arms, collision of vehicles, the dynamics of fall of human bodies from considerable height, fracture of glass and other impact problems which are accomplished in a time which precludes their perception by the human eye.

It is well known that the human eye is a most remarkable instrument and a highly developed receptor for information. In combination with brain, it has the capability to receive and interpret an enormous quantity of information at a very rapid rate. Inspite of this versatility, it suffers from a serious limitations in as much as it cannot meet the requirements of observations occurring at high speeds. If a phenomenon occurs at a frequency greater than about 10 Hz/sec, it goes beyond the analytical ability of an average eye. Thus it becomes necessary to devise a method of time magnification whereby a human eye is able to study the high speed phenomenon at an apparently slower rate within the power of assessment of the human eye. High Speed Photography is nothing but a means of recording high speed phenomena as they occur and subsequently project the recorded phenomena at a slower rate or as a series of still photographs thereby enabling the normal human eye to analyse the phenomena in depth.

With the rapid advances in the field of instrumentation and the attendant objectivity achieved, the scope of work in almost all the disciplines of forensic science has been enlarged. The firearms experts who were so long acquainted with the use of Comparison Microscope as the only instrument have also unearthed new vistas of work in the field of Forensic Ballistics, hitherto unimaginable, due to the availability of sophisticated electronic chronometers, high speed photography, flash X-ray, computers, etc., to mention only a few. This has enabled them to enlarge the scope of ballistics work and also understand the basis of various phenomena.
occurring at a very rapid rate. The field of instrumented ballistics is bound to register an enormous growth in the coming years and more complicated ballistics problems of Wound and Terminal Ballistics will be amenable to objective solutions and thus help the reconstruction of the shooting incident. With this in view, the CFSI, Calcutta, which has all along aimed at achieving excellence in the field of forensic science, has already entered and experimented in the arena of computers, NAA, etc., with success. The most recent entry has been in the field of high speed motion picture photography, a unique facility and the first of its kind in the forensic set up of the country. The present paper gives an introductory resume of the facility established, its potentialities for work and describes the results of a preliminary trial experiment.

INSTRUMENTATION:

NAC 16 HD Camera.—The High Speed Motion Picture facility established in the CFSI, Calcutta consists of a 16 HD model NAC High Speed camera providing a speed range of 100 to 8000 frames per second (fps) with full frame, 200 to 16000 fps with half frame and 400 to 32000 fps with quarter frame apertures. The camera uses ordinary 16 mm movie films which could be 100 feet or 400 feet in length. The exposure time can be further reduced (equivalent to increasing the speed) by using rotating shutters which reduce the time of exposure of a frame by a factor varying from 5 to 80. To begin with, three C-mount objective lenses have been procured with focal lengths of 25 mm., 50 mm., 150 mm. for close and distant shots. Still closer shots can be made using extension tubes. The full frame of a 16 mm. film measures 10.26 mm. X 7.5 mm. It measures 10.26 mm. X 3.7 mm. and 10.26 mm. X 1.8 mm. in case of half and quarter size apertures respectively. The weight of the camera is 10.7 kg. and that of the magazine is 7.5 kg. The input voltage required is 200 to 240 V AC, the surge current being 80 to 100 amp. (at maximum speed) and the normal current 30 amp. or more. A special power line has been erected to draw the heavy current of 100 amp. at maximum operating speed.

The 16 HD camera is basically a rotating prism camera based on the principle of image compensation. Three interchangeable rotating prisms have been provided to attain different apertures. The camera can also be operated from remote control and synchronization with the event can be achieved either mechanically or electronically. The illumination is provided with four 2 K V lamps. There is a built in reflex view finder which makes focussing extremely easy. Facility for time marking the film is provided by the light from a LED lamp flashing at a pre-determined frequency and thus use the exposed points as time marks. As the camera has a timing pulse generator built into the controller, the recording speed can be precisely known. In rotating prism cameras, the camera accelerates rapidly after starting, reaches the specified speed, and then keeps the speed almost constant therefrom until the end of the film. Speed versus time curves in respect of the camera have been provided to expose the event after the camera attains the correct speed. The controller is a camera driving device by which a desired recording speed can be set and the camera can be started or intermittently stopped during recording or automatically stopped at the end of recording. The controller has a built in power voltage switch circuit.

NAC 160 B Analyser.—The film record will be of no practical value unless it is properly analysed at slow speed and even frame by frame so that measurements can be made. This has been accomplished with the help of a NAC 160 B film motion analyzer for qualitative observation and analysis of movements and changes recorded on cine produced by means of high speed, slow motion, and ordinary filming techniques. The projector provides flickerless projection, thus allowing highly accurate determination of frame number, shape of image, degree of movement and speed. A magnified image of the film (23 X) is projected which can be viewed at speeds varying from 1 to 30 frame per second in both forward and reverse motion. A computerized analysis of the number of frames advanced as well as the X, Y co-ordinates and the angular displacement of the image can be measured. A 300 W Halogen lamp is used for lighting with adjustable intensity. Damage to film on account of heat from the lamp is prevented by a special heat insulating device.

EXPERIMENTATION:

The camera has been set up and experimentation involving different types of situations in forensic work are being attempted. This development work
is a pre-requisite for the routine use of the camera in forensic case as well as research work. In the first instance, a drilling machine fitted with a cardboard on its rotating drill has been photographed (Fig.) and an attempt has been made to estimate its rotational speed by measuring the angular rotation of the wheel as a function of time on the analyzer. For this purpose the 150 mm, lens was used as an objective. While keeping the aperture as F|4 (full aperture), the working distance was 3.5 metres. The cardboard was fitted with its plane perpendicular to the axis of the drill. It was square in shape and bore black cross marks for easy identification. It was illuminated with one 2 KW lamp. The image of the cardboard was accomodated in the full frame of the camera. The camera speed was set at 300 fps and while photographing, a K5 shutter was used. A shutter constant of value 5 (K5) coupled with a camera speed of 300 fps exposed each frame for 1/1500 Sec. A consecutive series of photographs of the rotating cardboard attached to the drill is shown in Fig. The film was analysed on the film motion analyser. It was found that the rotation of the drill during one frame was 12 °. Therefore, one complete rotation of the drill (360°) will be accomplished in 0.1 Sec. which gives the rotational speed of the drill as 600 revolutions per minute. The speed as mentioned on the drill was 600 rpm. It is thus seen that the rotational speed of the drill can be ascertained with a very fair degree of accuracy. It was also possible to visualize the point to point motion of the drill via frame by frame analysis and also by running the film at low speeds. This phenomena which could not be perceived by visual observation could be analysed with ease.

With the success achieved in the preliminary trial mentioned above, the camera is now being experimented with higher speeds for recording the ejection and impact of small arm projectiles. Experiments are in progress to photograph the projectiles fired through air rifles, .22 rifle and a .410 musket. A study of the muzzle blast which leads to close range phenomena like charring, blackening, etc., is also in progress. A computer programme which can be executed on the DCM Microsystem 1121 has been developed to analyse in depth, the phenomenon to be studied prior to recording. This programme enables to know in advance the speed required to achieve a required blur, amount of light in the form of KV values, and other photographic and dynamical parameters relating to the phenomenon under study.

This being a preliminary and introductory report, the results of comprehensive experiments such as those mentioned above and other relating to cavitation in gelatin gel, etc., are expected to be reported in the very near future.
Sequence of frames showing the cardboard attached to the drill photographed at 300 fps using a full flame and a K 5 shutter.
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of present day technological developments this can be achieved successfully with the help of a computer. A computer not only permits economy of space in data storage but make the search and retrieval fast and automated. The Central Forensic Science Laboratory, Calcutta has acquired a BDP-100 computer (Electronics Corporation of India Ltd) with 64K memory. It is equipped with four floppy disk drives and a 132 column dot matrix printer. As a part of a continuous programme for finding the forensic applications of computer the feasibility of computerizing the manufacturers' codes has been taken up. The present paper reports the work done on this project.

Development of computerized system

As mentioned above, manufacturer codes assume a variety of forms but in the present scheme, codes consisting of English names/alphabetics, such as WCC, DA, DI, KYNCH, etc. alone have been considered. The first and foremost step in computerizing the codes will be to organize them in a file. Since the codes of two different manufacturers can have the same letters, the opening of a random access file was not considered. The codes were therefore, arranged in a sequential file. As is well known, the search in a sequential file is more time consuming than a random access file because in the former, items in the file are serially checked. To cut short the time of search, codes starting with alphabet 'A' were grouped together, those with 'B' were grouped together and so on and so forth. Thus a maximum of 26 sequential file containing the codes were created. Files containing the codes on firearms were distinguished from those containing the codes found on cartridges. Thus all the codes found on firearms and starting with letter 'A' were entered in one file which was designated as CODEF, 'A' and all similar codes found on ammunition in another file were christened as CODEC. A. Here the letter 'F' and 'C' just before the dot indicate that it is a file of codes found on firearms and cartridges respectively. The letter 'A' after the dot suggests that all the codes in this file start from 'A'. The file designations as adopted for codes starting from 'A' to 'M' are given in Table I as an illustration. The entries in the file consisted of code, manufacturer and remarks, if any. In the remarks, any special feature is mentioned. Further, a reference of the source from which the code was obtained is also given. The letter is considered necessary for matching the exact pattern, if available. This pattern consisting of design features cannot be computerized and therefore the matching is done visually once a match of code is obtained. The sequential files, as mentioned above, were created on floppy diskettes. An extract of the data image as recorded on the diskette of file CODECA is given in Table II.
COMPUTERIZATION OF MANUFACTURER CODES ON FIREARMS CARTRIDGES

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30, Gorachand Road, Calcutta-700014.

Summary

A scheme for the computerization of codes of manufacturers encountered on firearms/cartridges in the form of English names or alphabets has been proposed. The scheme has been worked out on BDP-100 computer (64K memory, Electronics Corporation of India Ltd) using the BASIC language. Flow chart depicting the flow of programme has been given and the logic of the programme has been made explicit. The computerized system so developed has been put to routine use in the Central Forensic Science Laboratory, Calcutta.

Keywords: Computer, Manufacturer Code, Firearms, Cartridge Identification.

Introduction

Firearms and cartridges are often found to be stamped with the code of the manufacturer. These codes assume a variety of forms. It is not uncommon to find the codes in the form of English names or alphabets. During the occupation of Germany, the US forces obtained a secret German document giving the identification code letters of various makers of arms ammunition. Deciphering the codes is of significance for military intelligence as well as for those involved in forensic work.

An important forensic problem is to determine the origin of firearms/cartridges involved in crime. This requires a comprehensive collection of manufacturer’s codes, trade marks, etc. Several such compilations are available (1, 2, 3, 4) but by and large, data on such codes is scanty and is widely scattered in literature. As new manufacturers are establishing themselves, the possibility of ever increasing variety of new codes is constantly arising. Further, changes in the codes by manufacturers over a period of time are also to be reckoned. It, therefore, becomes necessary to have a comprehensive collection of such codes and this should be continuously updated.

While manual systems for deciphering the codes have worked, there is a need for modernizing and automating the whole process. In the context
<table>
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<th>DESIGNATION</th>
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<th>CARTRIDGE CODE FILE</th>
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<tr>
<td>A</td>
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<td></td>
<td>CODEC.A</td>
</tr>
<tr>
<td>B</td>
<td>CODF.B</td>
<td></td>
<td>CODEC.B</td>
</tr>
<tr>
<td>C</td>
<td>CODF.C</td>
<td></td>
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<td></td>
<td>CODEC.M</td>
</tr>
<tr>
<td>N</td>
<td>CODF.N</td>
<td></td>
<td>CODEC.N</td>
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TABLE II

EXTRACT OF DATA IMAGE IN FILE CODEC-A

AXG, ERFURT-LADEN-INDUSTRIE ERFURT NORD: WWII GERMAN CODE: MATCHER'S NOTE BOOK P 412

ADDER, BIRMINGHAM METAL AND MUNITIONS U: THE CARTRIDGE GUIDE BY I. V. HOOG P 57

ATS, ATELIER DE CONSTRUCTION DE TARBES FRANCE JANE'S MILITARY SMALL ARMS AMMUNITION BY IAN V. HOOG P 106

AGUILA, CARTUCHOS DEPORTIVOS DE MEXICO CUERNAVACA MEXICO THE CARTRIDGE GUIDE BY IAN V. HOOG P 58

ART.VIS, ATELIER DE FABRICATION DE VINCENNES SERIFONTAINE FRANCE: CARTRIDGE HEADSTAMP GUIDE BY BURTON & MUNHALL P 60

AYR, RAUFOS AMMUNISJONS-FABRIKKER NORWAY: CARTRIDGE HEADSTAMP GUIDE BY BURTON & MUNHALL P 62
A search programme flow charted vide Fig. 1 was written in BASIC language to search an unknown code. The logic of the programme is also briefly explained here. As the programme starts, the unknown code is entered. The computer then identifies its first letter and opens the relevant file. Thus if it is a firearm code and the first letter of the code is 'X', the file CQDEF. X will be automatically opened. The other files will not be touched. This leads to a great saving of time in searching the code. Having opened the relevant file, the unknown code is compared with the codes in the files sequentially and if a match is found, it is relayed to the printer as well as to the video screen with full details of manufacturer and remarks, if any. In case no match is found, a "NO MATCH FOUND" message is communicated after the end of the file is reached. The file is now closed and the computer asks for any further search. If any further search is to be conducted, the cycle is repeated otherwise the programme terminates. In this way, the programme is made interactive and in addition a hard copy of the result of search is available for record.

The scheme outlined above has been put to routine use in the Central Forensic Science Laboratory, Calcutta and it has been found to be extremely useful in economizing storage space as well as the time of search.

References
AN ANALYSIS OF BIOLOGICAL EXAMINATIONS AND RESEARCHES IN THE CENTRAL FORENSIC SCIENCE LABORATORY, CALCUTTA.

P. K. Banerjee
Central Forensic Science Laboratory, Calcutta.

Abstract

The article deals with different types of biological and biochemical examinations and the researches that have been carried on in the Central Forensic Science Laboratory, Calcutta since its inception. General trend of research and exhibit examination, procedural merits and demerits and the inference therefrom can help the present and future generation of this discipline of science in conducting research and exhibit work.

Keywords: Alkaloid test. Group specific substances. Superimposition of skull. Cytology.

Introduction

An account of the main topics of biological examinations and researches of the last 27 years (1959 to 1985) at the Central Forensic Science Laboratory, Calcutta has been recorded. Percentage of successful examination satisfying the query of investigating officer number of the different items of examination (viz. blood, semen, hair, bone and fibre), number of exhibits (on average) per case, negative and inconclusive results, serological examination have been included. Average trend of result with passing of years have also been noticed.

Inference from the number of exhibits

1. Blood cases mostly concerned with murder or attempt to murder comprise approximately 5/6th of the total cases and the blood exhibits 5/4th of the total exhibits examined. Semen cases concerned with sexual offences are approximately 1/7th of the blood cases.

2. In all the hair exhibits human and non-human hair have been differentiated and quite a satisfactory number of hair have been compared with other hair samples but number of hair exhibits meant for age and sex determination is quite less and the report of such examination has not been so helpful in the courts of law.

3. Number of bone and tooth cases is only 164 but number of exhibits is as high as 3307. Bone cases include superimposition of skull which contains generally 2 or 3 exhibits whereas in some bone cases almost all the bones of a skeleton were sent for examination.
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Journal of the Indian Academy of Forensic Sciences
COMPUTERIZED ANALYSIS OF BALLISTIC EVENT PRIOR TO HIGH SPEED MOTION PICTURE PHOTOGRAPHY

M. JAUHARI, M. S. RAO and S. M. CHATTERJEE,
Central Forensic Science Laboratory,
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Summary

Based on the theory of high speed motion picture photography, a computerized system has been evolved which enables one to undertake an indepth analysis of a high speed ballistic event prior to photography. This automated analysis enables one to fix the photographic parameters without ambiguity thereby speeding the work by eliminating the trial and error method. The computer programme has been written in the BASIC language with special reference to 16HD NAC camera and it has been executed on the BDP-100 computer (Electronics Corporation of India Ltd.) recently installed in the laboratory. It has been put to routine use in the Central Forensic Science Laboratory, Calcutta.

Keywords: High speed photography, Computer, Ballistics.

Introduction

High speed motion picture photography is recognized as an analytical tool in analyzing a high speed event. Inspite of this development, the technique has failed to make any significant impact in the broad field of forensic science. This is primarily due to the non-availability of the expensive equipment in a forensic set up. Realizing the potentiality of the technique, a high speed motion picture facility consisting of a 16 HD NAC high speed camera and 160B motion picture analyzer has been set up in the Central Forensic Science Laboratory, Calcutta. This facility, the first of its kind in the forensic set up of the country, is expected to develop the forensic applications of the technique. Work has already been initiated to study a variety of ballistic phenomena of forensic interest and it is proposed to find its applications in the other branches of forensic science as well.

During the course of development work, it was felt that prior to the actual photography of a ballistic event, it is necessary to carry out an indepth analysis of the event in relation to the photographic parameters that combine to make a successful shot. Several value combinations of the parameters may be possible. It is for the analyst to choose the
correct combination for achieving optimum results. The parameters are, therefore, required to be defined and a fast automated method has to be developed so that all the parameters can be computed rapidly and repeatedly for different sets of initial conditions.

In the present paper, based on the theory of high speed photography, important parameters relevant to the pre-record analysis of a ballistic event have been defined in relation to the 16HD NAC camera. The computation of these parameters has been programmed on the BDP-100 computer (64K memory, manufactured by the Electronics Corporation of India Ltd.) using the BASIC language. The entire pre-record analysis has thus been automated and the results are available for video display as well as in a printed format. With minor alteration, the programme can be made to work for other cameras also.

Definition of Parameters

The following parameters have been found to be relevant in performing the pre-record analysis:

1. **Projectile Velocity (V):** This is the most important parameter affecting the entire pre-record analysis. Higher projectile velocities require higher framing speeds provided other parameters are the same.

2. **Angle between the Camera Axis and Projectile Path (θ):** It may not be possible to always ensure that the above angle is 90°. When the angle is less than 80°, the distance travelled by the projectile in the objects space gets compressed on the photographic film by the trigonometric Sine of this angle and this alters some of the photographic parameters.

3. **Blur (B):** During exposure, the projectile moves. This causes its image also to move on the photographic film leading to blur. Unless the blur is kept within limits (.02—.05 mm on film in the case of NAC camera/160B analyzer), the photographic record will not be sharp and be of little value for measurements and analysis.

4. **Working Distance (D):** This is the distance between the camera lens and the object to be photographed. The camera has to be at a safe distance so that the ballistic event does not damage it in any way. The distance has also to be such that the required field of view projects as big an image as possible on the photographic film.
(5) **Focal length of Camera Lens (F):** The focal length of the lens determines the distance at which the camera will focus an object.

(6) **Apertures (f):** For each lens, there are certain permissible apertures. Aperture controls the light admitted into the camera as well as the depth of focus. Smaller apertures are conducive to a better depth of focus but necessitate stronger illumination.

(7) **Magnification (M):** Depending upon the choice of the working distance (D) and the focus length (F), the magnification on the photographic film is given by the approximate relation

\[ M = \frac{F}{D}. \]  

(1)

It will be desirable to have as large a value of \( M \) as possible subject to field of view requirements.

(8) **Field of view (FV):** The full size format of NAC camera is 10.26 mm \( \times \) 7.5 mm. It is possible to use half size and quarter size formats whose sizes are 10.26-mm \( \times \) 3.75mm and 10.26-mm \( \times \) 1.875mm respectively. Half size and quarter size formats effectively result into a higher framing rate but they restrict the field of view. If the projectile is elongated and does not extend much in the lateral direction, half and quarter size formats can be used. The field of view contained in the format of the camera is given by

\[ FV = \frac{10.26}{M} \times \frac{7.5}{M} \quad \text{(Full frame).} \]  

(2)

\[ FV = \frac{10.26}{M} \times \frac{3.75}{M} \quad \text{(Half frame).} \]  

(3)

\[ FV = \frac{10.26}{M} \times \frac{1.875}{M} \quad \text{(Quarter frame).} \]  

(4)

(9) **Shutter Constant (K):** The NAC camera is provided with a shutter which can reduce the time of exposure by a factor which varies from 3 to 80. The use of shutter thus enables one to restrict the blur without increasing the camera speed.

(10) **Camera Framing Speed (R):** The speed of NAC camera can be fixed up to 8000 frames/sec. Upto 5000 frames/sec., the speed falls in the regulated range and above that in the non-regulated range. The framing speed (R) is given by

\[ R = \frac{MV \sin \theta}{KB}. \]  

(5)
Fig. 1. Flow chart of computer programme.
HIGH SPEED PHOTOGRAPHIC ANALYSIS

PROJECTILE DESIGNATION: .303 BALL MK 7
PROJECTILE VELOCITY = 2400 FT/SEC
ANGLE BETWEEN CAMERA AXIS AND PROJECTILE PATH = 90 DEGREES
DISTANCE BETWEEN CAMERA LENS AND OBJECT = 3 FT
FOCAL LENGTH OF CAMERA LENS = 50 MM
CAMERA LENS APERTURE = 1.8
CAMERA SHUTTER CONSTANT = 40
BLUR ON THE FILM = .05 MM
MAGNIFICATION ON FILM = .0546807
LENGTH X HEIGHT OF VIEW FIELD (FULL FRAME) = 187.635 MM x 137.16 MM
LENGTH X HEIGHT OF VIEW FIELD (HALF FRAME) = 187.635 MM x 68.58 MM
LENGTH X HEIGHT OF VIEW FIELD (QUARTER FRAME) = 187.635 MM x 34.29 MM
NO. OF FRAMES EXPOSED = 5.12
EXPOSURE TIME OF EACH FRAME = 1.25E-06 SEC
BULLET TRAVEL BETWEEN CONSECUTIVE FRAMES = 36.576 MM
DISTANCE TRAVELLED BY PROJECTILE DURING EXPOSURE = .9144 MM
CAMERA FRAMING SPEED (FULL FRAME) = 20000 FRAMES/SEC
CAMERA FRAMING SPEED (HALF FRAME) = 10000 FRAMES/SEC
CAMERA FRAMING SPEED (QUARTER FRAME) = 5000 FRAMES/SEC
EXPOSURE/LIGHT VALUE = 21.3102

Fig. 2. A typical hard copy of computer output.
The above expression gives the camera speed for a full frame format. If half or quarter frame formats are used, half or quarter its value will achieve the same result.

(11) **Exposure time of each Frame (ETF)**: This is the actual time for which each frame is exposed. It is given by

\[
ETF = \frac{1}{KR}.
\]  

(12) **No. of Frames Exposed (NF)**: Before the projectile goes out of the field of view commanded by the camera, a certain number of frames are exposed recording the progress of the event. The number of frames exposed is given by

\[
NF = 10.26 \frac{KB}{26}.
\]  

(13) **Bullet Travel between Consecutive Frames (BT)**: This is the distance travelled by the projectile during the inter-frame time. It is given by

\[
BT = \frac{V}{R}.
\]  

(14) **Bullet Travel during Exposure of a Frame (BTE)**: The distance travelled by the bullet image on the film during exposure of a frame is the blur. Corresponding to this blur, the actual distance travelled by the projectile in the object space is given by

\[
BTE = \frac{B}{M}.
\]  

(15) **Exposure Value (EV)**: Exposure in relation to photography is defined as the product of the intensity of light and the time during which the light acts. Use is often made of exposure meters in measuring the light reaching the camera. In this connection, one often comes across the term Exposure Value or Light Value abbreviated as EV. Any given value of EV covers a range of aperture shutter-speed combination that yields the same exposure. A given value of EV represents a given amount of light passed through the lens. The EV is given by the equation

\[
EV = \frac{\ln KR}{.693}.
\]
Computerization

In the above computation the input data consists of projectile velocity, angle between the camera axis and the bullet path, blur, working distance, focal length of the camera, aperture and the shutter constant. The rest of the parameters are computed as functions of input data. For a particular projectile velocity, one can have different permissible values for the other input parameters depending upon the experimental conditions which obviously involves repeated calculation of the other parameters for each combination of input values. To speed up this calculation for various value combinations of the input parameters, the computation of different parameters has been programmed in BASIC language on the BDP-100 computer recently installed in the Central Forensic Science Laboratory, Calcutta. The computerized system thus developed helps to consider the various value combinations of the input parameters and select the best one for actual photography. The advance calculation of EV enables one to ensure with the help of an exposure meter that enough illumination is present to give the required value of EV and thus the success of the photographic shot is fully assured. Care has also been taken to develop the programme as an interactive one so that any junior scientific staff having no knowledge of the theory of high speed photography can feed the data in the computer and obtain a hard copy of the result. The programme is a simple one and is flowcharted vide Fig. 1. A typical hard copy of the result for .303. ball, MK7 bullet flying at a velocity of 2400 ft/sec is given vide Fig. 2.

The high speed programme so developed is in routine use in the Central Forensic Science Laboratory, Calcutta and has been found to be very useful in obtaining successful shots in the first attempt. In addition, it gives a complete picture of the motion of the bullet during the short time interval of photography which is helpful in post record analytical work.

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DETERMINATION OF ABH SUBSTANCES IN SEMEN STAINS

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Abstract

Semen stains once identified for their nature and origin, must be tested for the presence of ABH substances by absorption-elution techniques. In the present study, 62.5 percent of the samples were found to give concurrent results for the presence of ABH substances by the absorption-elution techniques.

Keywords: ABH substances. Donor. Absorption-elution technique.

Introduction

Identification of semen stains found quite often in crime cases, is a problem. Conclusive identification of a stain being of semen is possible only when spermatozoa or the sperm specific LDHX band is detected in the stain. However, with the increasing number of vasectomy as a means of limiting the population growth, semen stains may be found lacking in spermatozoa. Sharma (1983) has suggested that if a number of tests for spermine, choline are done, semen stains can be conclusively identified even in cases where there is no spermatozoa.

In the present paper, an attempt has been made to determine the presence or absence of ABH substances in semen stains which is expected to increase its evidential value in linking the suspect with the victim or the scene of crime.

Material and Method

Eighty samples of blood, saliva and semen stains were collected from the Boys' hostel of the Punjabi University, Patiala. All the donors were healthy and in the range of 18-25 years.

The donors were asked to collect the semen samples on a piece of white cloth washed thoroughly earlier and then dried in the laboratory. Blood and saliva samples were also collected from each donor in test tubes bearing the same number of semen. The blood samples were collected by the finger prick method in normal saline and were typed for
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