INTERNATIONAL BALLISTICS SOCIETY

The International Ballistics Society (IBS) promotes the science of ballistics internationally. The IBS provides for technical interchange via an International Symposium on Ballistics and provides professional development for its members by providing opportunities for publication, short courses, student programs, and other activities to promote career development.

Editorial by the President

Firstly, as it is now 2016, I wish all of the IBS members and the newsletter readers my best wishes for the year.

The IBS was formed in 2010 and its website was created the same year. Since then it has become increasingly obvious that the website is not very accessible using mobile devices. Therefore the Board took the decision to revamp the website this past summer. If you have logged on recently, from September onwards, you will have noticed the changes. It is certainly much more usable now for people using mobile phones and tablets. It also looks fresher, cleaner and less cluttered. My many thanks to Ian Cullis, Nicolas Eches, Markus Graswald and Dinesh Pal who helped test the new website and made comments on its design. I hope you like the new format. If you have any comments on it then please contact me.

Membership Promotions

The IBS has several membership grades above ordinary member: Senior, Fellow, and Ballistic Science Fellow. The Membership Committee periodically reviews the IBS members and promotes those who meet the eligibility criteria. Nominations for promotions are always welcome from members themselves or from colleagues. For example, if you have attended 6 International Symposia on Ballistics (ISB), then you should be eligible for Senior membership. Or, if you have been active in ISB for 20+ years, then you might be eligible for Fellow membership. If you would like to nominate somebody or yourself, then please send details, with supporting data, to the Membership Committee at membership@ballistics.org.

Issue #7, February 2016

Contents

Help Needed from Members!

1. ***Recruit new members:*** spread the word and get your colleagues to join
2. ***Get involved:*** see the website for a list of committees & projects with contacts
3. ***Send or post cool photos:*** Wanted: good photos showing ballistic events in each field
   - **Interior Ballistics**
   - **Exterior Ballistics**
   - **Launch Dynamics**
   - **Vulnerability**
   - **Terminal Ballistics & Impact Physics**
   - **Explosion Mechanics**

   Upload photos at www.ballistics.org

As always, remember to be responsible with sensitive or restricted information!

Looking ahead

The next ISB, the 29th, will be held in Edinburgh, Scotland, May 9-13, 2016. Ian Cullis and I are the co-chairs. Based on the abstracts received and the interest shown to date (see later in this newsletter for details) it promises to be a great symposium with a high attendance. Please keep your eye on the IBS website for further information and key dates. Information on the registration process will be appearing soon. I look forward to seeing you there.

Defence Technology

This peer-reviewed journal, published by Elsevier, switches to a bi-monthly schedule in 2016. It will publish a special edition containing selected papers presented at the 29th ISB. Please remember to reference appropriate papers from this journal in your own papers to improve its rating.

If you have any views on the IBS or wish to help then please contact me. I look forward to receiving them.

Clive Woodley
IBS President

LOOKING BACK TO ATLANTA:
ABSTRACTS FROM THE AWARD-WINNING PAPERS

It is not always easy to get an idea of the content of the awarded papers during the award ceremony. That's why you will find in this section the abstracts of those papers. If you want more, we invite you to refer to the symposium proceedings, which can easily be found on the IBS website.

LOUIS AND EDITH ZERNOW AWARD: Ove S. Dullum, Haakon Fykse, and John F. Moxnes

"ENGRAVING, FRICTION AND WEAR IN SMALL CALIBER GUNS"

The paper investigates experimentally and theoretically the forces that apply to the small arms projectiles during the interior ballistic process. These forces are determined by the material and the geometric design of the projectile. The forces determine muzzle velocity and the amount of metallic dust emitted during the use of the weapons. We find that the frictional forces are due to the pressure between the bore and the projectile caused by the setback forces and the squeezing of the projectile into the bore and that the energy loss due to friction is 20-25% of the muzzle kinetic energy. The result complies with experimental work made by others. Finally, it gives some suggestions on how to minimize the friction forces by modifying the geometry and through selection of more appropriate material.

AWARD-WINNING PAPERS (CONT'D)

NEILL GRIFFITHS AWARD: W. Arnold, E. Rottenkolber, and T. Hartmann

"AXIALLY SWITCHABLE MODES WARHEADS"

An increasing number of asymmetric conflicts, often within urban terrains (MOUT: Military Operations in Urban Terrain), require not only a high precision in deployment but also ammunition with a high flexibility in performance. But today's warheads do not have these capabilities allowing only a significantly reduced freedom of action. During the last decade TDW put a lot of effort into the research of new warhead technologies trying to change this inappropriate situation. In a previous paper [1] the very first ideas meeting these challenges were presented. In the meantime further progress was achieved leading to new warhead concepts. A radially Switchable Modes Warhead (SMW) and a Scalable Effects Warhead (SEW) were demonstrated in the 26th Symposium on Ballistics [2] & [3]. In the current work two other concepts on axially Switchable Modes Warheads will be presented.

SABO AWARD: Long H. Nguyen, Shannon Ryan, Stephen J. Cimpoeru, Adrian P. Mouritz, and Adrian C. Orifici

"THE EFFECT OF TARGET THICKNESS ON THE BALLISTIC PERFORMANCE OF UHMW POLYETHYLENE COMPOSITE"

The ballistic performance of thick ultra-high molecular weight polyethylene (UHMW-PE) composite was experimentally determined for panel thicknesses ranging from 9 mm to 100 mm against 12.7 mm and 20 mm calibre fragment simulating projectiles (FSPs). With increased thickness the panels demonstrated a two-stage penetration process: shear plugging during the initial penetration followed by the formation of a transition plane and bulging of a separated rear panel. An analytical model is developed to describe the two-stage perforation, based on energy and momentum conservation. The model was found to provide very good agreement with the experimental results for thick targets that displayed the two-stage penetration process. This paper is an extended abstract of a journal paper submitted for publication in the *International Journal of Impact Engineering*.

ROSALIND AND PEI CHI CHOU AWARD: A. Weiss and D. Durban

"CAVITATION THEORY APPLIED TO POLYCARBONATE BALLISTIC RESPONSE"

Cavitation fields in spherical and cylindrical configurations which include damaged zones were studied and applied to predict the specific cavitation energy (S_c) for polycarbonate targets subjected to ballistic impact. We followed the standard approach of steady state cavitation presented in [6]-[11] and obtained formulae for the cavitation pressure that apply for assessment of resisting stress during projectile ballistic penetration. We found that the spherical cavitation pressure in presence of damaged zones is in satisfactory agreement with test data. Material response is modeled as elastic/perfectly-plastic of Mises type with neglect of elastic compressibility. Sensitivity to failure strain is examined and useful closed form formulae are derived.

Ulf Deisenroth 1944-2015

Ulf Deisenroth, known as "Dizi" to his many friends in Israel, began his extensive professional career as an explosives and propellants chemist at MBB and was one of the most promising young researchers working under Dr. Manfred Held.

At a later stage, he left Dr. Held's group to establish **IBD Ingenieurbüro Deisenroth**, a private engineering and R&D firm dedicated to developing advanced armour solutions, mainly implementing Ulf's creative ideas, which were promoted by the German MOD.

Ceramic armour protection, inner protective liners, and reactive armour were all very important issues, targeted by everyone in our field. Ulf implemented IBD's solutions for all of these, all over the globe.

Active armour is still a major research area by everybody in our field; Ulf initiated an active defense system, which is still in in use today. While everybody was talking about advanced technologies, IBD was actually implementing worldwide its protection systems on APC's, AFV's, etc.

When logistic German vehicles entered the Yugoslavia war, Ulf collaborated with KMW and Plasan to protect all of them in actual real time.

"Dizi" was a true friend.

Ulf was, and will always be remembered, as the wizard of ballistic protection of all sorts and kinds and its adaptation on vehicles and especially AFV's.

Ulf was very creative and superior with both his scientific and business vision, he gained enormous know-how in almost all aspects of the ballistics disciplines.

Ulf was a brilliant chemist with great pyrotechnic skills, as a master of fireworks no doubt he could have been a Chinese favorite. These skills of dealing with explosives and the fantastic creativity led him to novel protection fields, reactive and later on active protection, and their implementation on different platforms.

His phenomenal influence extended beyond energetic materials to armor steels, ceramics, composites, adhesives, special paints, ballistic concrete, camouflage, physical effects, electronics and micro-electronics, and other many fields and matters. He always paid particular attention to the small details, understanding and explaining them naturally and easily.

His impressive figure is already being missed by the IBS community,

Dr. Moshe Ravid

Rimat Ltd. team.

LOOKING AHEAD TO EDINBURGH:
UPDATE ON THE 29TH INTERNATIONAL SYMPOSIUM ON BALLISTICS

Clive Woodley and Ian Cullis

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The Co-Chairs for the 29th ISB, Ian Cullis and Clive Woodley, together with the abstract reviewers, have been working hard to process the vast number of abstracts submitted. To date, 356 abstracts have been received. This number is significantly greater than those submitted for each of the last two ISB in Germany and Atlanta, which were both about 280.

All authors should have received an email informing them whether their abstract was accepted or rejected.

It is encouraging that the lead authors of a significant number of the abstracts have indicated that they intend to apply for a Student Award. This number of 44 is significantly greater than those received for the last two ISB, which were 12 (Freiburg) and 14 (Atlanta).

Based on the number of abstracts received and the level of interest shown by people worldwide, the 29th ISB promises to be a great symposium!

The number and types of technical sessions have now been decided. Oral and poster presenters have been informed. A draft programme is now available at http://www.ndia.org/meetings/6210/Documents/6210%20-%20agenda.pdf

Known dates for networking activities include the following:

- Monday 9 May 2016: Reception at the Edinburgh International Conference Centre
- Wednesday 11 May 2016: Reception at Edinburgh Castle
- Thursday 12 May 2016: Banquet at National Museum Scotland.

Further information on the 29th ISB will appear on the IBS website under Events and then 29th ISB.

Registrations for the 29th ISB are now open. Please see the 29th ISB page for details.

If you have any questions on the 29th ISB or about your paper then please contact Ian or Clive using the addresses below:

Ian Cullis: info@ballistics.org

Clive Woodley: membership@ballistics.org or president@ballistics.org

International Ballistics Society

Periodic Bulletin

Questions, input, or feedback should be directed to communicatioins@ballistics.org

FACTS ABOUT EDINBURGH,

venue of the upcoming 29th International Ballistics Symposium

Metric System: Did you know ...

… that **William John Macquorn Rankine** (1820-1872), a founder of the science of thermodynamics, and who was born in **Edinburgh** in 1820 and attended university there, had strongly negative feelings about the Metric System (now known as the **International System** (SI)) and refused to use what he called "foreign units"? He expressed his opinion eloquently in a poem, which reads in part:

> Some talk of millimetres, and some of kilogrammes,
> And some of decilitres, to measure beer and drams;
> But I'm a British Workman, too old to go to school,
> So by pounds I'll eat, and by quarts I'll drink,
> And I'll work by my three-foot rule.

http://www.poemhunter.com/best-poems/william-john-macquorn-rankine/the-three-foot-rule/

(image: Wikipedia)

… that vehicle drivers visiting **Scotland** from other countries should be aware that speed limits are posted in *miles-per-hour* (mph), rather than kilometres-per hour? While the United Kingdom committed in 1973 to adopting SI units, exceptions remain for traffic signs (also travel distances and height clearances) and dispensing of draught beer and cider (Imperial pints).

Edinburgh celebrities: Did you know ...

… that, in addition to Rankine, **James Clerk Maxwell** (formulator of the classical theory of electromagnetism), **Arthur Conan Doyle** (creator of Sherlock Holmes, whose statue marks his birthplace), **John Napier** (inventor of logarithms and a precursor of the slide rule called "Napier's bones"), **Robert Louis Stevenson** (author of *Strange Case of Dr. Jekyll and Mr. Hyde*), **Sir Walter Scott** (author of *Ivanhoe* and *Rob Roy*), and **Alexander Graham Bell** (inventor of the telephone) were also born in Edinburgh?

Bronze statue of Sherlock Holmes in Picardy Place, Edinburgh, unveiled 1991 (image: Wikipedia).

… that **haggis, the national dish of Scotland**, is a savoury pudding consisting of a sheep's heart, liver, and lungs, minced together with onions, oatmeal, suet, and seasonings, traditionally encased in the animal's stomach? It is traditionally served with boiled, mashed rutabaga ("neeps") and potatoes ("tatties") and a "dram" of Scotch whisky.

Platter of haggis (image: Wikipedia)

MEMBER ARTICLE

IBS members are always welcome to submit papers for inclusion in the newsletter. This issue features an article by Ian Cullis, Philip Ottley, and Andrew Wood.

VISUALISING IGNITION AND BURNING OF PROPELLANTS

by Ian Cullis, Philip Ottley, Andrew Wood
QinetiQ, Fort Halstead, Sevenoaks Kent, TN14 7BP

INTRODUCTION

The study of the ignition and growth of energetic materials is a very topical and active research area, driven by the need for increased levels of safety in their storage and transport.

In the defence arena there are two main areas of interest, the response of an energetic material to thermal and mechanical insults. In the case of the latter the interest lies in understanding the response to projectile impact. There are three possible responses: Shock to Detonation Transition (SDT), where the impact velocity generates a shock wave that is strong enough to cause an immediate detonation; Deflagration to Detonation Transition (DDT), where the impact generates an initial burning response which rapidly accelerates to a detonation; and Unknown Detonation Transition (XDT), where the impact of a fragmented cloud of energetic material impacts another surface, ignites, and reacts violently or detonates.

Whilst various theoretical models have been developed to describe these ignition processes, the experimental evidence to support them has been lacking, particularly with regard to ignition and the rate of reaction.

QinetiQ, in partnership with Cambridge University and Roxel, have been undertaking research into XDT in rocket motors as part of a Weapons Science and Technology Centre (WSTC) sponsored programme. One of the core elements of the programme was to develop a small scale test to determine the propensity of a rocket motor propellant to undergo XDT. The propellant being studied is a double base propellant that contains Nitrocellulose, Nitroglycerine, and a Nitramine.

TEST DESCRIPTION

The test involves gun-launching a spherical projectile at a sample of propellant. The projectile penetrates the sample and emerges from its rear surface surrounded by a debris cloud of propellant fragments. The projectile and debris cloud then impact a glass plate with an angled mirror behind the glass plate to allow the impact surface and any ignition of the propellant fragments to be observed. The initial test arrangement is shown in Figure 1.

Using a Phantom 7 High Speed Video camera we have been able to visualise the range of possible reactions from burning through to XDT, Figure 2. The burning in the debris cloud generated by the initial impact of the projectile is caused by the impact of the sabot, used to launch the projectile, impacting the debris cloud.

The XDT response is so rapid that the camera interframe time of 2.56 μs is too slow to capture the ignition process, reaction growth and the retonation back through the cloud into the propellant sample. The burn-back velocity is a crucial validation parameter for validation of numerical simulations.

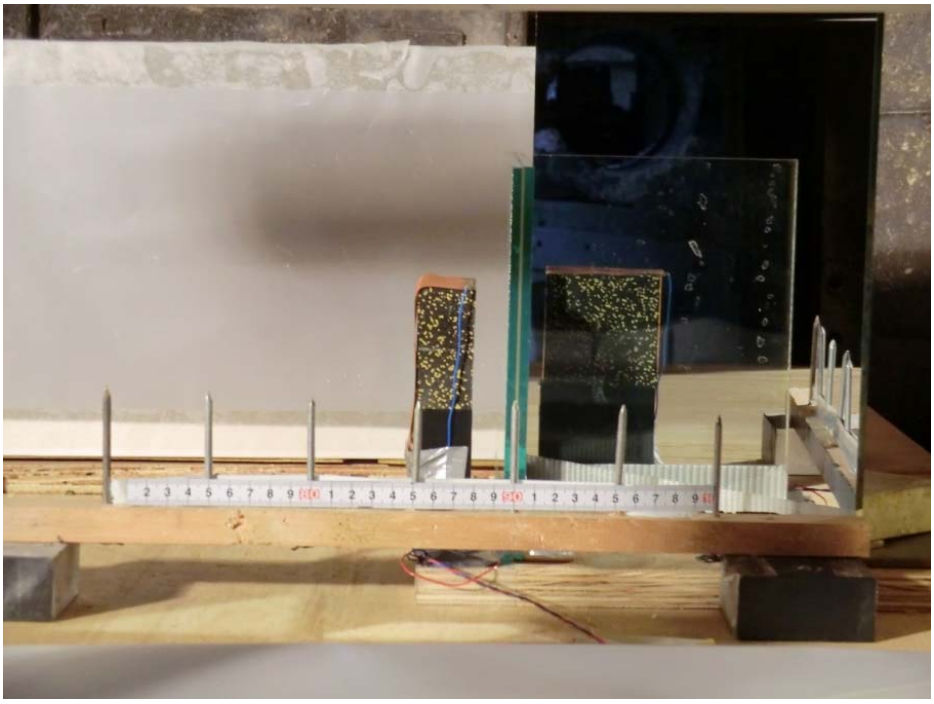


Figure 1: Initial experimental arrangement

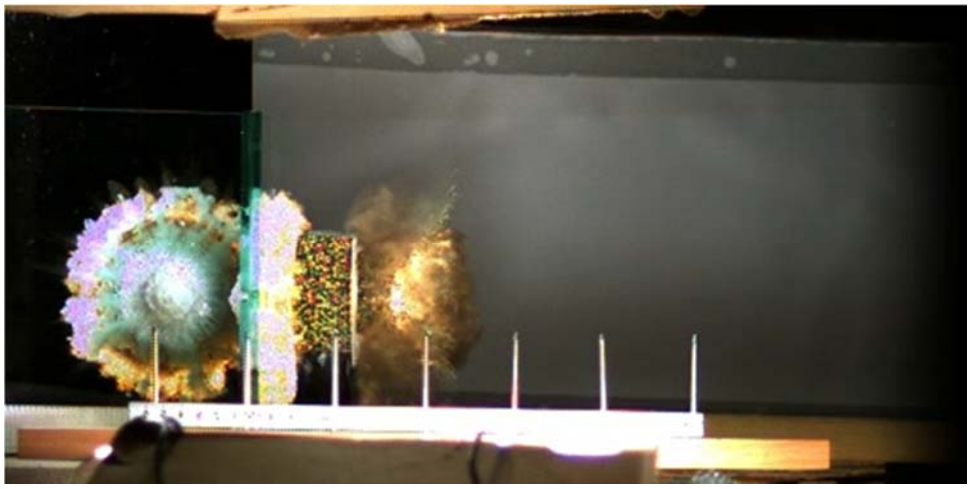


Figure 2: Burning response

To improve the time resolution we have therefore investigated the use of the new high-speed Karana camera. The Karana runs at 2 million frames per second to record a total of 180 frames, each 964×768 pixels in size. The results from one of our experiments are shown in Fig. 3.

The ignition of individual pellets that contain the nitramine can be clearly observed as more of the debris cloud impacts the glass plate. As more pellets ignite and burn the reaction grows. If there are sufficient number of pellets in the debris cloud the reaction can become self-sustaining and a violent detonation results, characterising the XDT response.

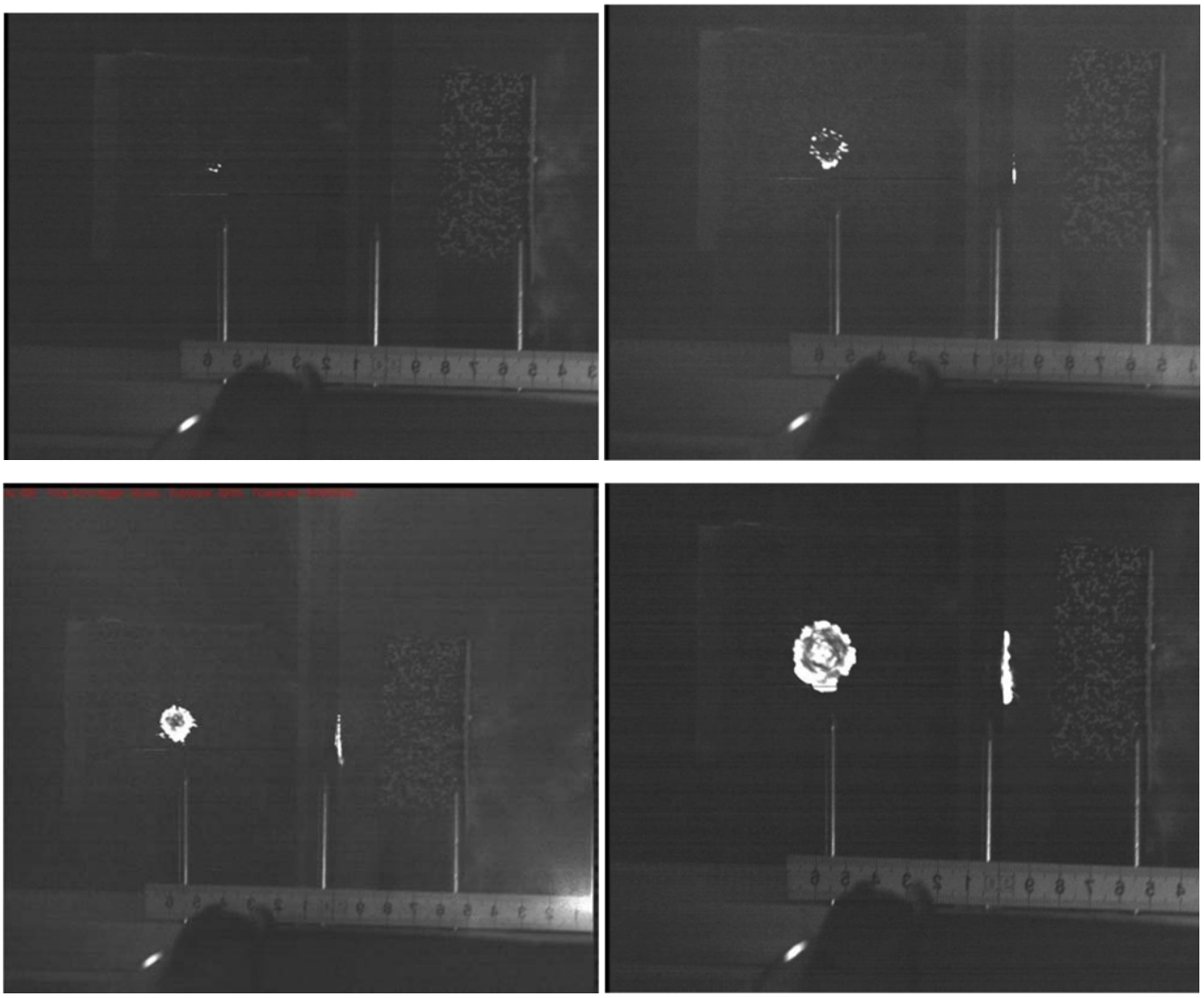


Figure 3: Karana images showing ignition and growth of reaction

The use of the Karana camera has opened up a new capability to study the fine details of the ignition and growth process in energetic materials, providing a rigorous test of our material and ignition and growth models and the numerical simulation techniques used to describe it.

ACKNOWLEDGMENT

This research was funded by DSTL, UK MOD, under a Weapons Science and Technology Centre contract.

AGENDA

29th INTERNATIONAL SYMPOSIUM ON BALLISTICS, Edinburgh, Scotland, 9-13 May 2016

- March 2016: Formal papers due
- April 2016: Powerpoints due

30th INTERNATIONAL SYMPOSIUM ON BALLISTICS, Long Beach, California, 11-17 Sept 2017

31st INTERNATIONAL SYMPOSIUM ON BALLISTICS, Hyderabad, India, November 2019

THE ACCREDITED BALLISTIC APPLICATIONS LABORATORY

by Alexandre Papy

The **Accredited Ballistic Applications Laboratory (ABAL)** is part of the department of weapon systems and ballistics, located at the Royal Military Academy in Brussels, Belgium.

The ABAL laboratory has a 103 meter long indoor range which is equipped with state-of-the-art apparatus. This allows for accurate measurements and visualizations of many ballistic phenomena. Through a continuous effort in research and academic teaching related to internal ballistics, gun dynamics, external ballistics, terminal ballistics, vulnerability and wound ballistics (both lethal and non-lethal), ABAL keeps innovating its equipment and measurement techniques, as well as its numerical computer simulation packages.

The laboratory is integrated into the DYMASEC interdisciplinary centre of excellence which focuses its attention on the dynamic loading of materials and structures for military and civilian applications. As such, ABAL is a service provider to the Belgian defence but also to many third parties, amongst which are police, governmental organisations and industrial companies, both nationally as worldwide. ABAL is ISO accredited for different kinds of impact tests.

The department of weapon systems and ballistics and its ABAL laboratory welcome Belgian and international students or active employees for conducting theoretical and/or experimental work in their facilities. Interested groups can contact the department for a short course in ballistics, both theoretical as well as practical.

ABAL is a member of different international organisations such as IBS, IPAC, DYMAT, ARA, VPAM, EEMLS, EWG and C.I.P.

http://www.rma.ac.be/abal/en/

BALLISTICS HISTORY: EARLY ELECTROMAGNETIC GUNS

The invention of the electromagnetic gun goes back more than a century.

"*Electromagnetic Pop-gun.*—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electromagnet (Fig. 53), consisting of a small bobbin, the core of which is an iron tube about two inches [50 mm] long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electromagnet in that respect. Now suppose I take a little round rod of iron, about an inch [25 mm] long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands, the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by *lengthening* it; by pushing the piece of iron out so as to afford more surface for leakage. That is exactly what happens; for, as you see, when I turn on the current, the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic popgun. This is an experiment which has been twice discovered. I found it first described by Count [Théodose] du Moncel [French inventor, writer, and advocate of applications of electricity, 1821-1884], in the pages of [the journal] *La lumière électrique*, under the name of the "pistolet magnetique;" and Mr. Shelford Bidwell [FRS, English physicist and inventor, 1848-1909] invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society, in 1885, but the reporter missed it, I suppose, as there is no record in the society's proceedings."—Excerpt, Professor Silvanus P. Thompson, D. Sc., B.A., M.I.E.E., "The Electromagnet," Lectures delivered before the Society of Arts, London, 1890. From the Journal of the Society, *Scientific American Supplement*, No. 787, p. 12573, January 31, 1891.

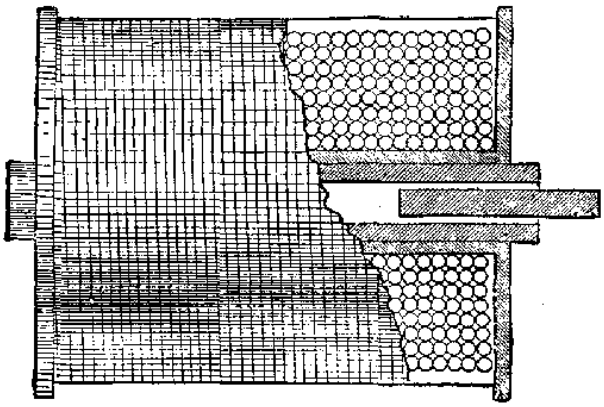
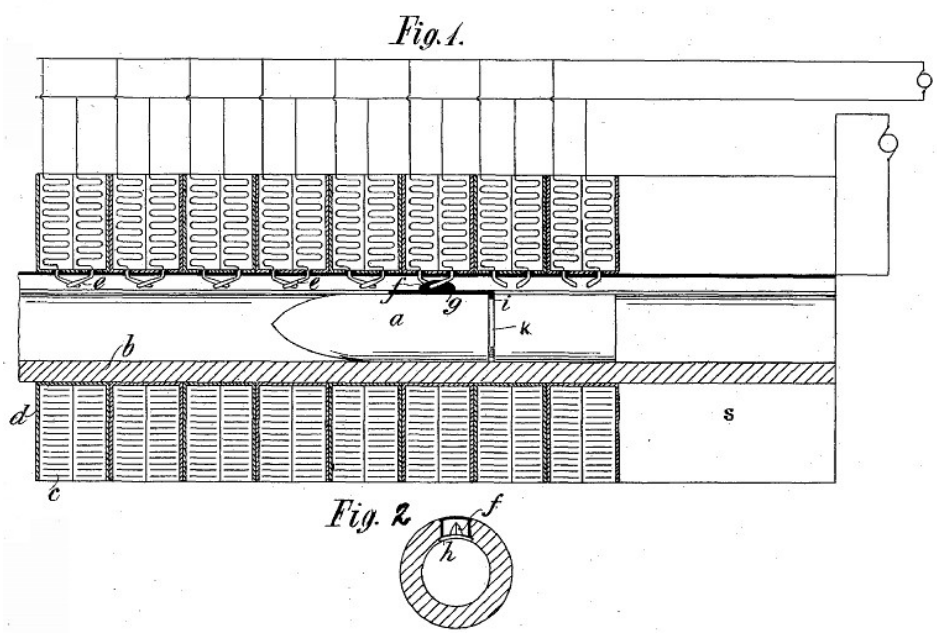


FIG. 53.—ELECTROMAGNETIC POP-GUN.

(Image: *Scientific American Supplement*, Jan. 31, 1891, public domain.)

Kristian Birkeland (1867-1917), an eminent Norwegian physicist, invented an "**electromagnetic cannon**," which he patented in 1902. With help from investors, he formed a firearms company and built a working prototype capable of launching 10-kg projectiles, but it yielded velocities disappointingly short of the hoped-for 600 m/s, only about 100 m/s, enough for a range of about a kilometer. Undaunted, Birkeland renamed his device an "aerial torpedo" and arranged a public demonstration with the aim of selling his company. A short circuit resulted in a spectacular failure, but before his gun could be repaired, his varied research interests wandered into other fields, forestalling further development.

(Photo: public domain)



Drawings from Birkeland's patent for his electromagnetic cannon (image: public domain).

The invention of the modern "rail-gun" apparatus based on the principle of the linear motor and its application of the Lorentz force is attributed to French inventor **André Louis Octave Fauchon-Villeplee**, who in 1919 applied for a patent for an "Electric Apparatus for Propelling Projectiles." Earlier, in 1917, he had applied for a related patent on an "Electric Gun or Apparatus for Propelling Projectiles," with the claim that it "produces no smoke and scarcely any noise or light." However, he apparently never built a prototype for either patent.

For more information, see "Early Electric Gun Research," by I.R. McNab, *IEEE Trans.* on *Magnetics*, Vol. 35, no. 1, Jan. 1999.

THIS NEWSLETTER NEEDS YOU!

The newsletter is a primary means of keeping you informed about the life of the society, and about the main events it organizes. You can participate in making this bulletin more lively and closer to your fields of interest by proposing technical papers about works you have performed, or facts about ballistics you are aware of. For instance, if in browsing the web you find sites related to ballistics you think are interesting, funny, or worthy of sharing, do not hesitate to send a message to communications@ballistics.org. However, be careful not to infringe any copyright or classification rules.

Also, we all belong to lots of different organizations, industries, and laboratories. It could be interesting for other members if, from time to time, one of you made a short informative presentation of its organization. This presentation should contain more information than advertising, and have the same obvious requirements about copyrights and classification.

Any other type of contribution is obviously welcomed!

Thanks in advance!

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"THE DIFFERENCE"

TDW Gesellschaft für verteidigungstechnische Wirksysteme mbH, a wholly owned subsidiary of MBDA Germany, is experienced in the design and manufacture of warheads, and the associated fuzes and safe & arm devices. TDW designs and manufactures all kinds of warhead systems such as shaped-, blast-, blast/fragmentation-, tandem-charges and penetrators for missile system houses worldwide. Our key technologies include insensitive explosive charges with outstanding safety even under extreme mechanical and thermal threats which provide nonetheless ultimate destructive performance.

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- **Scalable Effects Warheads (Dial-a-Yield)**
- **Aimable Warheads (Dial-a-Direction)**
- **Multi-Effects Warheads (Dial-an-Effect)**
- **Intelligent Penetrator Fuzes**

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SECRAB Security Research works with research and technology, mostly within public safety and security.

Some specific competencies:

- Large projects, research applications, coordination for the EU FP7 etc.
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- Energetic materials, effects and protection, detection and remediation
- Advanced rock blasting, underwater blasting and shaped charges
- Protection against metal theft, other organized crime and terrorism
- Protection of critical infrastructure against physical attack, explosives, fire
- Short courses on related subjects

SECRAB is owned and managed by Professor Bo Janzon.

SECRAB is a Partner in Osprey Investments LLP, and Trace-in-Metal Ltd., both in UK.

www.secrab.eu bo.janzon@secrab.eu

Phone: +46 70 433 4630 Fax: +46 8 519 89239

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for Defence Industry and Government Agencies

NUMERICS is an engineering services and software development company located close to Munich, Germany. We are serving our customers world-wide with innovative tailored solutions to their problems in the complete field of ballistics: from detonation to terminal effects and from constitutive modeling to vulnerability and lethality analyses.

NUMERICS offers a broad range of supporting consultancy services designed to meet the clients' specific needs, including

- specialist software development,
- product development and optimization,
- turnkey analyses and
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We are in permanent contact with universities and other research organizations to include modern technologies, modern methods, and the state-of-the-art in physical and engineering research in all our products and services.

NUMERICS is proud to support the International Ballistics Society as a Corporate Member.

For further information, please visit www.numerics-gmbh.de/en.

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中国兵工学会
China Ordnance Society

Founded in April 1964 and affiliated with the China Association for Science and Technology, the China Ordnance Society is an academic social group composed of science and technology workers for China Ordnance.

The purpose of the China Ordnance Society is to serve the defense construction and economic development by organizing science and technology workers and to promote and develop scientific ideas and disciplines. Its main task is to organize academic exchange, publish academic periodicals, promote the development of science and technology, propagate scientific information and popularize scientific knowledge.

The Society has general members, senior members and fellows and so on. It has all together 22562 members, among which more than 585 are senior members and 34 are fellows.

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ABAL : The Department of Weapon Systems & Ballistics of the Belgian Royal Military Academy

The department of weapons systems & ballistics is unique as it is the only place in Belgium to teach courses in ballistics and weapon systems on a university level. The department is equipped with a modern laboratory featuring a 102-m indoor range.

www.rma.ac.be/en/rma%20-%20weapon%20systems%20and%20ballistics.html

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QinetiQ

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- **Our scientists and engineers solve some of the world's most important problems.**
- **We are the UK's largest research and technology organization.**
- **We are the world's leading supplier of military robotics.**
- **More than 75% of our workforce carry high-level national security clearances.**

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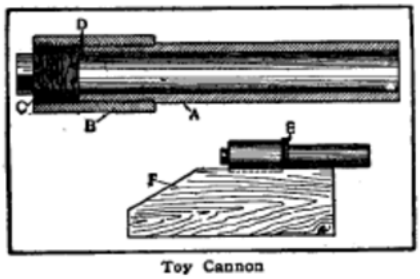
How to Make a Cannon

A cannon like the one in the cut may be made from a piece of 1-in. hydraulic pipe, A, with a steel sleeve, B, and a long thread plug, C. Be sure to get hydraulic pipe, or double extra heavy, as it is sometimes called, as common gas pipe is entirely too light for this purpose. Don't have the pipe too long or the cannon will not make as much noise. Seven or eight inches is about the right length for a 1-in. bore. Screw the plug and pipe up tightly and then drill a 1/16-in. fuse hole at D. If desired the cannon may be mounted on a block of wood, F, by means of a U-bolt or large staple, E.—*The Boy Mechanic, Vol. I, 700 Things for a Boy to Do*, Popular Mechanics Co., 1913.



Toy Cannon

This entire entertaining but highly hazardous book can be downloaded at:
http://www.gutenberg.org/ebooks/12655
The frontispiece (p. 6 of the PDF file) is especially interesting.


(image: Wikipedia)

REMINDER FOR YOUNG AUTHORS: THE ROSALIND & PEI CHI CHOU AWARD

The Rosalind and Pei Chi Chou Award for Young Authors is given at the International Symposia on Ballistics. Its purpose is to enrich the program of the Symposia by encouraging young authors to submit papers and attend the Symposium. Young Authors are reminded that they must apply for the Award, using a special form available on the IBS website (http://www.ballistics.org/the_rosalind_pei_chi_chou_aw.php), on submitting their paper for publication in the proceedings or the journal. Send your completed application form, along with a copy of your paper, to Dr. William Flis at flis@detk.com.

To be eligible, the Young Author must be 35 years of age or younger at the time of the Symposium. The paper may have multiple authors, but the Young Author must have made a major contribution to the paper. Further, the Young Author must attend the Symposium and give the oral or poster presentation.

The Award selection is based solely on the written papers, which are judged on original contribution to the ballistic sciences. The Award consists of a plaque and a stipend, prepared by the National Defense Industrial Association (NDIA). The plaque and stipend are presented by representatives of the International Ballistics Society and the NDIA.