Dr. Manfred Held
Memorial Presentation
A Celebration

Scientist
Innovator
Educator
& Friend

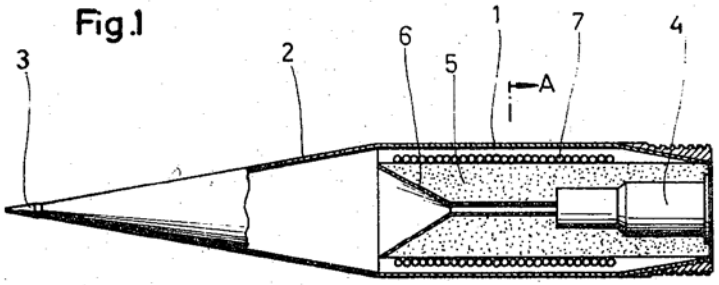
1933 to 2011

Determination

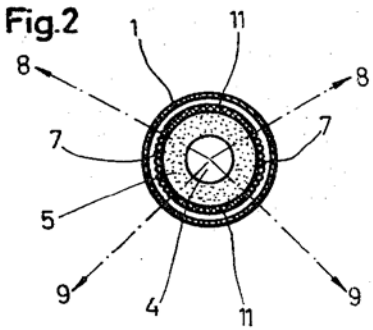
Strength

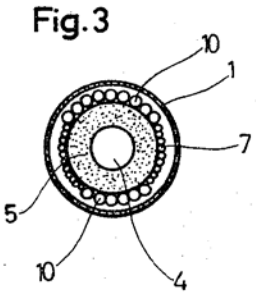
Generosity

The same qualities that the German Flag symbolizes
were embodied in our colleague;
who was also an ambassador of ballistics to the world.



US Patent 3,474,731 Warhead Containing a Hollow Charge and Fragmenting Section



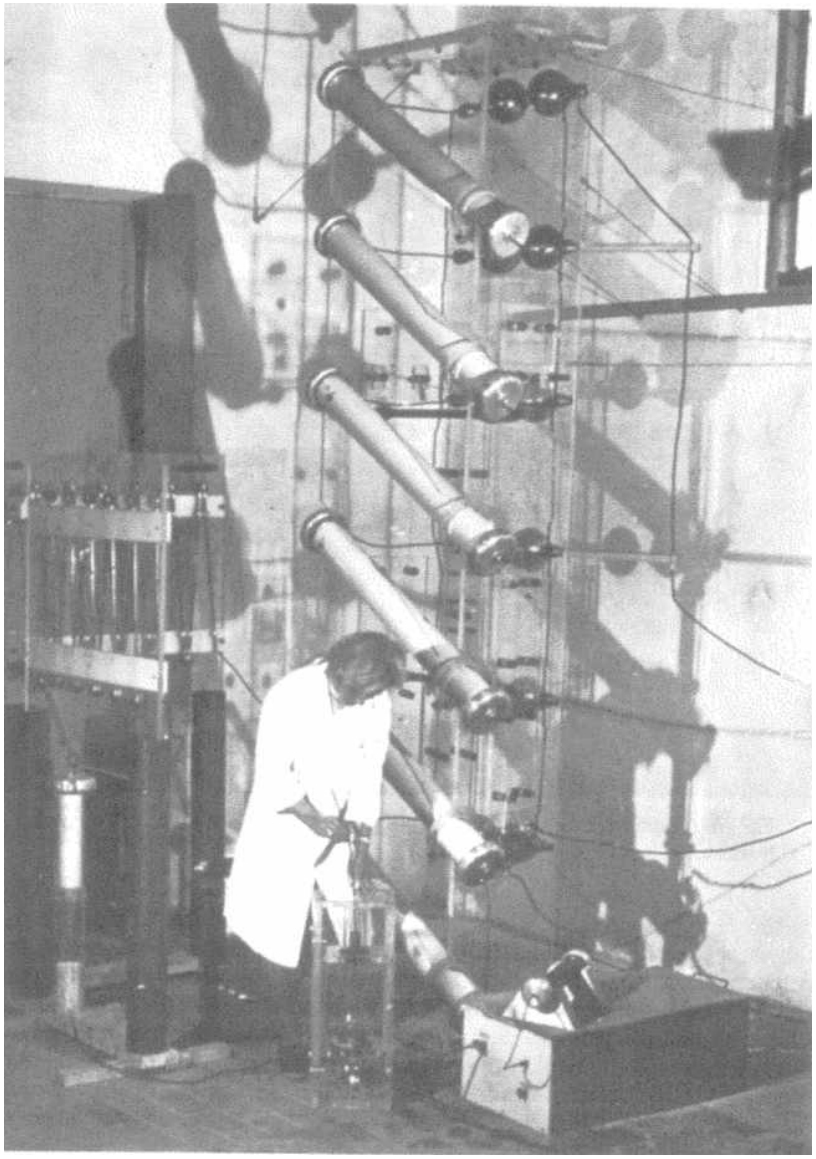


Thomanek (Walter Trinks) → Held

A LEGACY INHERITED TO A LEGACY GAINED

international ballistics
MIAMI, USA

Manfred’s First Challenge



The Essential Tool of Held's Work

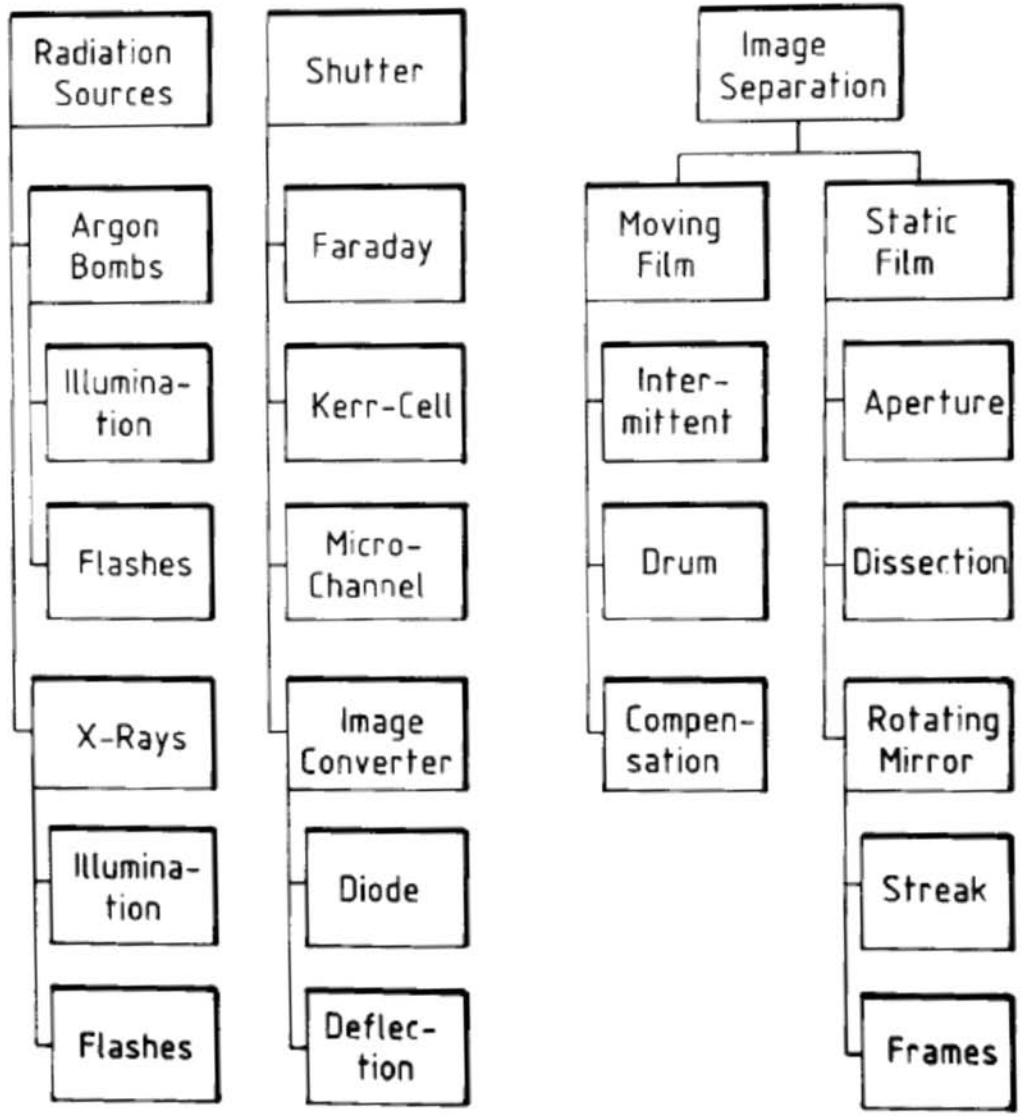
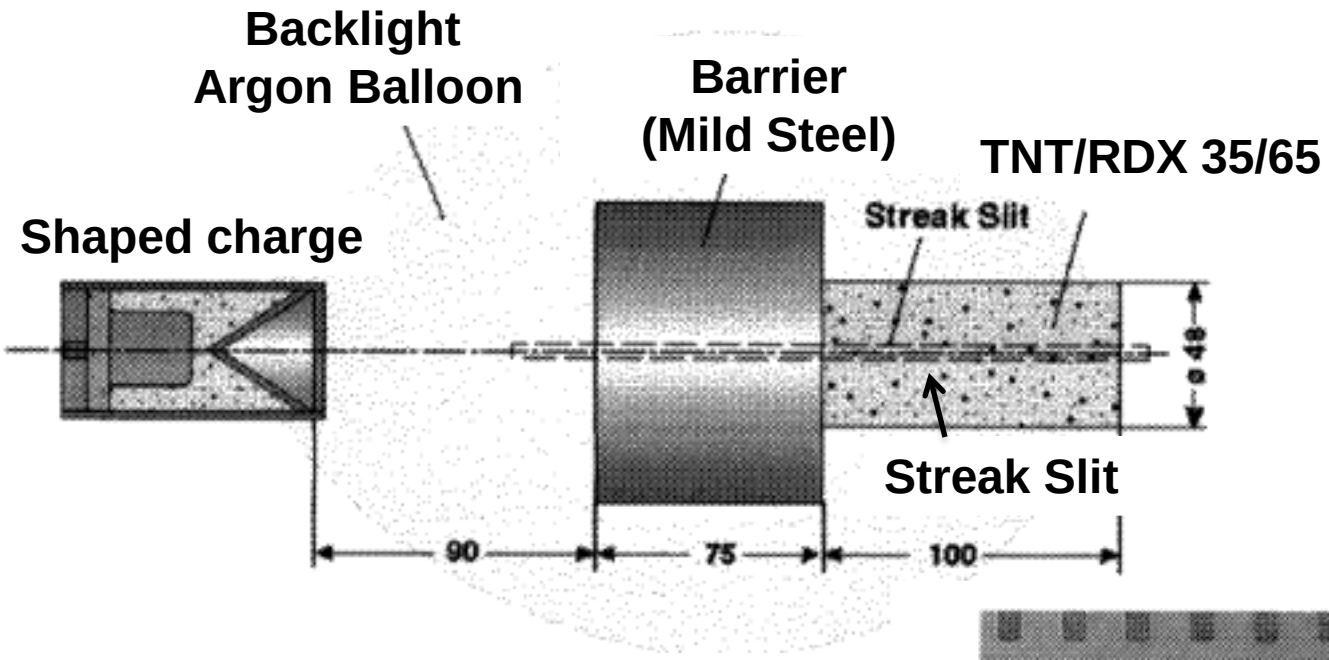


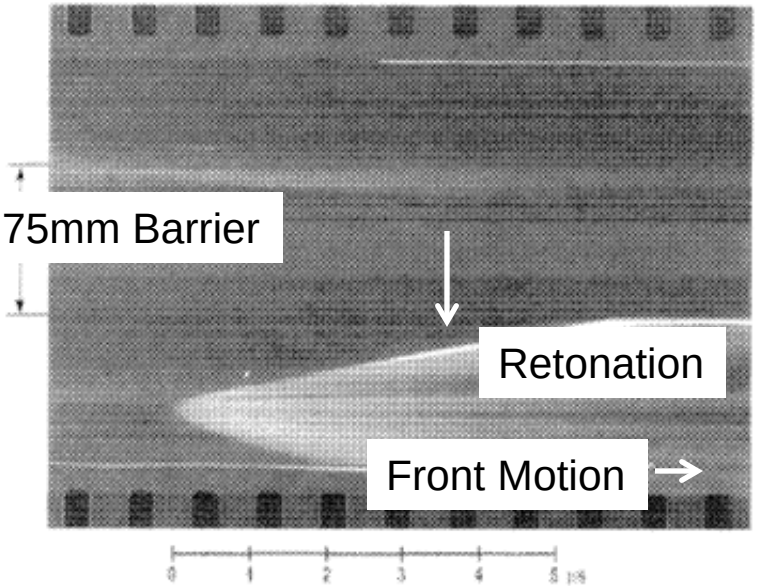
Fig. 1 Diagram of topics in this chapter.

international ballistics
MIAMI, USA



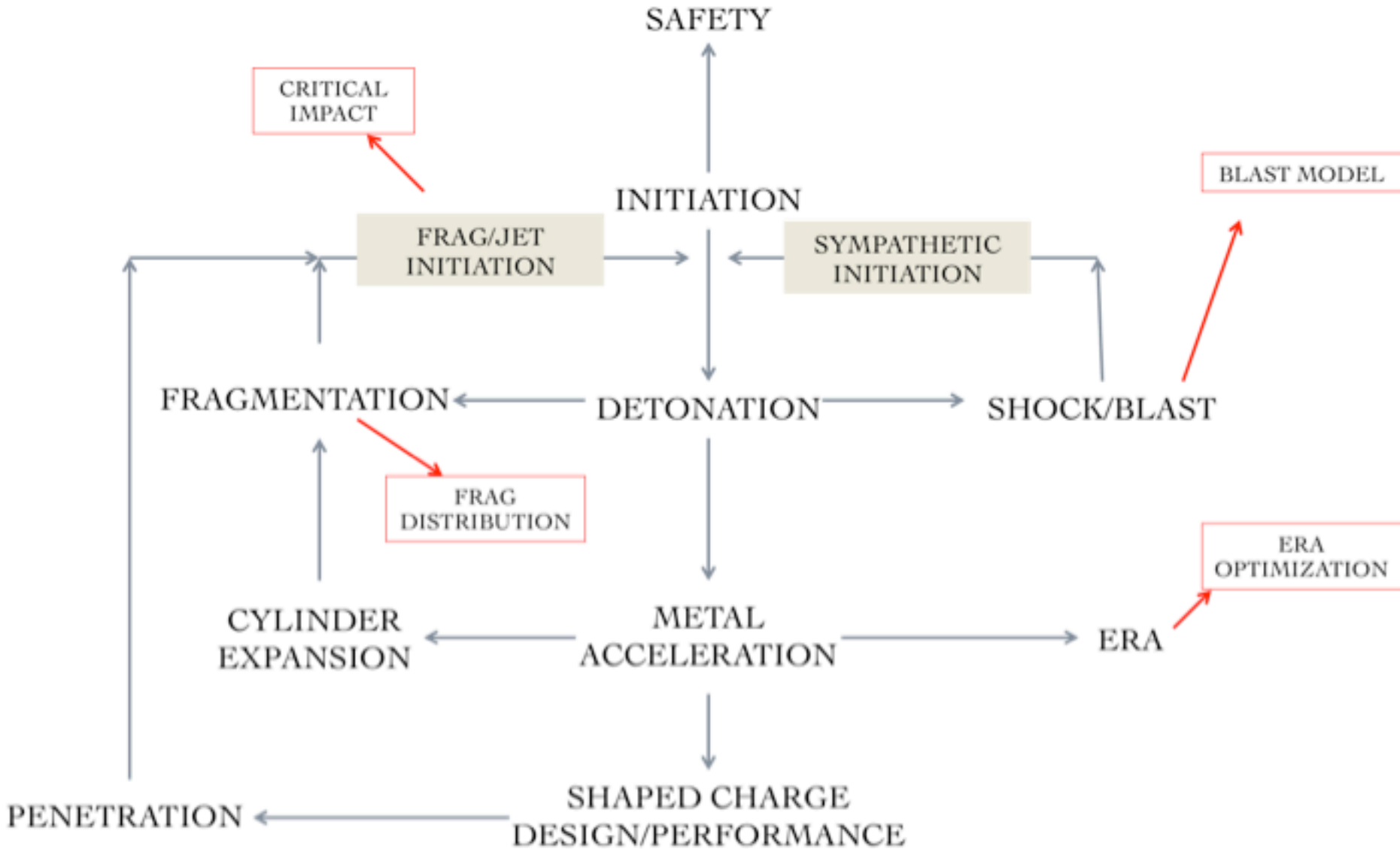
Application for

- ✓ Explosive Trains & Fuzing
- ✓ Gap Testing
- ✓ Protection & Safety
- ✓ Initiation



~5.5 mm/usec Streak Velocity

"Diagnostic of Jet Initiation Phenomena", 25th SPIE, 4948 (2003)



international ballistics
MIAMI, USA

Chronology of ISB Papers

ISB	Year	Title
1	1974	Streak Technique as a Diagnostic Method in Detonics
2	1976	The Performance of the Different Types of Conventional High Explosive Charges
3	1977	Explosive Formed Projectiles **
4		
5	1980	Cutting Charge
6	1981	Evaluation of Shaped Charge Penetration Efficiency by Advanced Diagnostic Techniques
7	1983	Characterizing Shaped Charge Performance by Standoff Behavior
8	1984	Transverse Shaped Charges
9		
10	1987	Refined Shaped Charge Jet Penetration Measurement in Various Materials Versus Hydrodynamic Prediction
11	1989	Particulation of Shaped Charge Jets
12		
13	1992	Aimable Fragmenting Warheads ***
14	1993	Armour
15	1995	Truncated Shaped Charges (**Defeat Mechanism for ERA)
16	1996	Design and Tests of Shaped Charges with L/D About 1
17	1998	Jet Observations in Synchro-Streak or Profile Streak Technique **
17	1998	Survivability of Fragments (with Kleinschnitger, Schmolinske, Stilp)
18	1999	Anti-ERA Shaped Charge Warhead System
18		Special Shaped Charges for Off-Shore Application
19	2001	Active Protection Against KE-Rounds and Shaped Charges at Short Distances*
19		Defeating Active Defense Systems by Double-Firing of Missiles
19		Steerable Hitiles Against TBM Warheads
20	2002	Improvements of the Probability to Kill Chemical and Biological Submunitions in TBM Warheads
20		Warhead Mechanisms (Review Article)
21	2004	Steerable Fragment Masses (shared session chair)
22	2005	The Future of Warheads, Armour and Ballistics (Keynote, shared authorship)
23	2007	Fuze Sensor Requirements of the Different Aimable Anti Air Warhead Layouts
23		Behind Armour Effects at Shaped Charge Attacks
24	2008	IED Mine Threats
	2010	RECOGNITION & TRIBUTES

international ballistics
MIAMI, USA

Chronology of ISB Papers

& the only person who has participated in each symposium.

ISB	Year	Title
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International Ballistics
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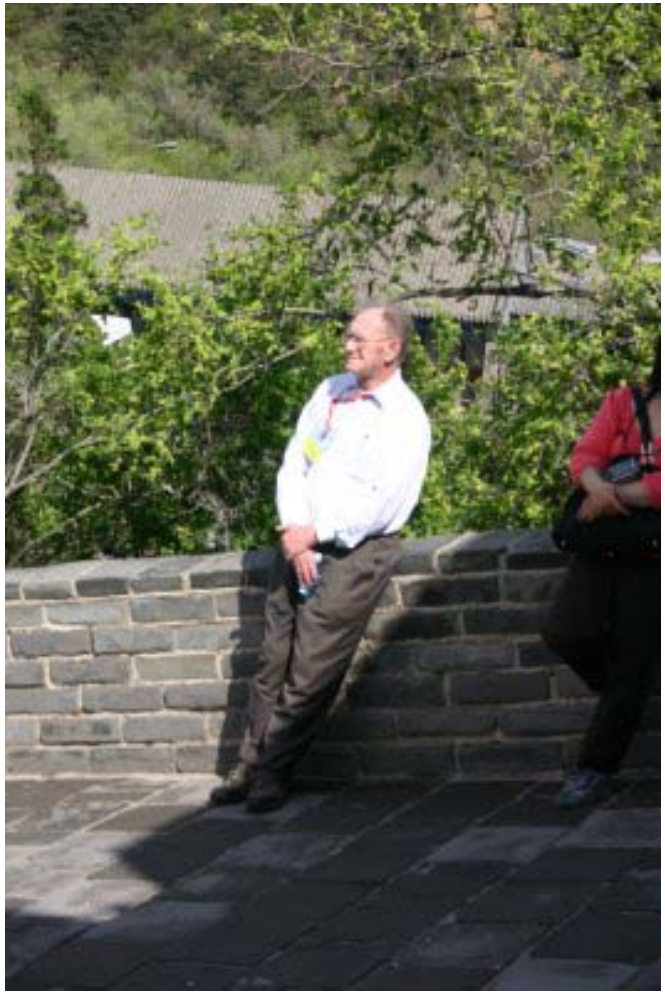
Including the Paper Selection Meeting for the 26th ISB

With Bo Janzon (7 Dec 2010)



Manfred Held, our first Ballistics Fellow resting on the Great Wall of China
at a break during the 25th Symposium.
(May 2010)

Author of major book chapters

•"*Shaped Charge Jet*", in: T. L. Boggs, R. L. Derr (Eds.), Hazard Studies for Solid Propellant Rocket Motors, NATO Advisory Group for Aerospace Research and Development, AGARD Monograph No. 316, 1990, pp. 117–36.

• "*Blast Effects of Detonating Small Charges*", Vol. 1–2, (to be published).

•"*Fragmentation Warheads*", in: J. Carleone (Ed.), Tactical Missile Warheads, American Inst. of Aeronautics and Astronautics, Washington, DC, 1993, pp. 387–464 (1993)

•"*High-Speed Photography*", ibid. pp. 609–673.

•"*Flash Radiography*", in J. Carleone (Ed.), ibid., pp. 555–608.

Other Seminal Papers covering

- Overviews of Detonation Theory
- Effects of aluminum on detonation & metal acceleration
- Fragmentation
- Energy Coupling
- Aimable Warhead
- Chemical/Biological Defeat

Publications per topics

Cross-Referenced Publications

- Initiation
- Detonation
- Fragmentation
- Blast/Shock
- Penetration
- Shaped charges
- ERA
- Safety
- Diagnostics
- Terminal ballistics
- Explosives
- Other

Publications per topics

Cross-Referenced Publications

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- Detonation
- Fragmentation
- Blast/Shock
- Penetration
- Shaped charges
- ERA
- Safety
- Diagnostics
- Terminal ballistics
- Explosives
- Other

Cross-referenced catalog of papers and patents incorporated in

EV2 Florian Bouvenot (French Navy)
"The Legacy of Manfred Held and Critique"
Master's Degree Thesis (Physics)
Naval Postgraduate School, Sept 2011

international ballistics
MIAMI, USA

One CLICK AWAY!

INITIATION

[005] Held, M. (1968). **Initiation of explosives, a multiple problem of the physics of detonation** [Initiierung von Sprengstoffen, ein vielschichtiges Problem der Detonationsphysik]. *Explosivstoffe* , *5*, 2-17.

The following will treat the induction or the excitation of a more or less continuous process, a process about which not much is known. By the process we mean here the detonation of solid (especially military) high-energy explosives such as TNT hexogen and octogen and their mixtures. The induction of detonation, or the excitation of explosive charges to undergo detonation-type decomposition is called "initiation." The first part discusses the general theory of initiation, and the second part reports on results and peculiarities in the initiation of explosive charges, as found at Schrobenhausen during the handling of various kinds of projects.

[006] Held, M. (1969). **Protecting and transport container for high explosive charges** [Schutz- und Transportbehalter fur Sprengladungen]. *Wehrtechnik, 8*, 266-268. No abstract available in English

[010] Held, M. (1974). **A structure for protection against projectiles** [Dispositif de protection contre projectiles ou corps analogues]. Patent, Messerschmitt-Bçlkow-Blohm GmbH, Munchen, Germany.

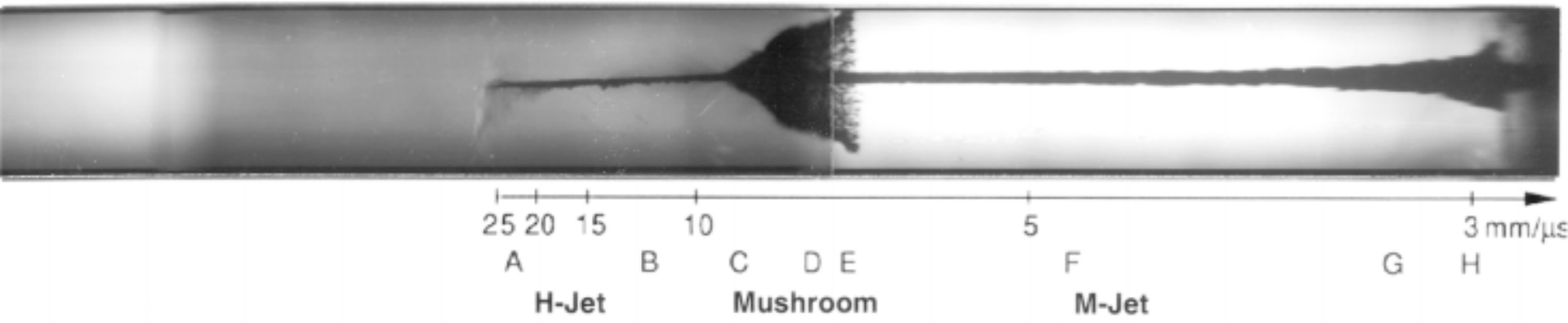
A protective arrangement against projectiles is a wall structure formed from a wall layer of explosive material, and at least one additional wail layer covering at least one face of the wall layer of explosive material. The additional wall layer is made of a non- explosive, inert high-density material such as metal. In one embodiment both faces of the explosive wall layer are covered with a layer of inert, non-explosive high-density material such as metal. The protective arrangement is particularly suitable for protection against the destructive force of hollow explosive charge projectiles.

SOME RESEARCH & DEVELOPMENT HIGHLIGHTS

Photographic challenges

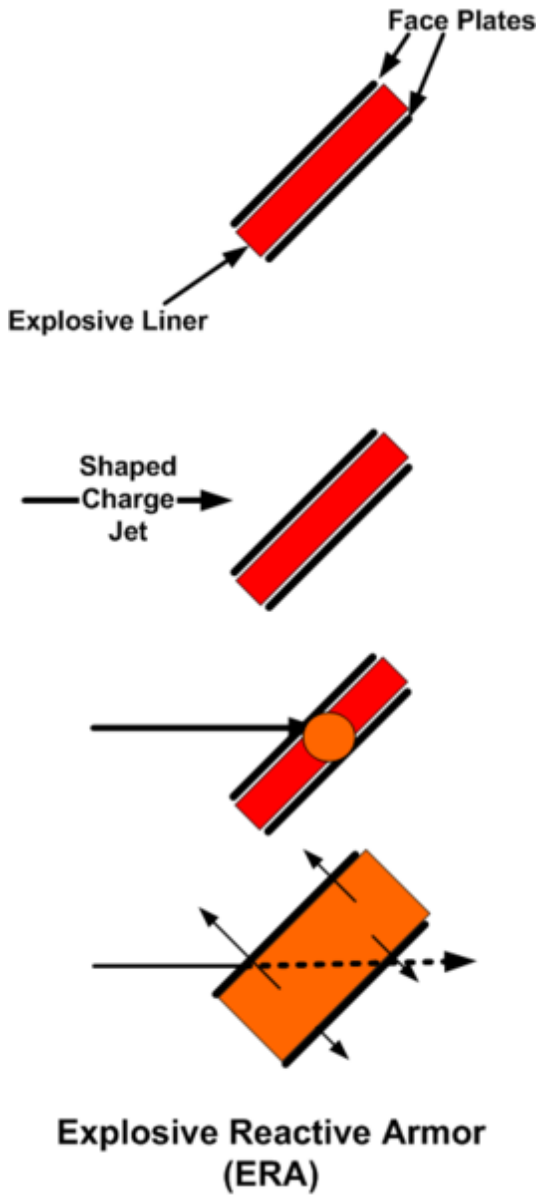
9.9 km/sec jet tip

25 km/sec



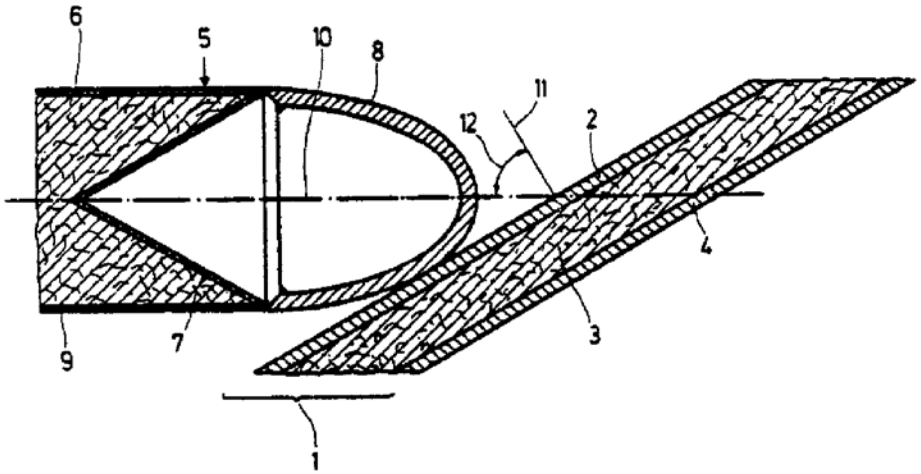
"Diagnostic of Super-fast Jets with 25 km/s Tip Velocities", Propellants, Explosives, Pyrotechnics, 23, 229 (1998)

1967-69 ERA
Israeli 1st application

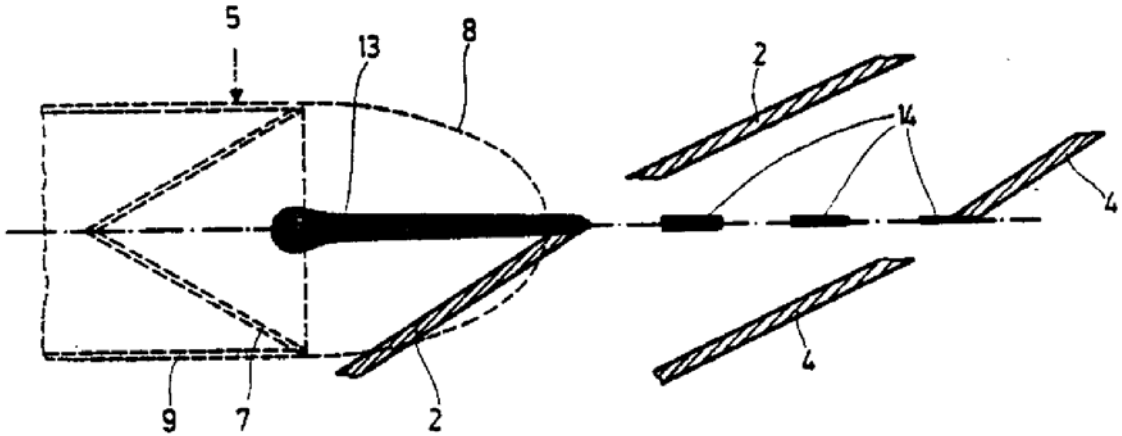


http://en.wikipedia.org/wiki/File:Image_Explosive_Reactive_Armor.png

Fig.1



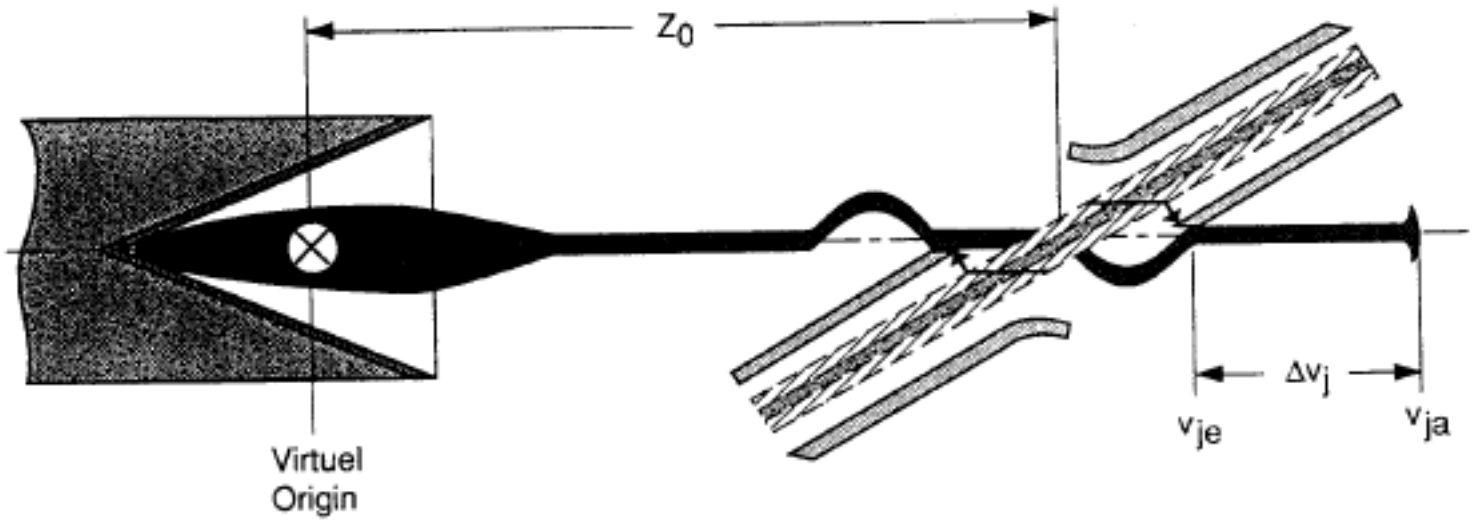
Year	
1980	US 4,368,660
	Applications
1978	951,085
1977	842,177
1976	706,067
1074	495,834



Protective Arrangement Against Projectiles, Particular Hollow Explosive Charge Projectiles

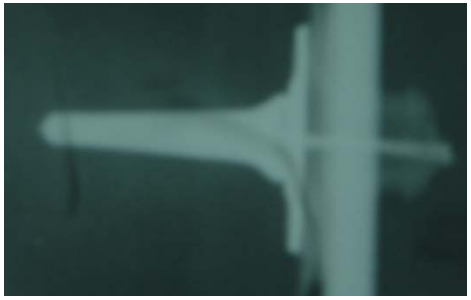
international ballistics
MIAMI, USA

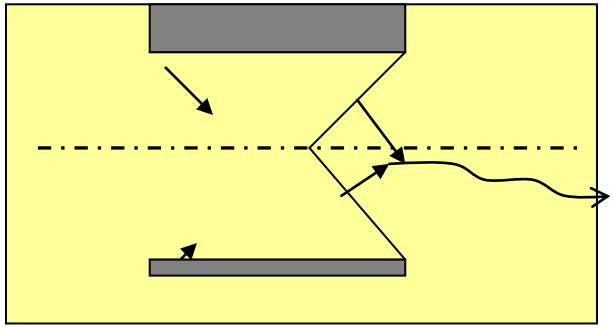
Stratgey for defeating ERA increase jet velocity

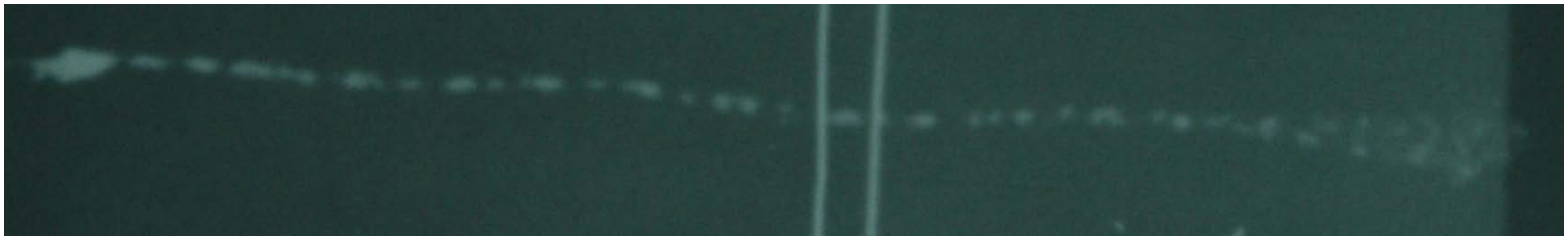


Can anyone dispute the observation that active protection was motivated by finding means for extending the basic effectiveness of ERA!

Continuation of Work Thomanek's Work: Effects of Asymmetry on Shaped Charge Jetting Confinement

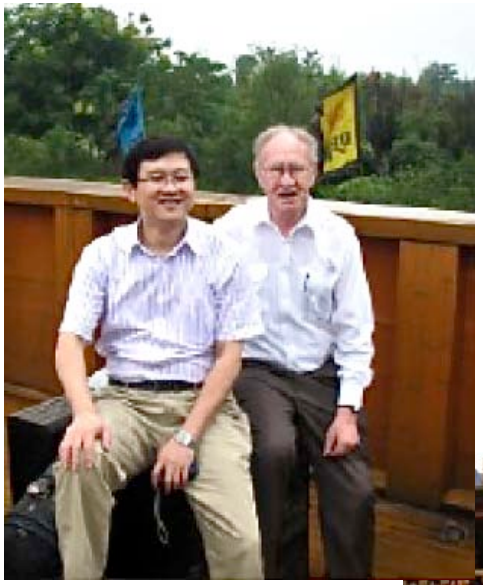






Australia, 2004

Tarragona, 2007



Beijing, 2010

Prof Held during a tour for the 25th ISB Paper Selection Committee

A toast between

- Mr. Ma, Chairman of the China Ordnance Society,
- Prof Dr. Manfred Held, First Ballistics Science Fellow of the society, and
- Mr. Riegel, President of the International Ballistics Society at the 25th ISB Banquet

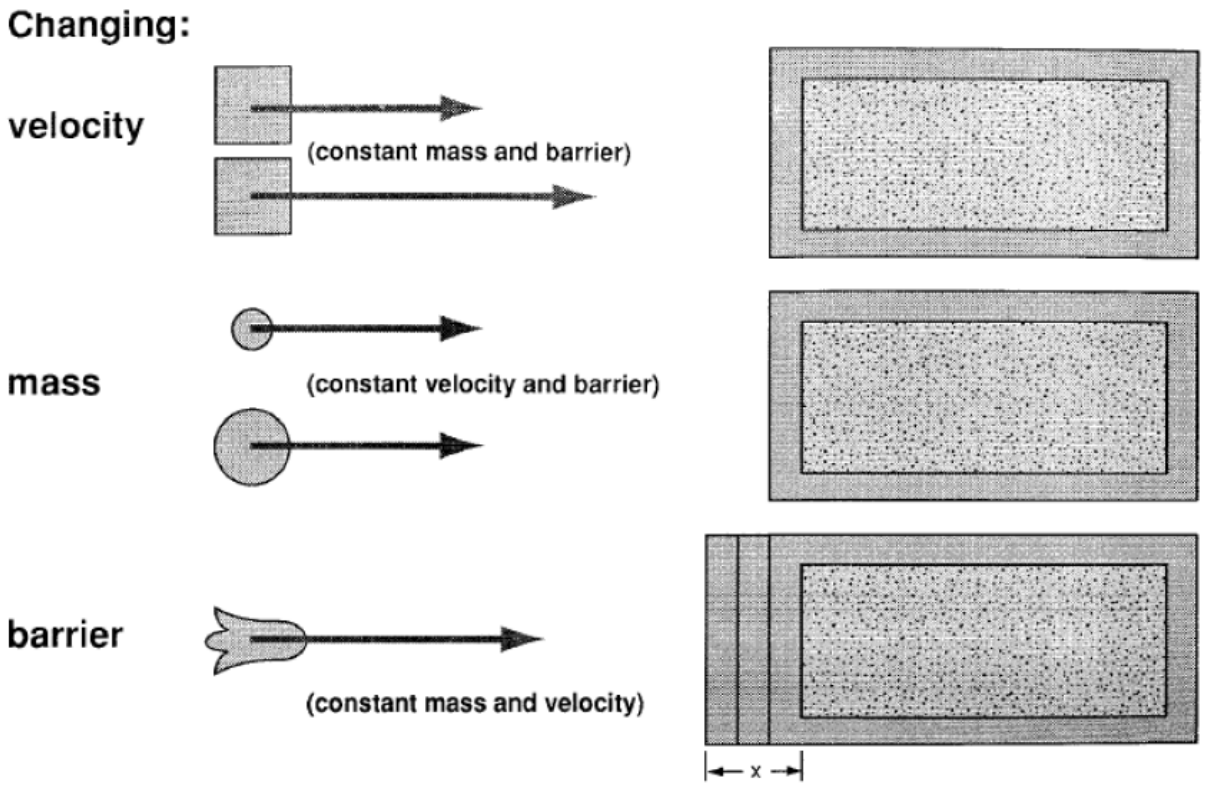
Propellants, Explosives, Pyrotechnics 21, 235–237 (1996)

Initiation Criteria of High Explosives at Different Projectile or Jet Densities

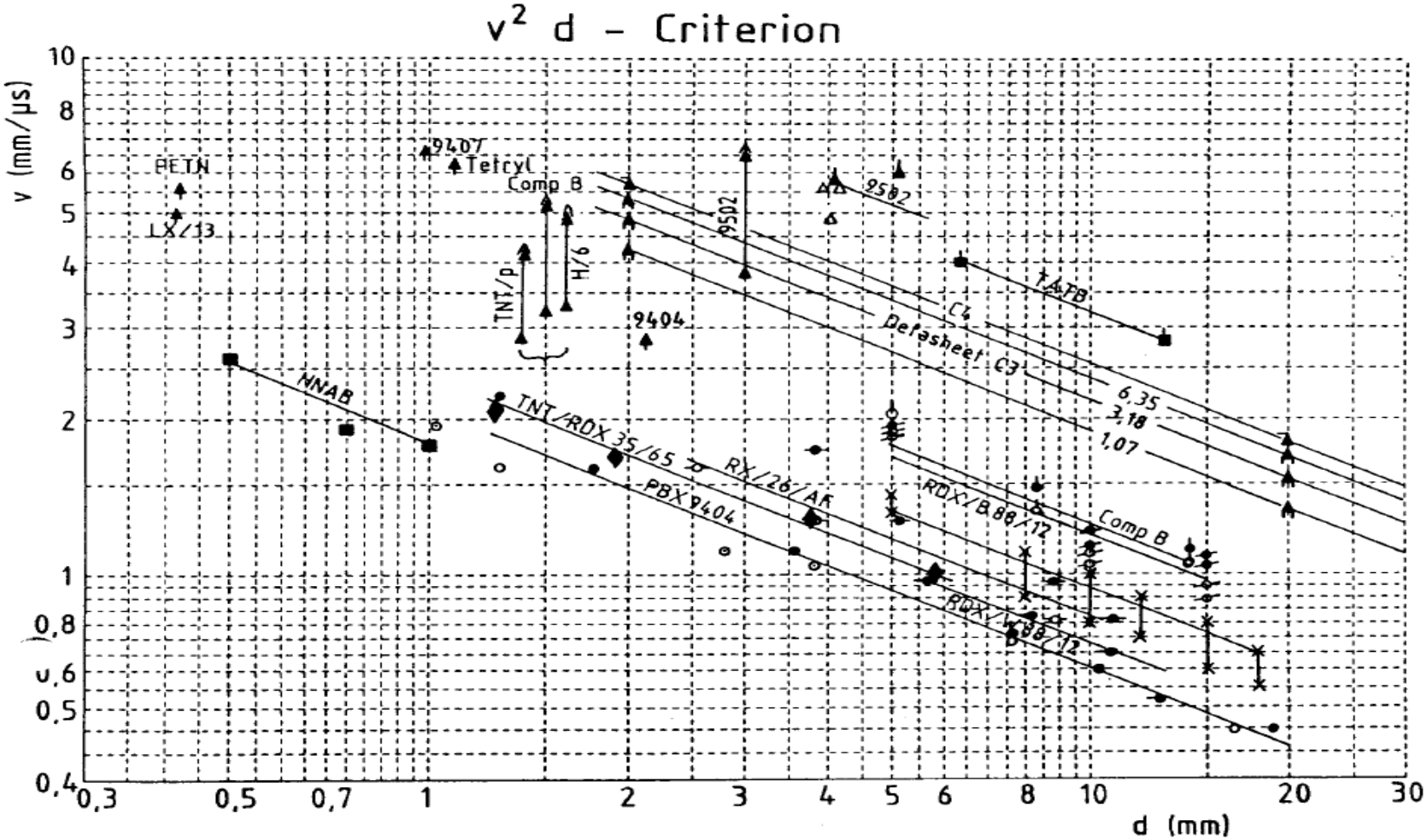
Manfred Held

TDW Gesellschaft für verteidigungstechnische Wirksysteme mbH, D-86523 Schrobenhausen (Germany)

Impact Initiation Investigation



Postulated Sensitivities



□ ○ *etc., no initiation,* ■ ● *etc., initiation*

Nature of the Problem

Explosive	Scientists	Experimental conditions (steel projectile)	Projectile diameters tested (mm)	Held values of v^2d ($mm^3/\mu s^2$)	Our Estimate ($mm^3/\mu s^2$)
PBX9404 (1.84 g/cm^3)	Weingart, [026]	Flat nosed projectiles	2 - 12		3.9 - 4.5
	Moulard [027]	Small cylindrical projectiles	2 - 8	4	4 - 5.5
	LeRoy Green [028]	Long cylindrical tool projectile	2 - 12		4.5 - 8.5
	James [029]	Flat nosed projectiles	2 - 12		3 - 4.5
Comp. B (35/65) (1.73 g/cm^3)	Moulard [027]	Small cylindrical projectiles	6 - 12	16	13 - 19.5
Comp. B-3 (60/40) (1.70 g/cm^3)	LeRoy Green [028]	Flat nosed projectiles	4 - 12		14.5 - 16
TNT (cast) (1.59 g/cm^3)	Zoellner [030]	0.25 mm thick flyer	13 - 17		325 - 425
Octol7030 (1.81 g/cm^3)	Zoellner [030]	0.25 mm thick flyer	3 - 8		44 - 83
TATB (1.80 g/cm^3)	Weingart [026]	0.25 mm thick flyer	6 - 12	108	87 - 96

New criteria “Pd” takes takes into account Hugoniot characteristics.

A Legacy to be continued!

12 April 2010 was the 50th anniversary of Manfred Held's association with the ordnance establishment in Schrobenhausen (formerly MBB). He was duly honored for his accomplishments, which extended from his contributions to the sciences of detonation to airbag development, and for his numerous publications and patents.

Prof. Dr. Manfred Held – 50 Jahre im Dienste des Unternehmens und der Wissenschaft

Anlässlich der 50-jährigen Firmenzugehörigkeit von Prof. Dr. Manfred Held würdigte Dr. Helmut Muthig am 12. April 2010 in Schrobenhausen das Lebenswerk von Prof. Dr. Held.

„Der Standort Schrobenhausen ist, unabhängig davon, wie die jeweils hier aktiven Firmen geheißen haben, untrennbar mit dem Namen Prof. Dr. Manfred Held verbunden", sagte Dr. Muthig bevor er einige Stationen der langen Karriere von Prof. Dr. Held aufzählte. Diese reichten von der Kurzzeit-Messtechnik über neuartige Gefechtsköpfe bis hin zum Airbag-Auslösesensor.

Prof. Dr. Held meldete in seinem Berufsleben mehr als 140 Patente an. 1986 erhielt er die Diesel-Medaille für seine zahlreichen Erfindungen und Patente in der Detonik und seine Leistungen in der Forschung und Entwicklung, die zur Einführung vielfältiger Innovationen in der industriellen Fertigung führten. Bis Ende letzten Jahres hatte Prof. Held 445 wissenschaftliche Beiträge veröffentlicht.

Werner Kaltenegger und Dr. Muthig bedankten sich bei Prof. Dr. Held für das, was er in 50 Jahren für das Unternehmen geleistet hat, und eröffneten eine Ausstellung über sein Lebenswerk. Die Ausstellung kann noch bis einschließlich 16. April 2010 im Foyer des Gebäudes 201 besichtigt werden.

Ballistics Science Fellow of the International Ballistics Society (IBS)
The first person in this society, receiving an Honorary Lifetime Membership with membership number 001.

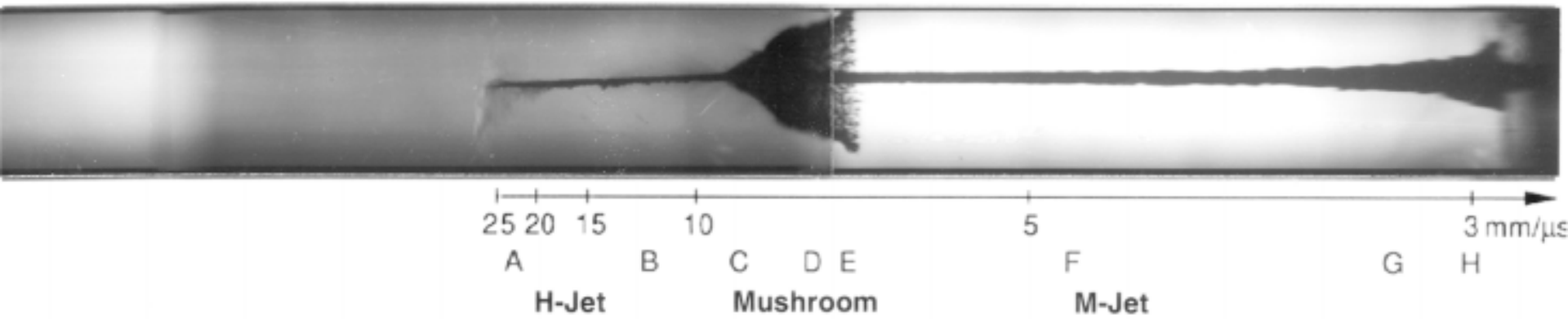
Mr. Jack Riegel, President of the International Ballistics Society presents Professor Held with a plaque to commemorate his being the first IBS Ballistics Science Fellow

SOME OF THE MANY MEMORIES & CONTINUING CHALLENGES

STOP

Photographic challenges

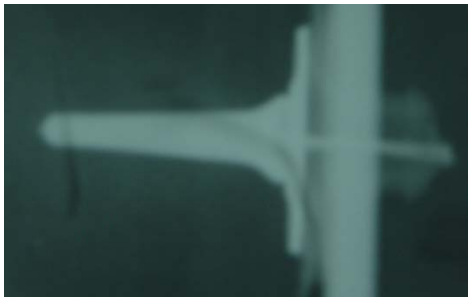
9.9 km/sec jet tip

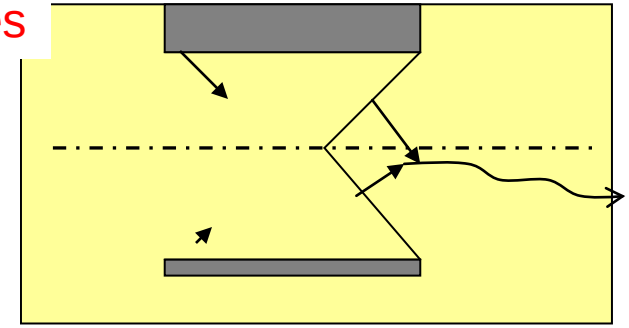


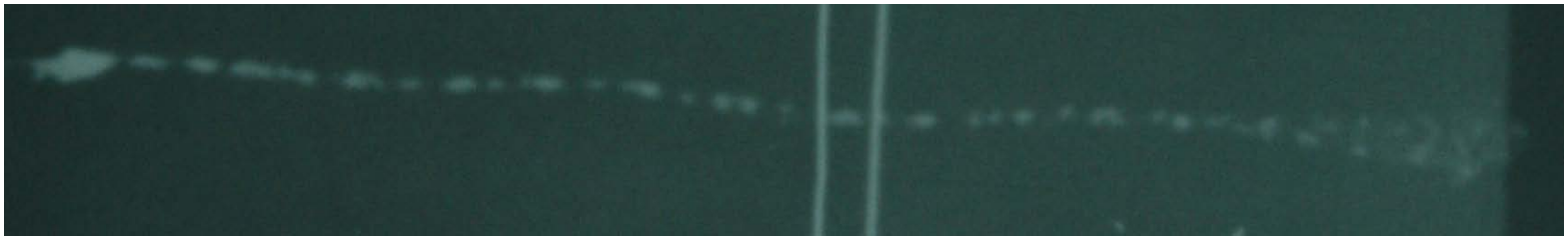
"Diagnostic of Super-fast Jets with 25 km/s Tip Velocities", Propellants, Explosives, Pyrotechnics, 23, 229 (1998)

Continuation of Work Thomanek's Work: Effects of Asymmetry on Shaped Charge Jetting Confinement

Higher pressures and
faster rebounding particle velocities







Manfred Held

1933–2011

On February 8th 2011, Professor Manfred Held passed away from a sudden heart attack.

Professor Bo Janzon Professor Manfred Held

26th International Symposium on Ballistics Paper Selection Meeting
7 December 2010, Miami, Florida

Franz Rudol Thomanek
Founder of MBB-Schrobenhausen

Walter Trinks, Prominent scientist and

•Manfred Held was born in Regensburg on the 28th of September 1933.

•Physics Diploma (Physics) and Doctorate (Physical Chemistry), Technical University of Munich (1959)
•Joined MBB-Schrobenhausen (1960)

•The founder of this establishment, Franz Rudolf Thomanek (1913–1990) worked closely together with Manfred Held and made him his successor.
•Thomanek was connected with Dr. Walter Trinks (1910–1996), German MoD, by their common endeavour of shaped charge weapons.
•Dr. Trinks supported the Schrobenhausen plant, enabling the acquisition of the latest and best technical equipment for high speed diagnostics research.
•Dr. Held and his colleagues further developed the associated electronic equipment, giving rise to a unique research facility.
•The product of this facility is documented in around 500 publications and 150 patents.

The nature of Held the ballistician & scientist

“Flash radiography is an important technique in all fields of ballistic experimentation, with the main emphasis undoubtedly on terminal ballistics . In what follows, we shall not dwell in scientific thoroughness on the fundamentals of flash radiography with all the related theories and details . For such details the reader is referred to an excellent book by Francis Jamet and Gustav Thomer and an article by Francis Charbonnier. 2 Both contain extensive lists of references .

To complement these references, the present contribution will demonstrate, by means of examples, why x-ray flash radiography holds such a preeminent position in the entire field of ballistics and particularly, in high-explosive warheads.”

- Dr. Held undertook many kinds of investigations investigations
  - Detonation and retonation
  - Corner turning effects
  - Initiation, initiators and related sensors including those for air-bag applications.
  - Shaped charge warhead systems (Milan, Hot, Kormoran, Roland)
  - Dispenser munitions
  - Explosively Formed Projectiles (EFPs)
  - Fragmenting warheads (including directional effects)
  - Invented reactive armour in 1970, which was later used by Israel and Russia.
  - Blast: developed the “momentum method” for determining and characterizing blast effects. Strongly involved with with this subject during his latter years.

Initiation Sensitivities

Type of HE	v^2d in $mm^3/\mu s^2$	Reference
HNAB	3	Hasman
PBX 9404	4	Bahl
RDX/Wax 88/12	5	Griffiths
TNT/RDX 35/65	6	Held
PETN 1.77	13	Vigil
Comp B	16	Chick, Moulard
H6	16.5	Chick
Detasheet	36-53	Weickert
C3 9407	40	Vigil
Tetryl	44	Vigil
C4	64	Weickert
TATB	108	Weingart
9502	128	Campell

3 - 8.5

13 - 19.5

international ballistics
MIAMI, USA

Material Location

STEEL 1006

PBX9404JU3

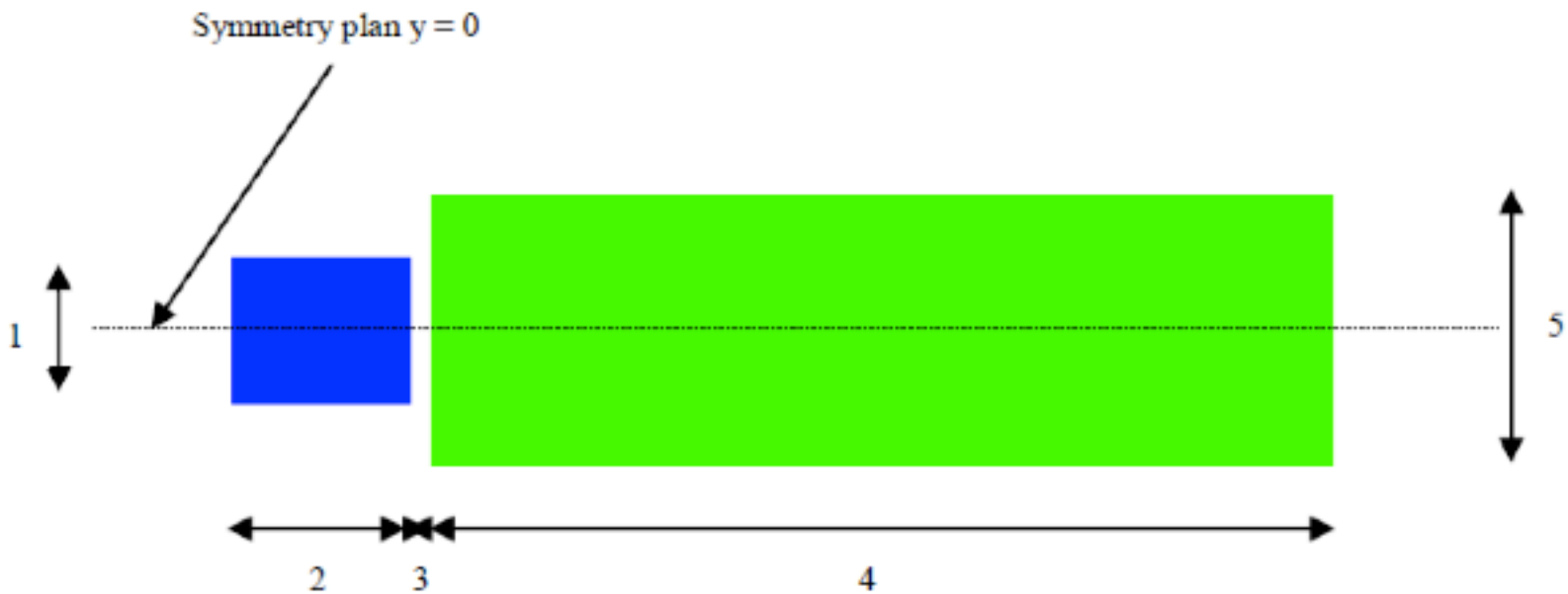
1 Projectile diameter from 2 mm to 12 mm

2 Projectile length of 10 mm

3 Air Gap width of 1 mm

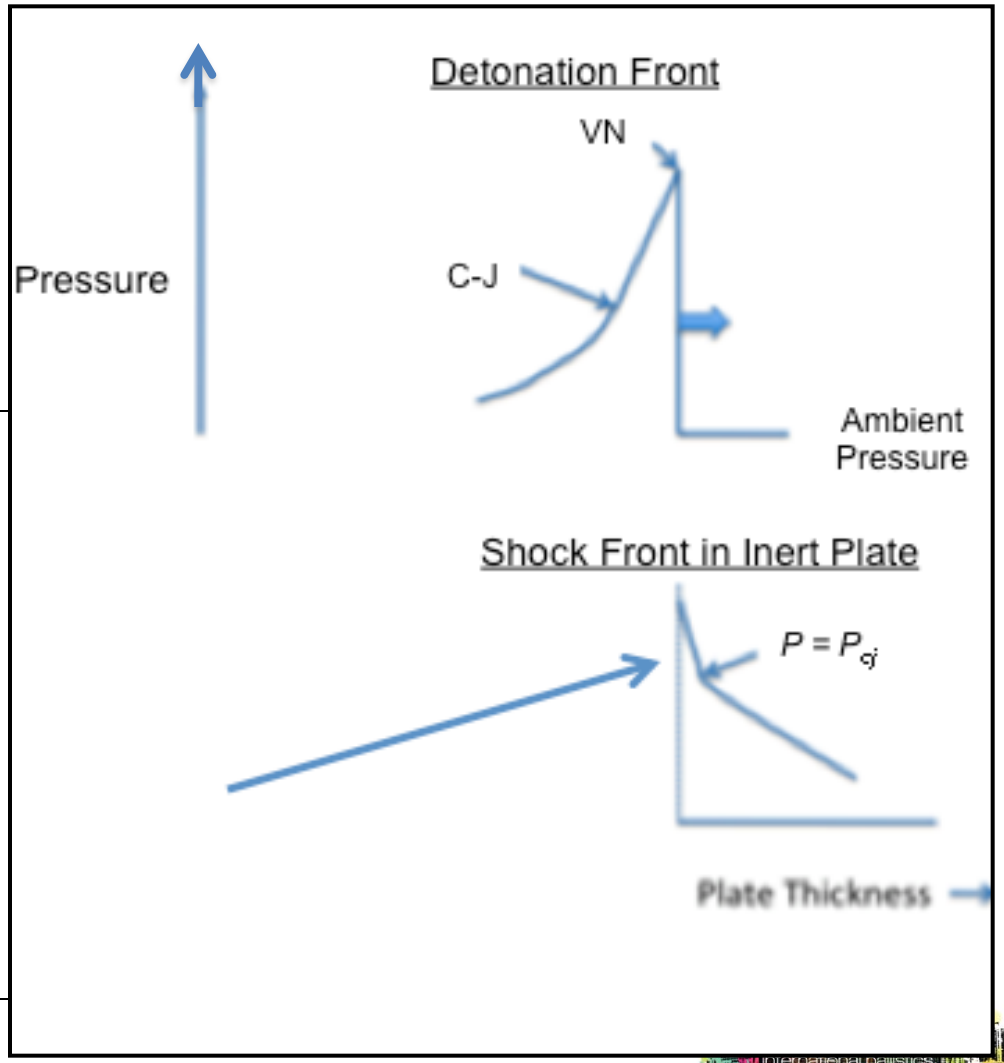
4 Explosive length of 50 mm

5 Explosive width of 15 mm



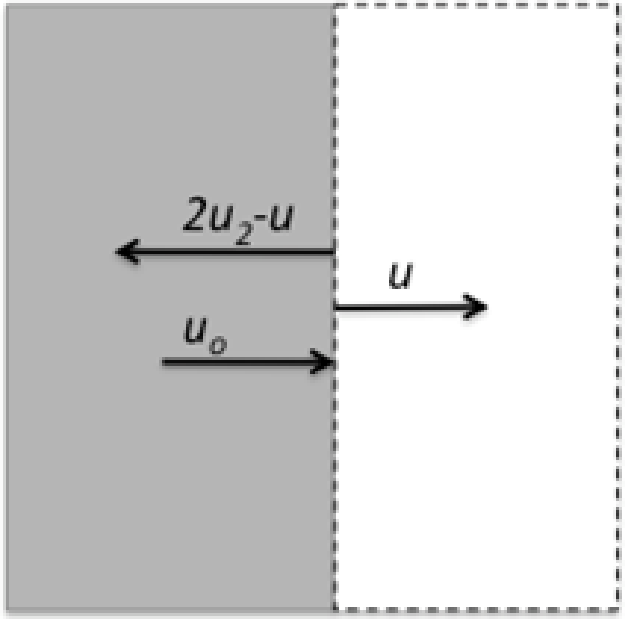
international ballistics
MIAMI, USA

Wave Impingement against a Plate



When a wave impinges upon an inert material in contact with the explosive, the wave transmitted is a shock followed closely by a steep rarefaction which is in turn followed by a more gradual rarefaction.
As this wave travels thru the material, the steep rarefaction overtakes and destroys that portion of the wave corresponding to the von

Review

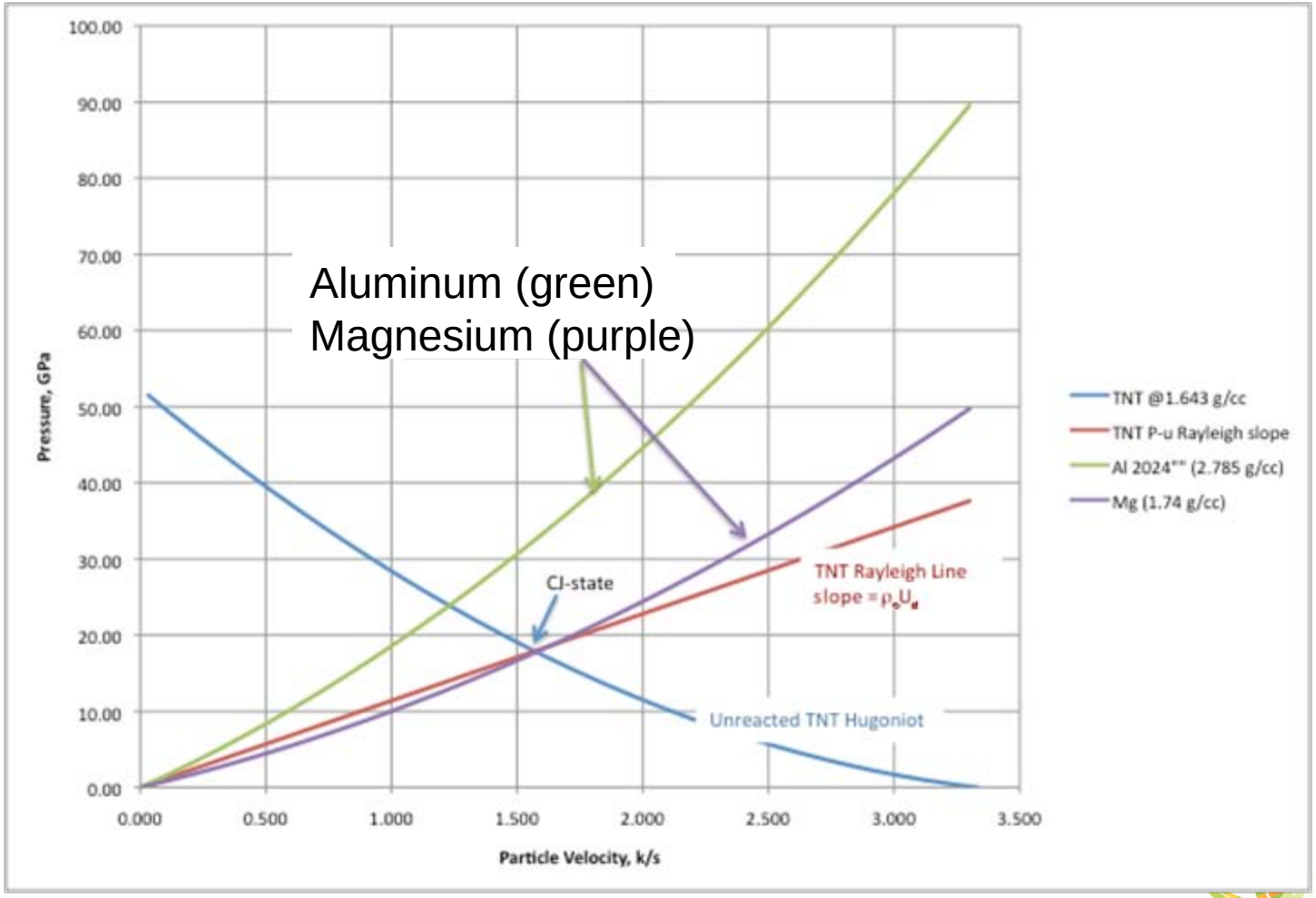


Zero

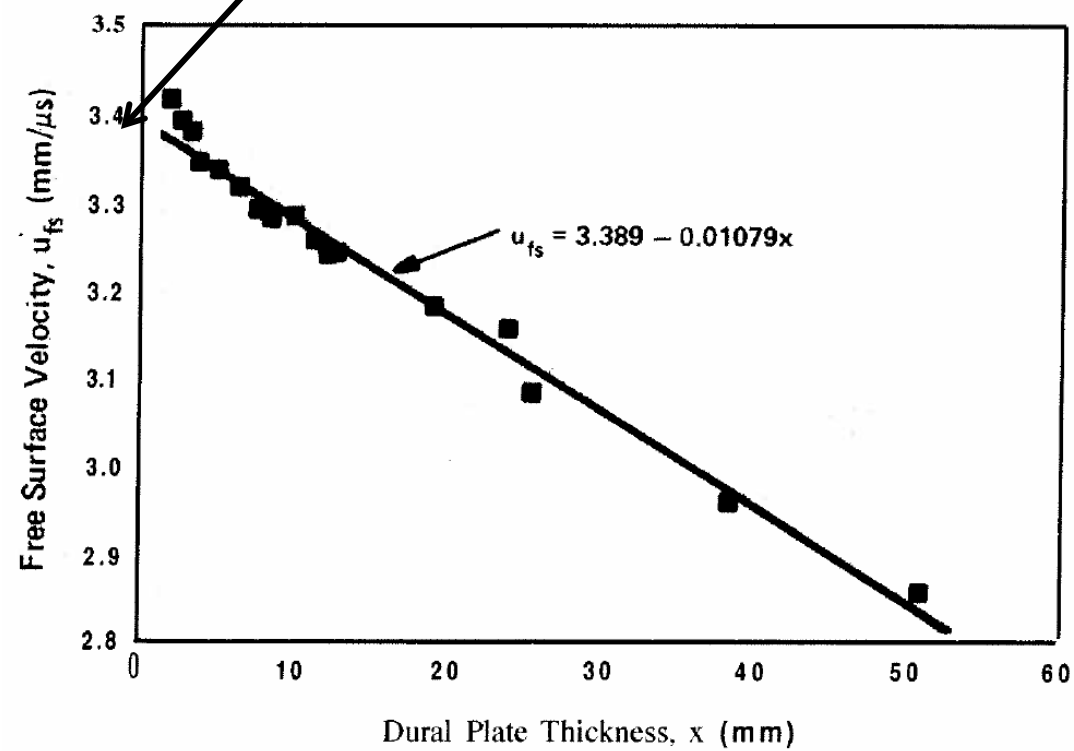
$$\rho_m\left[c_{mo}(u-2u_o)+s_m(u-2u_o)^2\right]=\rho_{air}\left[c_{air,o}u+s_{air}u^2\right]\cong 0$$

$$u=2u_o$$

Effect of the Free-Surface Material Shock Response

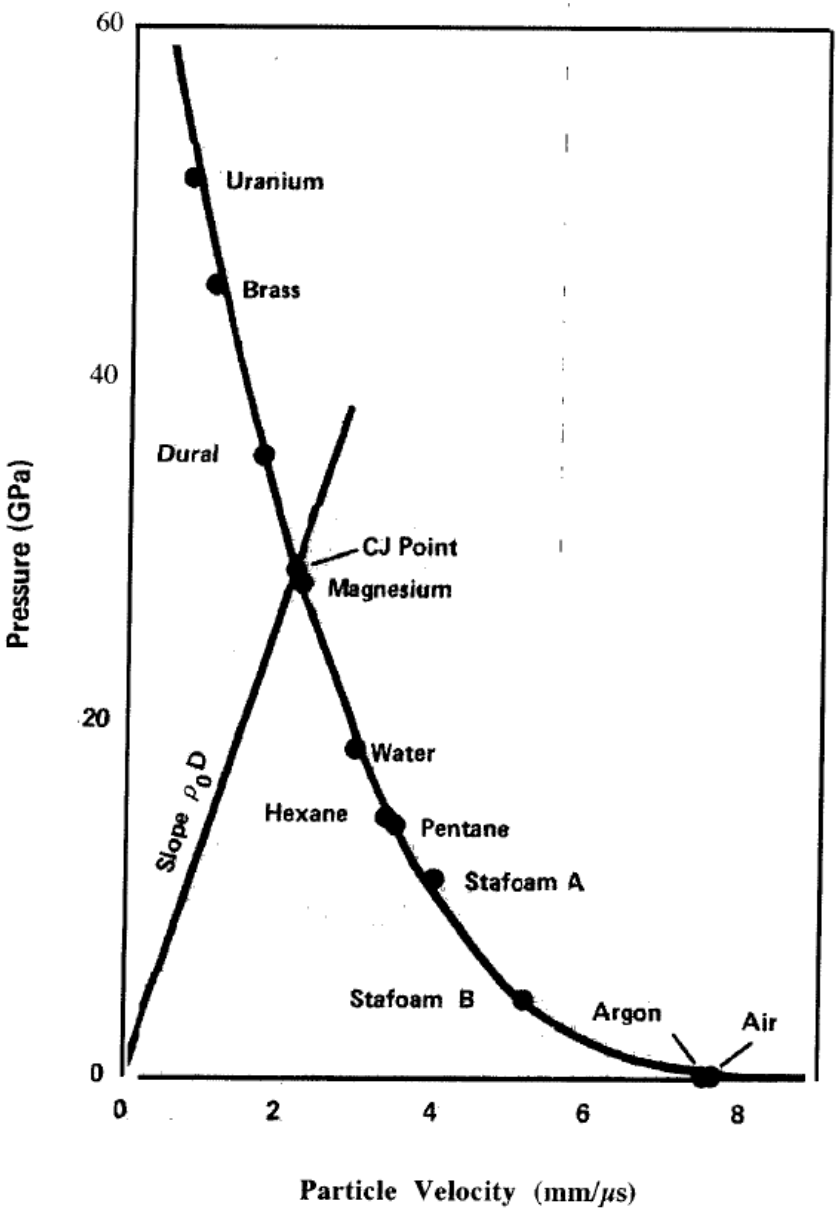


“Remnants” from the Von-Neumann spike.



Estimated free-surface velocity imparted to 24ST aluminum plates by Composition B detonation. The line is the linear least square fit to the data. The intercept with the ordinate corresponds to the free-surface velocity of a zero-thickness plate.

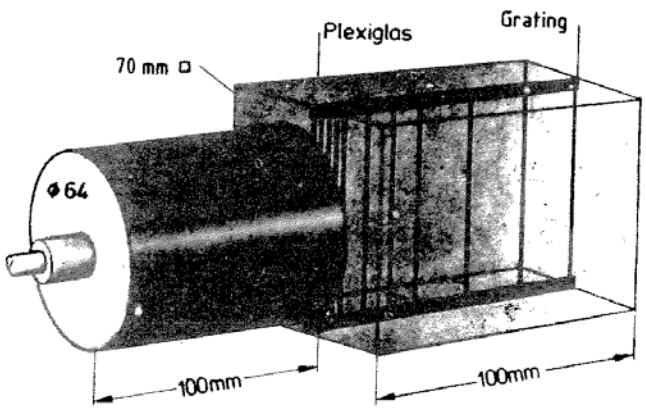
From Deal, W.E., “The Measurement of Chapman-Jouguet Pressure for Explosives” , 1st International Symposium on Detonation, 327-342 (1955)

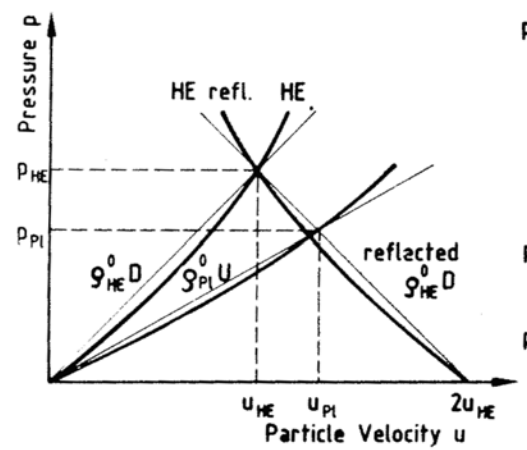


Pressure and particle velocity obtained from zero-thickness free-surface velocity measurements from various materials at the surface of Composition B detonation.

<u>The CJ point must lie on the Rayleigh lined from the measured detonation velocity</u>

Held's Use of Polymethacrylate Reduces Number of Tests





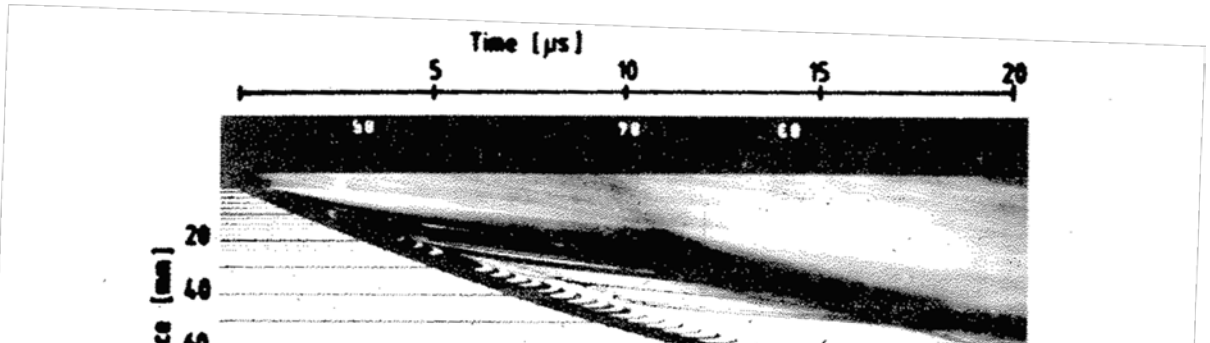
$$p_{Pl} = \rho^0_{HE} D\,(2u_{HE} - u_{Pl})$$

$$p_{HE} = \rho^0_{HE} D \cdot u_{HE}$$

$$p_{Pl} = \rho^0_{Pl} U \cdot u_{Pl}$$

$$p_{Pl} = \rho^0_{HE} D\,(2p_{HE}/\rho_{HE} D - p_{Pl}/\rho^0_{Pl} U)$$

$$p_{HE} = \frac{p_{Pl}}{2}\left(1 + \frac{\rho^0_{HE} D}{\rho^0_{Pl} U}\right)$$



Contributor : Bettina Pinegger
Last changed : 18/02/2011

Professor Dr. Manfred Held passed away

18/02/2011

On 8 February, Professor Dr. Manfred Held passed away at the age of 77. For over 50 years, he worked for MBDA Germany and its predecessors. His name and his work are indelibly linked with the history of our Schrobenhausen site.

The physicist worked on warheads for the Milan, HOT, Kormoran and Roland missile systems and on many other projects.

He invented the so-called "reactive" armour in 1969. Another of his successes was the tandem shaped-charge warhead in 1974.

Professor Held was internationally renowned for his research in the field of high-speed diagnostics, explosive reactive armour and tandem shaped-charge warheads.

He also taught at numerous institutes of higher learning, such as the Bundeswehr University at Neubiberg near Munich and the Cranfield University in Shrivenham.

During his career, Professor Held registered over 140 patents and published more than 500 scientific articles.

He was also named an honorary member of the well-known International Ballistics Society (IBS). China's Nanchang University awarded him the title of Honorary Professor in recognition of his achievements. In 1986, he received the Diesel Medal from the German Institute for Invention (DIE).

Jacquet

Current Headlines

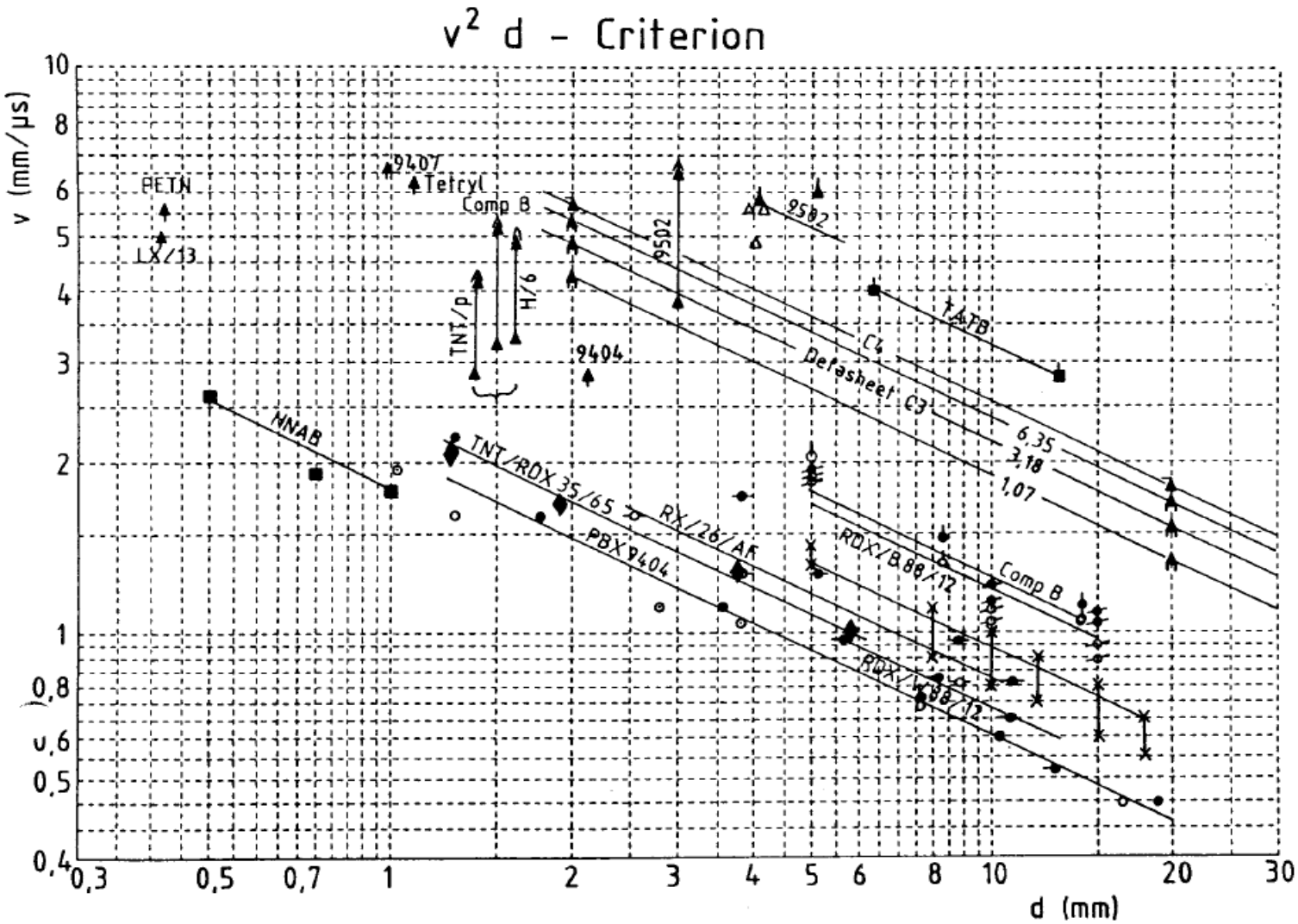
Professor Dr. Manfred Held passed away

Defence analysis - February

MBDA Employee Opinion Survey

international ballistics
MIAMI, USA

A Look at Held's Initiation Criteria



□ ○ *etc., no initiation,* ■ ● *etc., initiation*

Guidance and expertise for National and International Authorities and Bodies.

•Editorial Board of this journal, the Chinese Journal of Energetic Materials (Henning Cailiao)
•Scientific Committee of the International Seminars NTREM at the Faculty of
•Chemical Technology, University of Pardubice, Czechia,
•Board of Trustees of the Fraunhofer Institute for Chemical Technology (ICT), Germany.

Lecturer
•University of the Federal Armed Forces, Munich
•Carl-Cranz educational seminars and courses
•Institute of Chemical Materials, CAEP., Beijing
•German Physical Society
•Presented at every International Annual Conference of the Fraunhofer ICT since 1970

Outstanding honours
•Diesel-Medal in Silver for his significant number of patents
•Professor h.c. by the University Nanking, China