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# **BALLISTICS : A BIBLIOVIEW**

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**G. J. NARAYANA**

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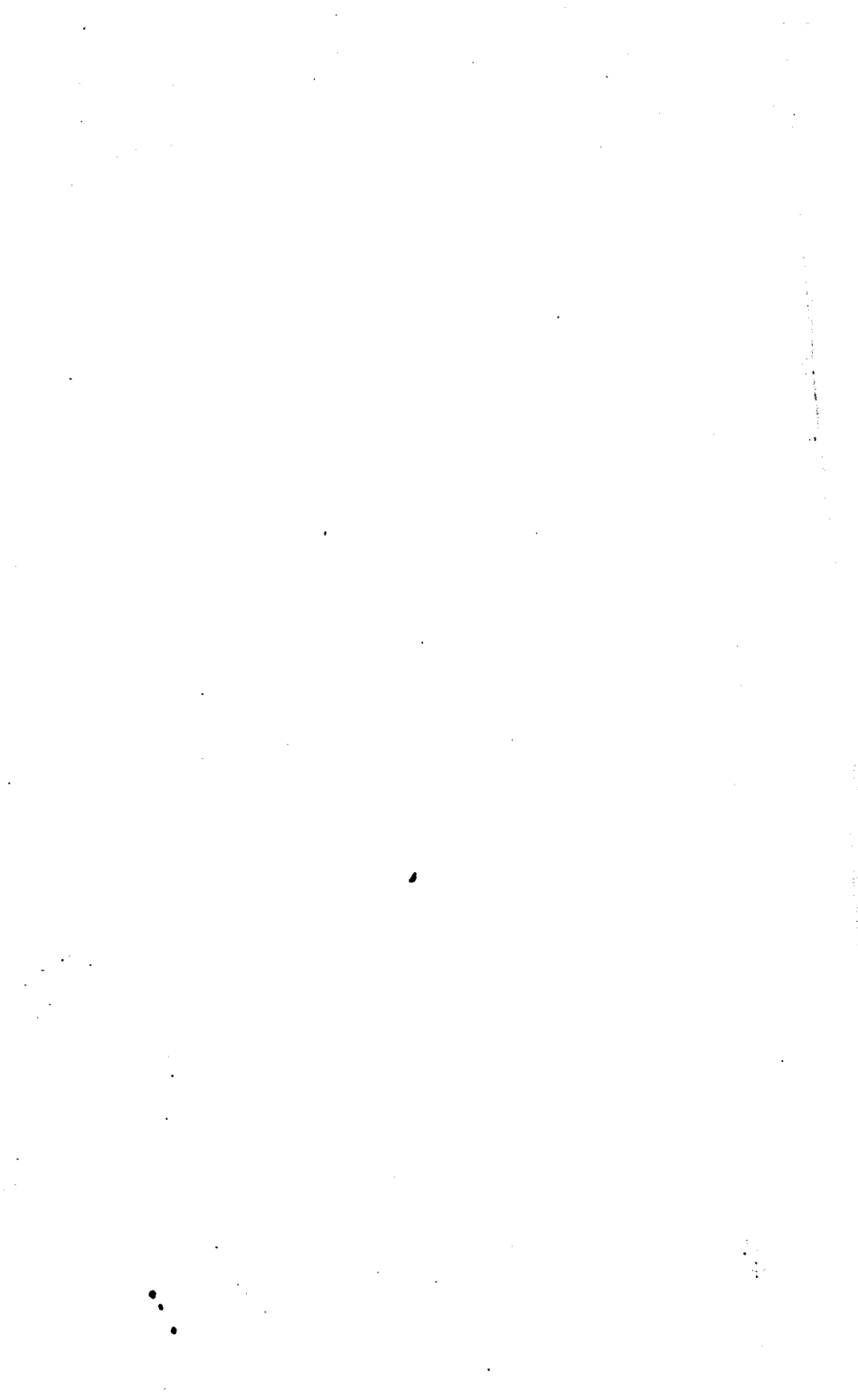
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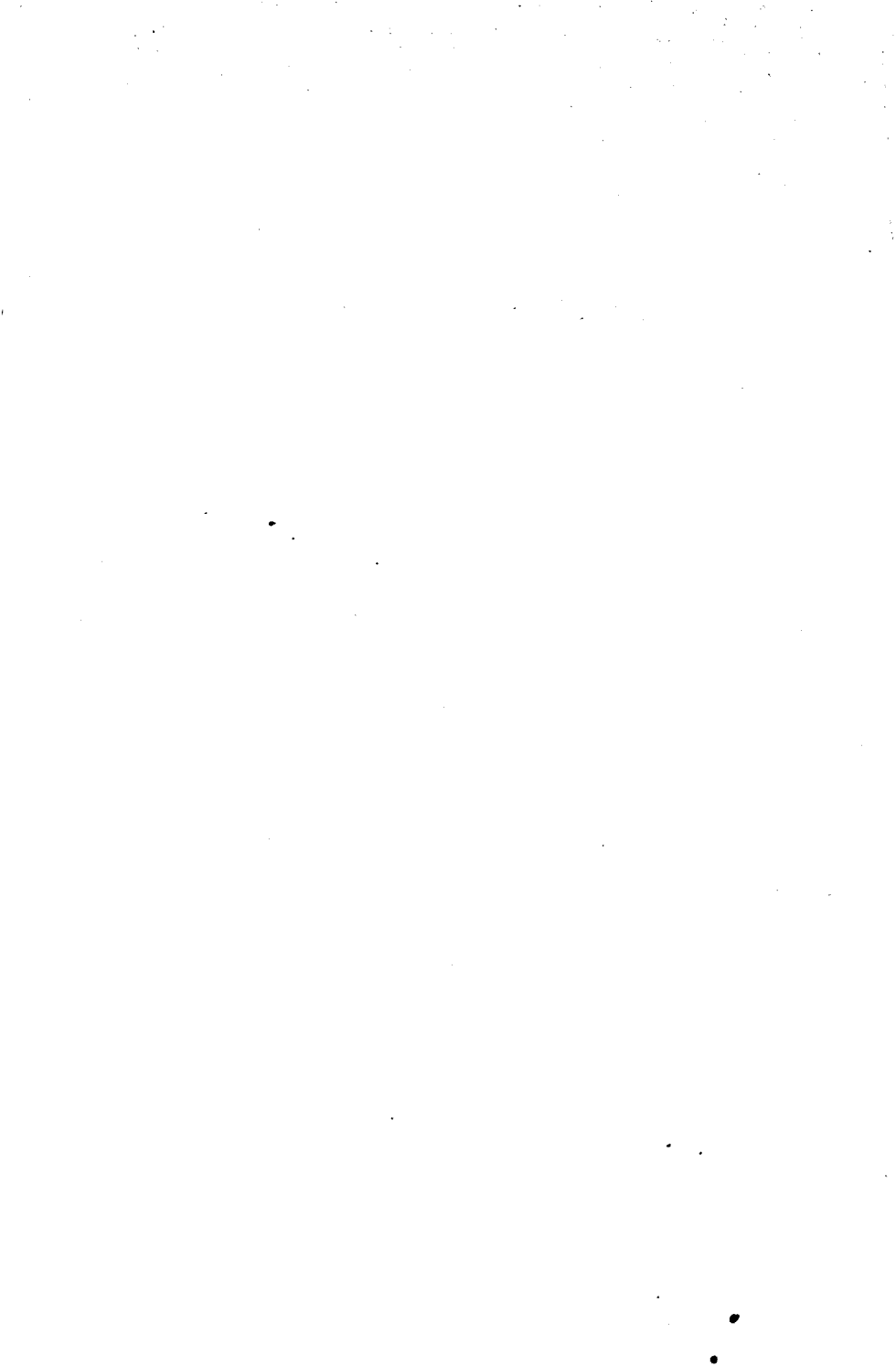
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# BALLISTICS : A BIBLIOVIEW

*Ballistics Information and Its Organization  
for Retrieval*

G. J. Narayana



Institution of Armament Technologists (India)

Pune

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## FOREWORD

Shri G. J. Narayana's "Ballistics : A biblioview" seems to be a refreshing effort of its type. Biblioview, which in itself is a beautifully simple expression, is here an overall view of ballistics. As he has presented it, it provides an introduction to the preliminary acquaintance with the multidisciplinary subject of ballistics followed by a broad survey of its literature. Since this work is based on the author's dissertation submitted for Master's degree in Library Science, it is quite pertinent that it does not stop at surveying the literature on ballistics but it provides some well thought out leads for organizing ballistics literature for its storage and retrieval as well as its dissemination.

Clarifying the distinction, which is often overlooked in much present day writing on information storage and retrieval, between document retrieval and information retrieval, the author has systematically dealt with different forms of documents or records of information and provided brief description of several indexing languages to help assess their suitability for application to ballistics literature. The adequacy of almost all of these indexing languages is well examined and the author has observed that a thesaurus approach is more efficient than classification even for ballistics.

An information system for ballistics requires to be specially designed keeping in view the special nature of the ballistics information such as numerical data, data that is not easily quantifiable or formattable, its multidisciplinary character

and the security angle necessarily associated with it. The author has therefore presented in tabular form a dozen information systems of which eight are from abroad which are known to be in operation and discussed in detail the system employed by the Australian Defence Science and Technology Information System which has greater relevance for organizing information system for ballistics and related subjects.

In the final Chapter on summary and observations, the author's last suggestion that the construction of a thesaurus for ballistics and weapons technology may be taken up by one of the ballistics research establishments in India is very pertinent and he has himself made a commendable contribution to it which is given in an appendix at the end.

Shri Narayana has been a professional colleague for many years and I sincerely hope that this work which has already received approval of the University of Bombay may not only attract the attention of all research workers in ballistics but may also enthuse many a special librarian in India to develop information systems for different highly specialized subjects in the world of learning.

N. M. Ketkar  
Social Science Documentation  
Centre  
New Delhi

1 March 1977

## PREFACE

This book is based on the dissertation submitted by the author for the award of Master's degree in Library Science of the University of Bombay. The subject is of interest to both ballisticians and librarians. A biblioview, is the bibliographical study of a subject and its literature conducted with the objective of finding out the best method of organizing its information for retrieval and dissemination. It is both an introductory guide to the subject and its literature, and an evaluation of all factors required for designing or selecting an information retrieval and dissemination system.

The three broad areas into which the study falls are the subject of ballistics; its information resources; and the information system design or selection.

Chapter 1 deals with the history and development of ballistics from the time of Aristotle to the present day and Chapter 2 covers the theory of ballistics. An awareness of the historical perspective of the subject not only enables the ballistics librarian to have a proper appreciation of the subject, but also provides him with an insight into the wider context in which the subject draws its strength and finds its applications.

Chapters 3 and 4 deal with the organizations engaged in ballistics research and development, and the sources of ballistics information respectively. The study also reveals for the first time a quantitative estimate of the literature generated in the field.

Chapters 5 and 6 covering the third area of the study are concerned with the main theme of the book, that is, organizing ballistics information for retrieval and dissemination. The problem is first analysed in terms of theory. The distinction between documents and information, which in turn differentiates a document finding system from that of an information transfer system is discussed. This is followed by a critical study of the available methods and systems of organization and their

suitability for ballistics. Under systems organization the suitability of various index languages – natural, pre-coordinate, and post-coordinate, and the organizational structure best suited for ballistics are evaluated. The need for treating ballistics data as different from ballistics information has been considered. The theoretical conclusions thus arrived are verified with those resulting from a study of the systems in operation following the method of questionnaire.

Concluding Chapter 7 gives a summary of the study and lists observations that have special significance to Indian conditions and can lead to fruitful results, if pursued further.

It remains for me to express my indebtedness to: Prof. B. Anderson, Head of the Department of Library Science, University of Bombay for his invaluable guidance; Dr. B. V. Ragavendra Rao, former Librarian of the Indian Institute of Science, Bangalore for his helpful suggestions; Dr. J. N. Nanda, former Dean of the Institute of Armament Technology, Pune for his encouragement; Dr. K. C. Sharma and Maj. H. S. N. Sastry for their academic help; Shri H. G. Desai and Kum. Meera G. Joshi for their help in numerous ways; and Shri G. R. Vakil for typing the manuscript, all from the Institute of Armament Technology. I owe a special debt of gratitude to Shri N. M. Ketkar, Director of the Social Science Documentation Center, New Delhi who has not only written the foreword but also guided me all these years. I am also thankful to the authorities of various ballistics establishments for their response to my questionnaire and to the Institution of Armament Technologists (India) for giving the imprint. I am deeply thankful to Shri V. V. Shingre of the Sarvodaya Mudranalaya, Pune, who undertook the printing solely out of his love for scholarship, and to my son Chi. Janna Herle for his help.

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## CHAPTER 1

### HISTORY AND DEVELOPMENT OF BALLISTICS

Ballistics is the study of the motion of a projectile during propulsion, free flight and impact. It is traditionally divided into exterior ballistics concerned with the flight of a projectile in different media, interior ballistics, dealing with the projection of a projectile, and terminal ballistics relating to the effects of a projectile on a target. The history of exterior ballistics goes back to the time of Aristotle in the 4th century B. C., and interior ballistics to the invention of gunpowder in the early 14th century. Terminal ballistics is comparatively, of recent origin.

#### EXTERIOR BALLISTICS

##### Aristotle's Theory of Motion

Aristotle reasoned out that no inanimate body can move without a motive force; unless it belonged to four natural elements from which the universe is made up of - fire, air, water and earth. Air and fire could only move upwards, water and earth downwards, their natural homes. This could not explain the flying of an arrow in the air or a ball roll along the turf after the motive power of man has been removed. To overcome this he introduced the concept of medium in which motion takes place. This medium assisted all 'violent' motions in the opposite in all natural things.

Aristotle's thoughts ruled supreme till the fourteenth century when it was subjected to the 'experimental' judgement of the 'impetus theory'. The new theory denied the role of the medium but affirmed, that the natural motion were still the normal states of a body, only, if it were once set in violent

## CHAPTER 2

### THEORY OF BALLISTICS

The theory of ballistics may be studied under three functional aspects, namely, interior ballistics concerned with the firing or launching of the projectile; exterior ballistics dealing with the flight; and terminal ballistics relating to the problem of target effect. Under these branches we further study the ballistic problems as encountered in a particular type of projectile, namely, shells, bombs, rockets and under-water projectiles.

#### INTERIOR BALLISTICS

Interior ballistics is the study of the events which take place from the moment of ignition of the propellant to the time when the projectile leaves the muzzle end of a gun, or the rocket achieves all-burnt position during flight.

#### Ballistics of Guns

The phenomenon taking place in a gun when fired is generally as follows. The propellant is located in the chamber of the gun. The front of chamber is formed by the base of the projectile, that is, shell or bullet and is more or less effectively sealed in the case of artillery by the driving band, or rotating band. When the propellant is ignited it begins to generate gas and causes the pressure in the chamber to rise. When the pressure reaches a value sufficient to overcome initial band resistance, usually of the order of  $200\text{--}300\text{ kg/cm}^2$ , the projectile begins to move thus increasing the volume available for the gases. The rate of burning is so rapid that the pressure continues to rise until the projectile has moved a distance of the order of one or two calibres, when the stage is defined as peak pressure. After reaching this point, the rate of increase of

## CHAPTER 3

### BALLISTICS RESEARCH ESTABLISHMENTS

Familiarity with the functions and activities of establishments engaged in ballistics research will immensely reward persons in the field of ballistics information in :

- 1 Locating the sources of information, particularly of reports and data type;
- 2 Intuitive directing to the possible sources of latest developments when called for; and
- 3 Helping to establish contact for mutual benefit.

Ballistics being an interdisciplinary subject is closely linked with physics, applied mathematics, aeronautics and astronautics, applied chemistry, engineering and metallurgy, electronics and military technology. It is beyond the scope of this study to cover all these fields. Only those organizations engaged in ballistics research or some related aspects of it are described.

Since ballistics finds direct applications in weapons development and testing, many times even the knowledge about the institutions where ballistics and allied research is conducted is kept a closely guarded secret. Hence, this account cannot be exhaustive.

#### AUSTRALIA

- 1 Materials Research Laboratories, Melbourne. *Field* : Terminal ballistics.
- 2 Royal Australian Navy Research Laboratory, Sydney, *Field* : Underwater ballistics.

## CHAPTER 4

### SOURCES OF BALLISTICS INFORMATION

The growth and development of scientific knowledge occur, according to Kuhn (1), as a result of the development of a paradigm, which sets guidelines for research. The paradigm consists of a vocabulary, mathematical structures, preferred methodologies, and examples which apply these components to carefully chosen problems. Popper (2) explains the growth of science in terms of "research programs", a modified form of paradigm, and concludes that science is constantly evolving via the rise and fall of many research programs. Apart from paradigm there is another important channel that facilitates and structures scientific and technical communication and helps the growth of scientific knowledge, and that is information.

A study of the growth and development of scientific knowledge, the process and the media of dissemination of this knowledge and the role of information in scientific research helps information dealers in many ways. Apart from the works of Kuhn and Popper, the studies made by Neelameghan (3, 4) on the structure, attributes and development of the universe of subjects, the survey on the information needs and uses by Lin and Garvey (5), and the review on user interface in interactive systems by Martin (6) are of interest even to ballistics and its information handling.

Ballistics being a composite subject, its information range encompasses many subjects. The following figure, derived from a study of the journal literature, shows the profile of the subject. The percentage refers to papers contributed by each subject.

## **CHAPTER 5**

### **ORGANIZATION OF INFORMATION FOR RETRIEVAL**

It is estimated that the number of useful periodical articles published each year in science and technology alone is in excess of one million. If we add to this the number of books, reports, patents, theses and other media of published information we will get an idea of the quantity of information that we are to deal with. All this information is published in the belief that somewhere sometime someone has or will have a need for it. In the previous Chapter we have considered the different sources of ballistics information, and now we will examine the problem of organizing this information for retrieval.

#### **PROBLEM OF INFORMATION RETRIEVAL**

The problem of information storage and retrieval is that of devising a system or a set of systems by which the published information is collected, stored and retrieved for a person who needs it. The simplest and a more common example of such a system is the organization of books in a library. Effective retrieval of information is possible only when the information is organized in a suitable manner. The problem is complex and no one ideal solution exists.

When we say we retrieve information, what we do in practice is to trace a book or an article or a patent or an index entry which has information required by the user. We may also supply the actual information in the form of an abstract, extract, formula or an equation. It is necessary to understand the difference between the two. This aspect of information problem has not been thoroughly gone into so far

## CHAPTER 6

# EVALUATION OF INDEX LANGUAGES FOR BALLISTICS

There are several factors that need to be considered in evaluating the suitability of a particular index language. The important among them are the nature of the subject, merits of the index language, intended use and the structure of the user organization and available facilities.

### SUBJECT OF BALLISTICS

Ballistics originated as a branch of applied mechanics and it has developed in two distinct directions, one devoted to the development of theory and the other applied to the fields of gunnery, bombs, underwater projectiles, rockets and aerospace applications. It is a very narrow specialised field, but interdisciplinary in nature drawing heavily from physics, mathematics, applied chemistry, materials and mechanical engineering, electronics and military technology. As a subject, it has not developed as a whole but the growth generally has been along its constituent branches and more particularly as applied to a particular field of utilization. Ballistics research generates a large amount of numerical data. Berul (1) distinguishes this type of data from information as those generally used to characterise material which is easily quantifiable, nonabstract and which can be formatted. The importance of the subject lies in its military applications and hence, a major portion of the ballistics information comes under security classification.

These special characteristics of the subject stipulate that the method of organization suitable for ballistics must provide for :

## CHAPTER 7

### SUMMARY AND OBSERVATIONS

Ballistics had attracted the attention of the brilliant minds of the past such as those of Galileo, Huygens, Leibniz and Newton as it formed the field where the hypotheses formulated by those minds in the field of mechanics were applied and tested. Because of its direct military applications, the subject has drawn the interest of governments since the beginning of the nineteenth century. For the same reason great secrecy surrounds ballistics research and development work.

The subject is multidisciplinary deriving its strength from physics, mathematics, chemistry, materials technology, engineering and even medicine. Traditionally it forms a part of mechanics. It is generally studied as applied to a particular field such as guns, bombs, rockets; though it is generally classified into external, internal and terminal ballistics.

Familiarity with the functions and activities of organizations engaged in ballistics research and development will greatly help persons dealing with ballistics information in locating the sources of information. But it is extremely difficult to gather information about such organizations. Our knowledge of ballistics research establishments in the communist world and some of the West-European Countries is too meagre.

Information plays an important role in the growth of scientific knowledge. Books, journals, reports and ballistics tables are the major primary sources of ballistics information. The published open literature is not very voluminous. Not many books are published on the subject. There are hardly any books on hydroballistics and terminal ballistics. About 250 to 300

**Appendix - A : Primary Sources : Books and Monographs**

1 Cranz, C. Lehrbuch der Ballistik. Berlin, Springer. Band I : Aussere Ballistik-Oder Theorie der Bewegung des Geschosses von der Waffe ab bis zum Eindringen in das Ziel. 5 Aufl. 1925. 707p.

Band II : Innere Ballistik die Bewegung des Geschosses druch das Rohr und ihre Begliet-erscheinugen. 1926. 454p.

Band III : Experimentelle Ballistik. 2 Aufl. 1927. 408p.

Erganzungen zum Band I, 5 Aufl. (1925), Band II, (1926), und Band III, 2 Aufl. (1927). 1936. 293p.

(Volumes 1 to 3 and the Supplement were republished by Edwards Brothers, Ann Arbor by Authority of the Allien Property Custodian ).

2 Mc Shane, E. J. Kelley, J. L. and Reno, F. V. Exterior ballistics. University of Denver Press, 1953. 834p.

3 Moulton, F. R. Methods in exterior ballistics. New York, Dover, 1962. 259p.

4 Corner, J. J. Theory of interior ballistics of guns. New York, Wiley, 1950. 443p.

5 United Kingdom. Scientific Advisory Council, Ministry of Supply. Internal ballistics. London, H. M. S. O., 1951. 311p.

6 United Kingdom. War Office. Text book of anti-aircraft gunnery. London, H. M. S. O., 1925. 867p.

7 Balleisen, C. E. Principles of firearms. New York, Wiley, 1945. 146p.

8 Robinson, C. S. Thermodynamics of firearms. New York, McGraw-Hill, 1943. 175p.

9 Whelen, C. T. Small arms design and ballistics. Vol. II : Ballistics. Planterville, Small Arms Publishing, 1946. 314p.

- 10 Hayes, T. J. Elements of ordnance : a textbook for use of cadets of the United States Military Academy. New York, Wiley, 1938. 715p.
- 11 Davis, L. E., Follin, J. W. and Blitzer, L. Exterior ballistics of rockets. Princeton, Van Nostrand, 1958. 457p.
- 12 Gantmakher, F. R. and Levin, L. M. Flight path of uncontrolled rockets. London, Pergamon, 1964. 379p.
- 13 Rankin, R. A. Mathematical theory of the motion of rotated and unrotated rockets. Phil. trans. Roy. Soc. Ser. A, 241 ( 837 ) : 457-585, March 1949.
- 14 Rosser, J. B., Newton, R. R. and Gross, G. L. Mathematical theory of rocket flight. New York, McGraw-Hill, 1947. 276p.
- 15 Sutton, G. P. Rocket propulsion elements : an introduction to the engineering of rockets. 3rd ed. New York, Wiley, 1963. 464p.
- 16 Wimpress, R. N. Internal ballistics of solid-fuel rockets, military rockets using dry-process double-base propellant as fuel. New York, McGraw-Hill, 1950. 214p.
- 17 Goddard, E. C. and Pendray, G. E. Papers of Robert H. Goddard, including the reports to the Smithsonian Institution and the Daniel and Florence Guggenheim Foundation. New York, McGraw-Hill, 1970. Vol. I: 1898-1924 559p. 559p. Vol. II : 1925-1937. 1104p. and Vol. III : 1938-1945.
- 18 Loh, W. H. T. Dynamics and thermodynamics of planetary entry. Englewood Cliffs, Prentice-Hall, 1963. 268p.
- 19 Morrow, C. T. and others. Ed. Ballistic missile and aerospace technology. Vol 4 : Reentry. New York, Academic, press, 1961. 240p. (Proceedings of the sixth symposium).

- 20 Eggers, A. J. Ed. Atmosphere entry. New York, American Institute of Aeronautics and Astronautics, (1970). 127p. (AIAA Selected Reprint Series Vol. 1).
- 21 Miele, Angelo Ed. Theory of optimum aerodynamic shapes, extremal problems in the aerodynamics of supersonic, hypersonic, and free-molecular flows. New York, Academic, 1965. 455p.
- 22 Korenev, G. V. Mechanics of guided bodies. London, Iliffe, 1967. 551 p. (Translated from Russian).
- 23 Kinslow, R. High-velocity impact phenomena. New York, Academic, 1970. 579 p.
- 23a Cole, R. H. Underwater explosions. Princeton, Princeton University Press, 1948. 437 p.
- 24a Fowler, R. H. and others. Aerodynamics of a spinning shell : Part I. Phil. trans. Roy. Soc. Ser. A, 221 : 295-381, 1920.
- 24b Fowler, R. H. and Lock, C. N. H. Aerodynamics of a spinning shell : Part II. Phil. trans. Roy. Soc. Ser A, 222 : 227-259, 1922.
- 25 Carrier, P. Perturbations ballistiques d' un projectile autopropulsea poudre, pendant la phase d' autopropulsion, C. Memorial d' Artillerie Francaise 25 (2) : 253, 1951.
- 26 Birkhoff, G. and others. Explosives with lined cavities. J. app. phys. 19 : 563-582, 1948.
- 27 U. K. War Office. Text book of ballistics and gunnery : No. 1 Definitions, motion in vacuo and laws of air resistance. 1948. 43p. No. 2 Stability and drift. 1951. 44p. No. 3 Meteorology and meteorological corrections. 1952. 88p. No. 4 Small arc calculations. 1957. 58p. No. 5 Construction of range tables. 1954. 30p.

28 U. K. War Office. Text book of ammunition :  
No. 3 Projectiles. 1927. 93p.

29 U. K. War Office. Text book of anti-aircraft  
gunnery. London, H. M. S. O., 1925. 867p.

30 Coates, J. B. Ed. Wound ballistics. Washington,  
U. S. Department of the Army, 1962. 883p.

31 Barrere, Marcel and others. Rocket propulsion.  
Amsterdam, Elsevier, 1959. 829p.

32 Sampooran Singh. Studies on explosives with  
lined cavities. Def. Sc. J. 5 (3) : 169-274, July 1975,

□ □ □

## Appendix- B : U. D. C. Schedule for Ballistics

## 53 PHYSICS

**Principle Divisions**

530.1 GENERAL PRINCIPLES OF PHYSICS

531/534 MECHANICS

531 GENERAL MECHANICS. MECHANICS OF SOLID &amp; RIGID BODIES

.1 Kinematics

.2 Forces. Masses. Statics. Equilibrium. Attraction

.3 Dynamics. Kinematics

.4 Work. Friction. Passive resistance

.5 Weight. Gravitation. Pendulum. *Ballistics*

.6 Mechanical energy. Conservation of mechanical energy

.7 Measurement of geometrical and mechanical magnitudes

.8 Theory of machines. Technical mechanics

532 .. MECHANICS OF FLUIDS

533... MECHANICS OF GASES. AERODYNAMICS

534/539 ACOUSTICS. VIBRATIONS / MOLECULAR AND ATOMIC PHYSICS

**Applications of Physics**

Purely theoretical and scientific questions are classified in 53, but the applications of physics in 6 Applied Science and 7 Art, according to the subject. Subjects not represented in 53 can be classified by the use of colons,

---

Note : ... after a number means that there exist further subdivisions in the schedule.

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**Effects and influences**

In various sections subdivisions for influence on physical phenomena are provided. Where this is not the case, influence can be classified by combining with one of the following numbers, with the aid of the colon :-

534.39 Physical effects of acoustic vibrations

535.21/539.166.9 Effects of radiations -- *upto* Effects of gamma rays

Secondary effects of physical phenomena can be indicated by combining with one of the following numbers, with the aid of the colon :-

534.37 Physical effects on vibrations

535.37/539.166.7 Luminescence -- *upto* Effects of gamma rays

**Special Analytical Subdivisions. Summary**

In the section 53 Physics, special analytical subdivisions can be used, which are developed under the separate subdivisions of 53. They are formed on the following basis :-

.01/.098 Theory and nature of the Phenomenon -- *upto* Magnetic effects

**Special Analytical Subdivisions for Measurements**

53.08/53.089.6 General Principles and Theory of Measurement and of the Structure of Instruments -- *upto* Calibration, testing and control of instruments

531 GENERAL MECHANICS. MECHANICS OF SOLID & RIGID BODIES

Special Analytical Subdivisions Applicable to 531

-1/-9 Lines -- *upto* Non-Euclidean space

- 531.5           WEIGHT. GRAVITATION. PENDULUM.  
                  *BALLISTICS*
- 531.55          *Laws of the motion of projectiles. External ballistics. Mean trajectory*
- For practical applications see 623.5 Gunnery  
                  For ballistic apparatus see 531.76  
                  Special analytical subdivisions
- .011   Abscissa or range  
                                  .012   Ordinate or rise  
                                  .013   Fall  
                                  .014   Duration of flight  
                                  .015   Inclination of the tangent  
                                  .016   Final velocity  
                                  .017   Asymptote  
                                  .018   Radius of curvature  
                                  .019   Other elements
- .551           Motion in a vacuum
- .1       Equation of the trajectory  
                  .2       Co-ordinates of any given point  
                  .3       Co-ordinates of the point of impact  
                  .4       Co-ordinates of the highest point  
                  .5       Geometrical properties of the trajectory  
                                  in vacuo. Parabola of safety
- .552           Motion in air. Principal motion. General conditions
- For secondary motions see 531.56
- .553           Differential equations of movement. Transformations. Hodograph
- .554           Inverse ballistic problem

- .555      General properties of the trajectory in air.  
Theoretical laws of the air-resistance
- .1          Quadratic law
- .2          Cubit law
- .3          Fourth power law
- .4          Binomial laws
- .556      Experimental laws of air-resistance.  
Characteristic index of the projectile.  
Ballistic coefficient
- .1          Spherical projectiles
- .2          Cylindrical projectiles with spherical caps
- .3          Cylindrical projectiles with pointed caps
- .557      Study of rectilinear motion. Horizontal motion  
and vertical motion
- .558      Calculations of range tables. Various tables
- 531.56    *Secondary motions in the air. Effects of the spin  
of the projectile and variations of the ballistic  
elements*  
*Probability of hitting*
- .561/.565    Unilateral deviations
- .561      Laws of spin and projectiles. Nutation. Drit
- .562      Experimental study of drift. Formulae. In-  
fluences of variation of the density of the air  
with the altitude
- .564      Influence of atmospheric disturbances. Devi-  
ations due to wind
- 531.565    Influence of other perturbing causes. Vari-  
ations of weight. Curvature and rotation of the  
earth, etc.

- .566.567 Accidental deviations
- .566 Experimental study of deviations of aim, misfiring, stray bullets
- .567 Probability of hitting. Distribution of projectiles  
See also 519.2 Calculus of probabilities
- 531.57 *Motion in the barrel and penetration into resistant media. Internal ballistics and perforation*  
For practical results see 623.5 Gunnery
- .571 Laws of combustion of powders in a closed vessel without entry of air. Velocities of combustion. Pressure relations
- .572 Laws of combustion of powders in fire-arms
- .573 Development of pressures at the breech. Resistance of the barrel
- .575 Motion of rotation in the barrel. Effects and resistance of the rifling
- .576 Initial velocities and velocities near the muzzle
- .577 Penetration of spherical projectiles into earth, masonry, armour plate and other solid blocks
- .578 Penetration of long projectiles into earth, masonry, armour plate and other solid blocks
- 623 MILITARY AND NAVAL ENGINEERING.  
ORDNANCE. ARMS PRODUCTION

### Scope

This section deals with the design, manufacture and technical handling of all weapons and fighting equipment used on land, at sea, or in the air, . . . .

**Principle Divisions**

- 623.1 Fortifications. Fortresses, Siege and defence works
- 623.4 Arms. Artillery, ordnance, guns, armoured and other vehicles. Small arms. Ammunition and war gases
- 623.5 *Ballistics. Gunnery, theoretical and experimental problems*
- 623.6 Field engineering : Equipment and operations
- 623.7 Military topography, aviation, camouflage, etc.
- 623.8 Naval engineering and construction : ordnance establishments, warships, etc.
- 623.9 Armouring and other protection armament. Underwater defences. Various methods of attack and defence

*Related Subjects* ( a selection of many, which can be related by the colon : to 623 or its subdivisions )

- 355/359... Art of war. Armed forces
- 531.5 Ballistics ... upto 799.3 Shooting as sport

**Auxiliary Numbers**

Maximum use of the colon ( rather than auxiliary numbers ) is recommended, especially for published abstracts, bibliographies etc. For libraries with adequate alphabetical subject indexes, the use of suitable auxiliary numbers, where available, may be simpler and more convenient.

( a ) The Common auxiliary should only be used to express concepts not otherwise provided for in this schedule.

( b ) The Special subdivisions - 2 and - 5/ - 8 ( given under 621 ) and -9 ( Armouring and armament ) are applicable throughout 623 :-

- 623-04/623-94 External shape and form — *upto* Armament, gunpower.
- 623.0 SPECIAL AUXILIARIES (applicable to arms and ordnance), See under 623.4.0 and 623.55.0
- 623.4 ARMS. ARTILLERY. ORDNANCE. GUNS. ARMOURED AND OTHER SERVICE VEHICLES. SMALL ARMS. AMMUNITION
- 623.4.0 Special auxiliaries applicable especially throughout 623.4/.5, except 623.43 where the .0 subdivisions of 629.11 may be used
- 623.4.02 Fire control. Ballistic tables  
For Ballistics and gunnery, see 623.5 where these are particularly applicable
- .021 Target detection. Identification. Interception
- .022 Ballistic preparation. Meteorology  
For details : 551.5
- .023 Topographical preparation. Artillery survey
- .024 Observation, ranging, fuze adjustment
- .2 Fall of shot
- .3 Ranging
- .5 Fuze adjustment
- .025 Fire control
- .026 Fire orders
- .027 Guiding of missiles
- .028 Target marking
- 623.4.03 ... Cartridge magazines. Feed mechanisms
- 623.4.04 .. Breech block and breech ring. Moving breech. Ancillary parts
- 623.4.05/.056.4 Sighting and sights. Laying mechanisms. Tracking studies — — *upto* Laying and range

- 623.4.06 Firing gear. Trigger mechanisms. Ejectors
- 623.4.08 Projectile parts, fillings, attachments  
For Ammunition, projectiles, etc. see 623.45
- .081 Body or case
- .2 Heavy ( H. C. ); armour piercing ( A. P. ),  
penetrating
- .3 Medium ( M. C. ); medium capacity
- .4 Light ( L. C. ); high capacity
- .082 Warheads.
- .3 A. P. capped ( armour-piercing )
- .4 Ballistic capped
- .5 Fragmentation
- .6 Blast
- .083 Fillings
- For filling operations, see 623.452  
Manufacturing details, see 662
- .1 High explosive ( H. E. )
- .2 Atomic
- .25 Hydrogen
- .3 ... Pyrotechnic
- For manufacture, see 662.1
- .084 Guiding devices in missiles
- .085 Driving band. Sabot
- .086 Fins, tails and trajectory-controlling devices
- .2 Fins, tails
- .4 Gliding devices
- .5 Parachutes
- .8 Accelerator rockets
- .087 Cluster devices. Bomb clusters

- 623.41 ARTILLERY WEAPONS (ACCORDING TO FUNCTION)
- 623.42 ORDNANCE
  - 623.422 Types of gun
  - 623.422 Guns according to method of loading and operating
  - 623.423 Gun tube and barrel construction
  - 623.427 Guns and mountings adapted for training, etc.
  - 623.428 Guns or projectors without explosive propellants
- 623.43 GUN CARRIAGES AND MOUNTINGS. SERVICE VEHICLES. ARMOURED FIGHTING VEHICLES
- 623.44 SMALL ARMS. SIDE ARMS. PROTECTIVE EQUIPMENT
  - 623.441 Early and primitive firearms, e.g. blunderbuss, arquebus (hackbut or hook-gun)  
For Primitive weapons generally, see 623.446
  - 623.442 Rifles, carbines. Muskets, etc.
  - 623.443 Pistols. Revolvers
  - 623.444 Side arms. Shafted weapons
  - 623.445 Protective equipment. Armour
  - 623.446 Primitive weapons. Hand weapons, blowpipes, bows, etc.
- 623.45 AMMUNITION. PYROTECHNIC DEVICES. WAR GASES
- 623.451 PROJECTILES. SHELLS. BOMBS  
For Projectile parts and fillings, see 623.4.08

- 519 Guided missiles
- .08 Fillings (details, see 623.4.08)
- .083.2 Atomic, nuclear fillings
- .1 Early forms ; Spherical projectiles
- .11 Round-shot, cannon shot
- .12 Spherical bombs
- .13 Spherical shells
- .14 Spherical grenades
- .2 Grape-shot, case-shot. Shrapnel
- .3 Elongated projectiles
  - For Fillings and parts, see 623.4.08
- .32 Shot: Cored projectiles with little or no explosive
- .4 Shells
  - .42 High explosive ( H. E. )
- .5 Mortar projectiles
  - For Shrapnel, see 623.451.2
- .7 Bombs, torpedoes, etc., for dropping from aircraft
  - For Parts and fillings, see 623.4.08
- 623.451.72 Torpedoes, Aerial torpedoes
  - For Naval torpedoes, see 623.946
- .73 Mines and depth charges
  - For these as naval weapons, see 623.95
- .74 Bombs ( dropped from aircraft )
- .746 Freefall bombs
  - .083.2 Atomic and hydrogen bombs

- .2 Heavy case; armour-piercing ( AP ),  
penetrating
- .3 Medium case; medium capacity
- .4 Light case; high capacity
- .5 Anti-personnel, fragmentation
- .747 Retro bombs
- .748 Accelerated bombs  
Subdivide as 623.451.741/.746
- .8 Rockets ( rocket missiles )  
For rocket artillery in general, see 623.419  
Launching ramps, chutes, etc., see 623.428
- 623.452 EXPLOSIVES. ARTILLERY AMMUNITION.  
ASSEMBLY  
For assembly and packing equipment, see  
623.457.  
For manufacture, see 662.2/.4
- 623.454 PYROTECHNIC DEVICES FOR FUZES AND  
VARIOUS SPECIAL USES. MINES.  
ATOMIC WEAPONS
  - .1 Matches. Fuzes generally. Also 622.45/.46
  - .2 Igniting devices
- 623.455 S. A. A. SMALL ARMS AND HAND  
AMMUNITION
  - .1/.82 Projectiles for small arms. Bullets... upto Rifle  
attachments for throwing grenades
- 623.456/ TRAINING AND PRACTICE AMMU-  
.459 NITION. BLANKS/CHEMICAL WEAPONS
- 623.5 BALLISTICS. GUNNERY, THEORETICAL  
AND EXPERIMENTAL PROBLEMS  
For Ballistics theory. see 531.55/.58

- 623.51 GENERAL AND COMPARATIVE INVESTIGATION OF ARTILLERY WEAPONS
- 623.52 INTERNAL BALLISTICS. EFFECTS OF POWDER. PROPELLANTS
- .522 Ballistic measurements
- .2 Pressures
- .4 Muzzle velocity
- .6 Temperatures
- .524 Determination of charge  
For details, colon to 662.2/.4
- .525 Ignition of propellant in gun. Premature ignition of projectile filling
- .526 Effects of propellant combustion. Erosion
- .4 Elastic vibration
- .6 Scoring deformations
- .7 Engraving of the projectile
- 623.53 INTERMEDIATE BALLISTICS
- .532 Gun blast phenomena
- .533 Flash and smoke
- .535 Gun and projectile behaviour at shot exit, e.g. jump
- 623.54 EXTERNAL BALLISTICS
- See also 531.55 External ballistics
- 531.6 Aerodynamics
- 534 Acoustic and other mechanical vibration
- .77 Ballistic photography and cinematography
- .541 Proving the gun

- .542 Time-measurement and measuring apparatus.  
Ballistic chronographs  
For details, colon to 531.76
- .544 Experimental apparatus and equipment
- .546 Trajectory measurement. Air resistance to the  
projectile
- .547 Determination of rectilinear motion, horizontal  
and vertical
- .548 Determination of ballistic tables, range  
tables, etc.
- 623.55 .. GUNNERY. LAYING AND FIRING
- .02 Fire control details. Ballistics tables  
(theory and practice)
- 623.56 EFFECT OF PROJECTILES. DISRUPTIVE  
EFFECT. BLAST EFFECT. FIRING  
TESTS  
For penetration, see 531.58 Terminal Ballistics
- 623.561 Against living targets
- 623.562 Against nonliving targets
  - .1 Fixed targets, earthworks, etc.
  - .2 Walls, buildings, bridges, etc.
  - .3 Armour
  - .4 Concrete (fortifications, pill-boxes, etc.)
  - .5 Movable targets (other than armour), e.g.  
rolling stock, aircraft, vehicles, ships  
Subdivide by colon to 625.2 and 629.1
  - .6 In water, against underwater objects
  - .7 Against explosives and propellants
- 623.565 Behaviour of projectiles. Fragmentation.  
Blast effects

- 623.565.1 In confined spaces
  - .12 Fragmentation
  - .13 Blast
  - .2 In the air
    - .22 Fragmentation
    - .23 Blast
  - .3 At the target. Damage to projectile
    - .32 Fragmentation
    - .33 Blast
    - .36 Damage to projectile
  - .5 In earth
    - .52 Fragmentation
    - .53 Blast
  - .6 In water
    - Subdivide as 623.565.5
- 623.566 Underwater ballistics
  - .2 Underwater bombs and shells
  - .3 Depth charges. Charges on sea bed
  - .5 Underwater explosives
    - .51 Effect on sea bed
    - .52 Effect at water surface
    - .52I Water projected above surface
  - .53 Time interval between explosions
  - .54 Depth of explosion
- 623.567 Controlled projectile trajectories  
For normal trajectories see 531.55
- 623.57... BEHAVIOUR OF MOUNTINGS DURING  
FIRING. RECOIL, ETC.
- 623.59... FIRING PRACTICE EQUIPMENT

**Appendix - C : LC Schedule for Ballistics****CLASS Q : SCIENCE****QA MATHEMATICS**

- 801-935 Analytical Mechanics  
 Mathematical works only classified here.  
 Experimental mechanics in QC 122-128  
 Applied mechanics in TA 350  
 cf. QB 351-421 Celestial mechanics
- 845-875 Dynamics  
 cf. UF 820 Motion of projectiles (Ballistics)
- 851-855 Dynamics of a particle
- 851 General
- 852 Specific aspects
- 853 Orbital and constrained motion
- 855 Motion on surfaces
- 861-863 Rigid bodies
- 871 General methods in dynamics
- 901-907 Statics and dynamics of fluids

**QC PHYSICS**

- 122-168 Experimental Mechanics  
 Analytical mechanics QA 801-935
- 122-131 General and solids
- 141-168 Fluids
- 171-197 Constitution and properties of matter
- 178 Theory of gravitation

**CLASS T TECHNOLOGY**

- TA 350 Applied mechanics
- TP 268-301 Explosives (General)

**CLASS U MILITARY SCIENCE**

- U Military science (General)
- UD Infantry

## UF

- Artillery
- 750-755 Projectiles
- 760 Shrapnel, shells, etc.
- 765 Grenades
- 767 Projectile for aircraft. Bombs, etc.
- 770 Bullets
- 780 Firing devices: Percussion caps, primers, etc.
- 800 Gunnery
- 805 Aerial observations and artillery
- 810 Results of firing tests. Deviations, etc.
- 820 Ballistics. Velocities and motion of projectiles
- 823 Interior ballistics
- 825 Exterior ballistics
- 830 Ballistic instruments, A-Z
- 840 Ballistic photography
- Artillery instruments, fire control, etc.
- 850 Range finders
- 860 Military explosives and pyrotechnics
- Explosives (General) See TP 268-301.
- 870 Explosions, force of powders, etc.
- 880 Rockets
- 890 Ordnance tests
- cf. UG 408 Testing of iron & steel for land forces. V 910 Armor-plate testing. VF 540 Naval ordnance testing
- 900 Resistance to projectiles

## CLASS V NAVAL SCIENCE

## VF NAVAL ORDNANCE

- 410 Machine guns
- 480-500 Projectiles
- (520) Gunnery See VF 144-302

## Appendix - D: C C Schedule for Ballistics

## B7 MECHANICS

## B7 [ P ] : [ E ] [ 2P ]

	Foci in P	321	Single force. Central force
1	Solid	322	Multiple force
11	Particle	324	Impulse
13	Rigid body	34	Constrained motion
19	Special system	35	Irrotational
193	Ballistic	351	Streamline
5	Liquid	353	Turbulent
8	Gas	354	Discontinuous
	Foci in [ E ] cum [ 2P ]	39	Rotational
1...	Fundamental principle	391	Motion of solid
2...	Statics		(in liquid and gas)
3	Motion, Dynamics	5	Vibration
31	Kinematics		
32	Kinetics		

## F TECHNOLOGY

## F [ P ] : [ E ] [ 2P ]

	Foci in P		Foci in [ E ] cum [ 2P ]
			by Alphabetical and Enumeration Device
5594	Explosive		
MV4	Science of War		
MV41	Military Science		
MV45	Naval Science		
MV48	Airfight		

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## Appendix - E : Thesaurus of Terms for Ballistics

Aeroballistic ranges	1402		
BT	Ranges ( facilities )		
	Test ranges		
RT	Ballistic ranges		
	Missile ranges		
Aeroballistics	1904	RT	Aeroballistics
BT	Ballistics		- Aerodynamic characteristics
RT	Aerodynamics		Aeroelasticity
	Ballistic trajectories		Aerothermodynamics
	Exterior ballistics		Boundary layer control
	Terminal ballistics		- Compressible flow
			- Control surfaces
			Exterior ballistics
			Flight characteristics
			Flight tests
			Ground effect
			Hypersonic flow
Aerodynamics	2004		Incompressible flow
BT	Fluid dynamics		Jets
	Fluid mechanics		Laminar flow
	Gas dynamics		Mach number
			Nonuniform flow

BT = Broad Term    NT = Narrow Term    RT = Related Term    UF = Used For

— Indicates that related and further narrower terms can be found under that descriptor in the TEST, Number at the end of a descriptor refers to COSATI subject category index.

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## Aerodynamics continued...

Reentry	RT	Reentry trajectories
Subsonic flow		
Supersonic flow		
Thermodynamics		
Transonic flow		
Turbulent flow		
Unsteady flow		
- Viscous flow		
Wakes		
- Wind tunnels		
Ballast	1310	
RT	Stability	
Ballistic ranges	1402	
BT	Ranges (facilities)	
	Test ranges	
RT	Aeroballistic ranges	
	Missile ranges	
Ballistic reentry vehicles	2202	
BT	Reentry vehicles	
Ballistics	1902	
NT	Aeroballistics	
-	Exterior ballistics	
-	Hydroballistics	
-	Interior ballistics	
-	Obturbatio ballistics	
-	Terminal ballistics	
-	Underwater ballistics	
-	Wound ballistics	
RT	Ballistic trajectories	
-	Drag	
-	Falling bodies	
-	Gunnery	
Ballistic trajectories	1904	
UF	Suborbital trajectories	
BT	Trajectories	
RT	Aeroballistics	
-	Ballistics	
-	Bomb trajectories	

## Ballistic trajectories continued...

Impact prediction  
 Missile trajectories  
 Projectile trajectories  
 Rocket trajectories

## Ballistic 1901

BT Explosives  
 Propellants  
 Smokeless propellants

## Bombs ( Ordnance ) 1902

UF + Photoflash bombs  
 + Smoke bombs  
 NT Armor piercing bombs

Bomblets  
 Chemical bombs  
 Cluster bombs  
 - Dispenser  
 - Fire  
 - Fragmentation  
 General purpose  
 Guided

-- Incendiary

Leaflet

Napalm

Practice

## RT Aircraft ammunition

- Antipersonnel

Arming devices

Bomb cases

Bomb racks

Bomb retarders

- Explosives

Exterior ballistics

Fin stabilised ammunition

- Free fall weapons

- High explosive ammunition

- Missiles

- Nuclear weapons

Photoflash ammunition

- Projectiles

- Pyrotechniques

Shaped charges

Spin stabilised ammunition

- Bombs (Ordnance) continued....
- Terminal ballistics
  - Warheads
- Bomb trajectories 1904
- BT Trajectories
  - RT Ballistic trajectories
- Bone fracture 0605
- BT Injuries
  - RT Joint dislocations
  - Osteology
  - Traumatic disorders
  - Wound ballistics
- CAD cartridge
- USE PAD cartridge
- Cartridge actuated device ( CAD cartridge )
- USE PAD cartridge
- Drag 2004
- NT - Aerodynamic drag
  - Pressure drag
- Supersonic drag
  - Wave drag
- RT - Aerodynamic configuration
- Air resistance
  - Ballistics
  - Boundary layer
  - Gravitation
  - Ground effect
  - Lift
  - Low drag aerofoils
  - Skin friction
  - Wakes
- Ejection-seat 0103
- BT Aircraft equipment
  - Aircraft seats
  - Seats
  - Cockpits
  - Ejectionable capsules
  - Jettisonable capsules
  - PAD cartridges
  - Pilot seats
- RT

- Ejector cartridge  
USE PAD cartridge
- Energy transfer 2011  
Macroscopic mechanical interactions :  
includes Quantum interactions  
Direct energy conversion  
Heat transfer and Transducers  
RT - Energy absorption  
- Explosion effects  
- Heat transfer  
Kinetic energy  
Momentum transfer  
- Terminal ballistics  
- Transferring
- Equations of motion 1201  
UF Motion equations  
NT Euler equation of motion  
Lagrange equation of motion  
RT Classical mechanics  
Navier-stokes equation  
- Stability  
- Trajectories
- Exterior ballistics 1904  
BT Ballistics  
RT Aeroballistics  
Aerodynamics  
- Bombs ( Ordnance )  
Underwater ballistics
- Falling bodies 2004  
RT - Aerodynamic configuration  
Air resistance  
- Ballistics  
Gravitation  
Terminal velocity
- Flight paths 0102  
RT -----  
-----  
- Flight control  
- Navigation  
- Orbits  
- Terminal guidance  
- Trajectories
- Fluid dynamics 2004  
UF Cascades (fluid dynamics )

## Fluid dynamics continued...

- BT Fluid mechanics
  - NT Aerodynamics
  - Gas dynamics
  - Hydrodynamics
  - Rarefied gas dynamics
  - Continuity equation
  - Convection
  - Fluid flow
  - Gas laws
  - Hydraulics
  - Hydromechanics
  - Kinetics
  - Magnus effect
  - Slamming
  - Stability criteria
  - Stagnation point
  - Steady state
  - Streamlining
  - Turbulence
  - Turbulent flow
  - Uniform flow
  - Unsteady state
- Fluid mechanics 2004
  - NT Aerodynamics
  - Aerostatics
  - Fluid dynamics
  - Gas dynamics
  - Hydraulics
  - Hydrodynamics
  - Hydrostatics
  - Rarefied gas dynamics
  - Continuum mechanism
  - RT - Fluid flow
  - Fluidics
  - Fluid power
  - Gas laws
  - Kinetics
- Fragmentation 1407
  - UF Shattering
  - RT Breaking
  - Bursting
  - Chipping
  - Communion

## Fragmentation continued...

- Explosion effects
- Fracturing
- Spalling
- Terminal ballistics

## Free fall weapons 1901

- RT Ballistic missiles
- Bombs (Ordnance)
- Rockets

## Free flight trajectories 1904

- BT Trajectories

## Gunnery 1905

- NT Aerial gunnery
- Antiaircraft gunnery
- Naval gunnery
- RT - Artillery
- Ballistics
- Fire control
- Guns (Ordnance)
- Lead angle

## Gunshot wounds 0621

- UF Bullet wounds
- BT Injuries
- Wounds
- RT Wound ballistics

## Homing torpedoes 1908

- BT Torpedoes
- RT Antiship torpedoes
- Antisubmarine weapons
- Homing
- Terminal guidance
- Underwater ballistics
- Underwater homing

## Hydroballistics 1904

- BT Ballistics
- NT Underwater ballistics
- RT Water entry

## Impact flash 1904

- RT Terminal ballistics

- Impact prediction 1602, 1707
  - RT Ballistic trajectories
  - Missile trajectories
- Interior ballistics 1904, 1906
  - BT Ballistics
  - NT Obturation ballistics
  - RT Underwater ballistics
- Missile trajectories 1602
  - BT Trajectories
  - RT Ballistic trajectories
  - Impact prediction
- Obturation ballistics 1904
  - BT Ballistics
  - Interior ballistics
- Orbits 2203, 0303
  - UF Keplerian tray
  - Orbital trajectories
  - Satellite orbits
  - NT Circular orbits
  - Earth orbits
- Elliptical orbits
- Equatorial orbits
- Inclined orbits
- Lunar orbits
- Parking orbits
- Planetary orbits
- Polar orbits
- Solar orbits
- Transfer orbits
- RT Artificial satellites
- Astrodynamics
- Celestial bodies
- Celestial mechanics
- Ephemerides
- Flight paths
- Interplanetary flight
- Lunar flight
- Many body problems
- Satellite attitude
- Space flight
- Space navigation
- Three body problem
- Trajectories
- Two body problems

- PAD cartridge 1901
- UF CAD cartridge
- RT Ejector cartridge
- Ejectionable capsules
- Ejection seat
- PAD propellants
- Penetration 1407
- RT - Boring
- Drilling
- Fluid infiltration
- Leakage
- Perforating
- Permeability
- Permeating
- Piercing
- Terminal ballistics
- Vulnerability
- Water influx
- Projectile trajectories 1904
- BT Rockets
- Trajectories
- RT Ballistic trajectories
- Missile trajectories
- Propellants 1901, 2109
- NT Ballistic
- Composite rocket propellants
- Cryogenic rocket propellants
- Double base rocket propellants
- Flashless propellants
- Gaseous rocket propellants
- Gas generator propellants
- Gelled rocket propellants
- Gun propellants
- Hybrid propellants
- Hybrid rocket propellants
- Hypergolic rocket propellants
- Liquid gun propellants
- Liquid propellants
- Liquid rocket propellants
- Monopropellants
- PAD propellants
- Rocket propellants
- Slurried rocket propellants
- Smokeless propellants

## Propellants continued...

- Solid propellants
- Solid rocket propellants
  - Storable rocket propellants
  - Subliming rocket propellants
  - Torpedo rocket propellants
  - Tripple base rocket propellants
  - Tripropellants
- RT Aircraft ammunition
  - Antiaircraft ammunition
  - Antisubmarine ammunition
  - Antipersonnel ammunition
  - Antitank ammunition
  - Armour piercing ammunition
  - Burning rate
  - Cartridges ( explosives )
  - Fin stabilized ammunition
  - Fragmentation ammunition
  - Guns ( Ordnance )
  - Incendiary ammunition
  - Projector charges
  - Propelling charges
  - Small arms ammunition
- Spin stabilized ammunition
  - Torpedoes
- Propellant binders 1901
  - RT Binders ( material )
  - Solid rocket binders
- Propellant compatibility 2109
  - RT - Propellant handling
  - Propellant sensitivity
  - Propellant storage
- Propellant control 2108
  - RT Combustion control
  - Fuel system
  - Propellant handling
- Propellant flames 1901
  - UF Gun muzzle flashes
- Propellant grain cores 2109
  - RT Cores

- Propellant grain cores continued...
- Mandrels
- Rocket propellant grains
- Propellant grains 1901
- NT Rocket propellant grains
- Propellant oxidizers
- USE Rocket oxidizers
- Propellant plasticizers
- USE Solid rocket plasticizers
- Ranges (facilities) 1402
- NT Acoustic ranges
- Aeroballistic ranges
- Ballistic ranges
- Bombing ranges
- Missile ranges
- Test ranges
- Reentry 2203
- BT Atmospheric entry
- RT Ablation
- Aerodynamic heating
- Aerodynamics
- Missiles
- Reentry vehicles
- Rockets
- Terminal guidance
- Reentry trajectories 2203
- BT Trajectories
- RT Aerodynamic heating
- Ballistic reentry vehicles
- Descent trajectories
- Spacecraft trajectories
- Terminal guidance
- Terminal trajectories
- Reentry vehicles 2202
- NT Aerospace planes
- Ballistic entry vehicles
- Boostglide vehicles
- Lifting reentry vehicles
- RT Ballistic missiles

## Reentry vehicles continued...

- Hypersonic vehicles
- Missiles
- Nose cones
- Spacecraft
- Terminal guidance

## Rocket trajectories 1904

- BT Rockets
- Trajectories
- RT Ballistic trajectories
- Missile trajectories

## Sabot projectiles 1901

- BT Projectiles
- RT Fin stabilised ammunition

## Shaped charge jets

- USE Shaped charges

## Shaped charges 1901

- UF Shaped charge jets
- BT Explosive charges

- RT Aircraft ammunition
- Antitank ammunition
- Armor piercing ammunition
- Bombs ( Ordnance )
- Demolition
- Depth charges
- Explosive forming
- Explosives
- Fin stabilised ammunition
- Perforators
- Projectiles
- Shaped charge warheads
- Torpedoes
- Warheads

## Smokeless propellants 1901

- UF Smokeless powder
- BT Explosives
- Propellants
- NT Ballistic
- RT Gun propellants

- |               |      |                            |  |
|---------------|------|----------------------------|--|
| Stabilisation | 1407 |                            |  |
| UF            |      | Stabilising treatment      |  |
| NT            |      | -----                      |  |
|               |      | Fin stabilisation          |  |
|               |      | -----                      |  |
|               |      | Spin stabilisation         |  |
| RT            |      | Balancing                  |  |
|               |      | Gyroscopes                 |  |
| Stability     | 1407 |                            |  |
| UF            |      | Controllability            |  |
|               |      | Instability                |  |
| NT            |      | Aerodynamic stability      |  |
|               |      | Longitudinal stability     |  |
|               |      | Static stability           |  |
| RT            |      | Amplification              |  |
|               |      | Angle repose               |  |
|               |      | - Altitude ( inclination ) |  |
|               |      | Ballast                    |  |
|               |      | Bearing capacity           |  |
|               |      | - Compatibility            |  |
|               |      | - Control surface          |  |
|               |      | - Damping                  |  |
|               |      | Drift ( instrumentation )  |  |
|               |      | - Durability               |  |
|               |      | - Dynamic response         |  |
|               |      | - Elastic theory           |  |
|               |      | - Equation of motion       |  |
|               |      | - Flight control           |  |
|               |      | Frequency stability        |  |
|               |      | Friction factor            |  |
|               |      | Metastable state           |  |
|               |      | Plastic theory             |  |
|               |      | - Quality                  |  |
|               |      | - Reliability              |  |
|               |      | Resonance frequency        |  |
|               |      | - Stabilisation            |  |
|               |      | Steady states              |  |
|               |      | Surges                     |  |
|               |      | Thermal stability          |  |
|               |      | Tolerances ( mechanical )  |  |
|               |      | Transient response         |  |
|               |      | Unsteady state             |  |
|               |      | Variability                |  |

## Stability continued...

## Vulnerability

Suborbital trajectories  
USE Ballistic trajectories

## Terminal ballistics 1904

UF Ricochet  
 BT Ballistics  
 NT Wound ballistics  
 RT Aeroballistics  
 - Bombs ( Ordnance )  
 Energy transfer  
 Fragmentation  
 Impact flash  
 Penetration  
 Underwater ballistics

## Test ranges 1402

BT Ranges ( facilities )  
 NT Acoustic ranges  
 Aeroballistic ranges  
 Ballistic ranges

## RT

Bombing ranges  
 Missile ranges  
 Proving grounds  
 Range safety

## Trajectories

1904

NT  
 Ascent trajectories  
 Ballistic trajectories  
 Bomb trajectories  
 Circumlunar trajectories  
 Descent trajectories  
 Earth moon trajectories  
 Free flight trajectories  
 Interplanetary trajectories  
 Midcourse trajectories  
 Missile trajectories  
 Projectile trajectories  
 Reentry trajectories  
 Rendezvous trajectories  
 Rocket trajectories  
 Spacecraft trajectories  
 Terminal trajectories

- Trajectories continued...
- Torpedo trajectories
  - Underwater trajectories
  - Beam rider guidance
  - Directional measurement
  - Distance
    - Equations of motion
    - Flight path
    - Missiles
    - Orbits
    - Particle trajectories
    - Space flight
    - Terminal guidance
  - Traumatic disorders 0605
    - RT Bone fracture
    - Epidural hemorrhage
    - Invertebral disc diseases
    - Pneumothorax
    - Pseudarthrosis
    - Subdural hemorrhage
    - Traumatic shock
  - Traumatic shock 0605
    - BT Shock ( Pathology )
    - RT Traumatic disorders
  - Underwater ballistics 1904
    - BT Ballistics
    - Hydroballistics
    - RT Exterior ballistics
    - Homing torpedoes
      - Interior ballistics
      - Terminal ballistics
      - Torpedo control
      - Torpedoes
      - Underwater homing
  - Wound ballistics 0621
    - BT Ballistics
    - Terminal ballistics
    - RT Bone fracture
    - Gunshot wounds
    - Shrapnel
    - Wounds.

**Appendix - F : Questionnaire**

( Please check or fill up as necessary )

1 Name and address of your establishment  
\_\_\_\_\_

2 Area of research/subjects covered \_\_\_\_\_

3 Type of documents held and their numbers

a) Books \_\_\_\_\_ d) Ballistic tables \_\_\_\_\_

b) Journals \_\_\_\_\_ e) Others \_\_\_\_\_

c) Reports \_\_\_\_\_

4 Method of arranging books/reports on the shelf

a) Books \_\_\_\_\_ b) Reports \_\_\_\_\_

5 Method followed in indexing information from journals, reports, etc.

a) Operation

1 Manual [Yes/No] 3 Others \_\_\_\_\_

2 Computer [Yes/No]

b) Method of indexing

1 UDC [Yes/No] 4 Coordinate indexing  
[Yes/No]2 LC Classification [Yes/No] 5 The~~s~~aurus [Yes/No]  
If yes, name of scheme  
\_\_\_\_\_3 Special schemes of classification [Yes/No] 6 Any other [Yes/No]  
If yes, name of scheme  
\_\_\_\_\_

c) Number of items indexed/abstracted per year

1) Journal articles \_\_\_\_\_ 3) Other items \_\_\_\_\_

2) Reports \_\_\_\_\_

- 6 Does the indexing method satisfies your requirements?  
[Yes/No] If No, what are the deficiencies?  
\_\_\_\_\_

7 Method of disseminating information

- |  |                                   |
|--|-----------------------------------|
| a) Current Awareness Service [Yes/No]              | c) Bibliographic Service [Yes/No] |
| b) Selective Dissemination of Information [Yes/No] | d) Others _____                   |

8 Names of publications issued by your organization

- |   |   |
|---|---|
| a) Journal [Yes/No]<br>If yes, name of it<br>_____                | c) Ballistic tables [Yes/No]<br>If yes, Nos., and their titles<br>_____ |
| b) Reports [Yes/No]<br>If yes, approximate Nos. per year<br>_____ | d) Monographs etc. [Yes/No]<br>If yes, their Nos., and titles<br>_____  |

- 9 Are your publications made available to outsiders directly / through normal trade channels/national information centres such as NTIS/NLL? [Yes/No]  
If yes, the name of agency \_\_\_\_\_

- 10 Names of other important organizations engaged in ballistics research / development both in your country and outside, you know of \_\_\_\_\_

Any literature you can send me such as the layout of indexing scheme you are following, specimen copies of your publications, etc. will be of immense value to my study.

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## Addenda

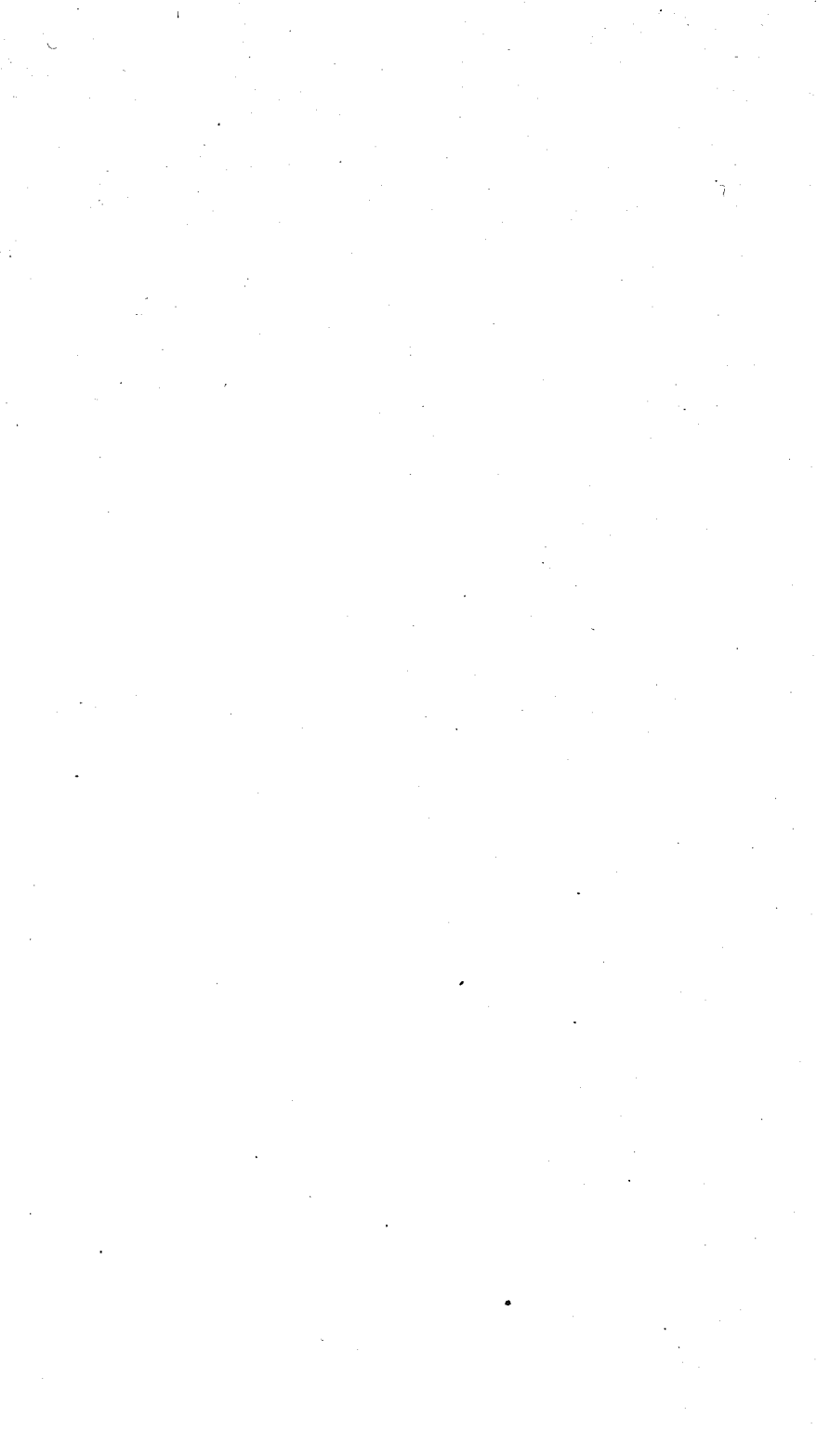
- Page 31, after Serial No. 1, add 2 Deutsche Gesellschaft fur Wehrtechnik. *Field* : Ballistics of weapons.
- Page 38, after Serial No. 14, add American Defence Preparedness Association, Washington, D. C. *Field* : Ballistics of weapons.
- Page 42, at the end of line 6, add International Ballistics Symposium and other symposia on specific ballistics problems sponsored regularly by the American Defence Preparedness Association are of immense value.

## Errata

- Page 11, line 15, read Naval, not Neval
- Page 15, line 32, read Heydenreich, not Heydenreieh.
- Page 37, lines 25 to 27, read objective is to advance the arts, sciences and technology of aeronautics, astronautics and hydronautics by encouraging research, fostering the dissemination of new knowledge, etc. The work
- Page 65, line 24, read microfiche, not microfishe
- Page 69, line 24, read relationship, not relatiopship
- Page 83, line 13, read whole, not wholə
- Page 77, line 28, read differences, not differeaces

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