Historical Overview of Aerial Gunnery Ammunition Development 1913 - 2022

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Dedication:

Dale M. Davis

Director

USAF Munitions Division

(1928 – 1988)

AFATL-TR-84-03

Historical Development Summary of Automatic Cannon Caliber Ammunition: 20-30 Millimeter

Dale M Davis
MUNITIONS DIVISION

JANUARY 1984

FINAL REPORT FOR PERIOD: 1952 - 1983

Approved for public release; distribution unlimited

Air Force Armament Laboratory
AIR FORCE SYSTEMS COMMAND★UNITED STATES AIR FORCE★EGLIN AIR FORCE BASE, FLORIDA

Structure:

i. *Preparation & First Engagements… 1913*

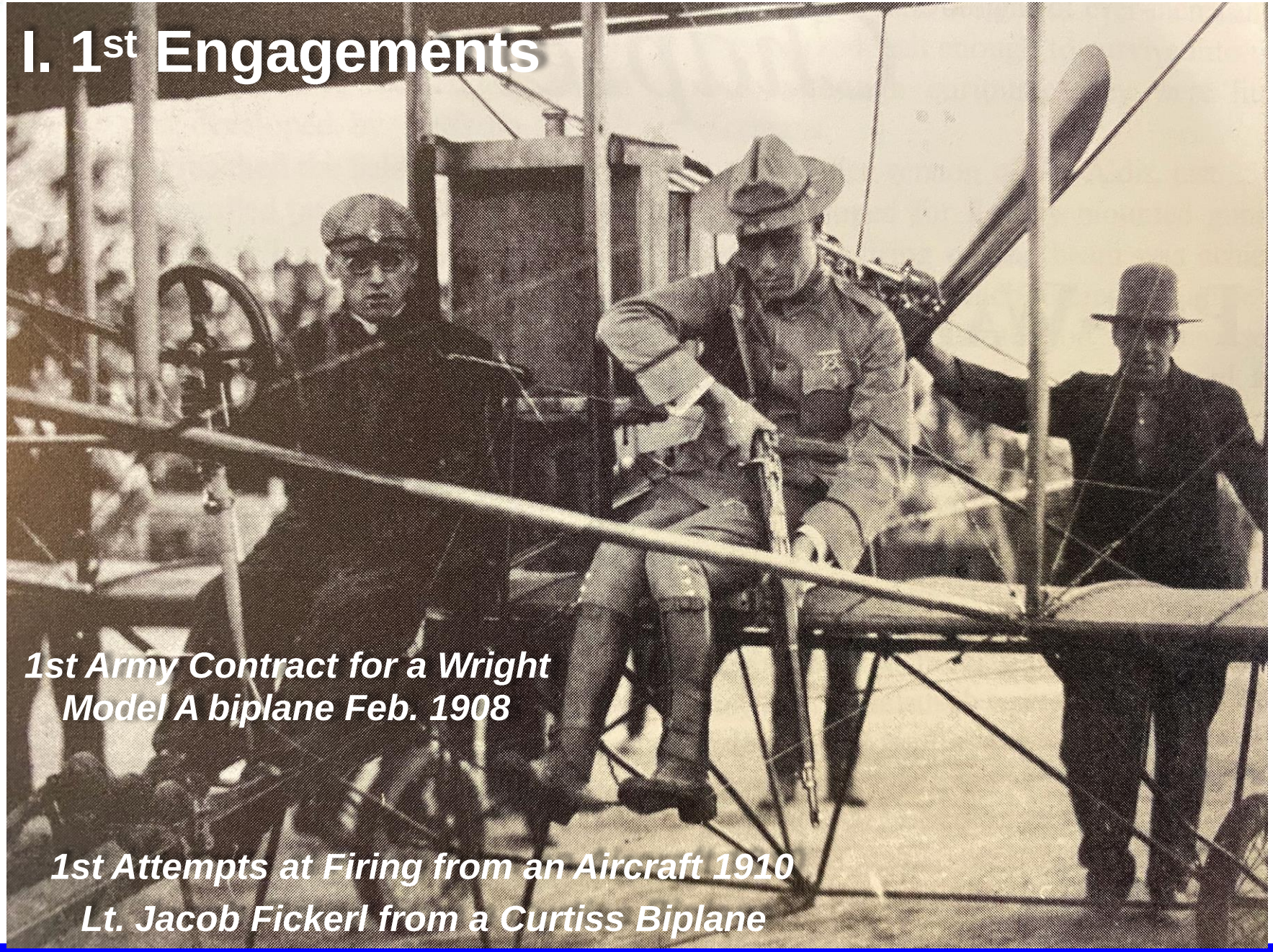
ii. *Aerial Gunnery Ammo Evolution - WWars*

iii. *Combat at 40kft, Mach 0.8…*

iv. *USAF Efforts to Design Advanced Flight-Safe Discarding Sabot Munitions*

v. *Ballistic Aeromechanically Stable Sabot (BASS) Rounds*

I. 1st Engagements



1st Army Contract for a Wright Model A biplane Feb. 1908

1st Attempts at Firing from an Aircraft 1910
Lt. Jacob Fickerl from a Curtiss Biplane

I. 1st Engagements

1st Airborne Machine Gun
(Lewis 0.303 Gun)
Wright Brothers Biplane 1912
Capt. C. Chandler (L)
Lt. R. Kirtland (R)

I. 1st Engagements

1st Aerial Battle
November 1913

Dean Ivan Lamb & Phil Rader
Soldiers of Fortune
Naco, Sonora & Naco, Arizona

I. 1st Engagements

THE INCURABLE FILIBUSTER

Adventures of COLONEL DEAN IVAN LAMB

Illustrated by PAUL BROWN

FARRAR & RINEHART
INCORPORATED
PUBLISHERS NEW YORK

1st Air-to-Air Gun Duel

1st Air-to-Ground Bombing

1st Air Defense Gunnery

1st Air-to-Ground Strafing

I. 1st Engagements

How the Flying
SOLDIERS of FORTUNE
Faked Their
AIR BATTLES

THE war-time aviator gets a lot of thrills, risks his neck innumerable times, and—if he comes out of it alive—has a lot of very exciting stories to tell the folks back home.

But if he happens, in addition, to be a soldier of fortune, fighting in a plane instead of on the ground—

And if, on top of that, he's in the service of a Latin-American country where nobody knows much of anything about aviation—

And if all the aviators on the "enemy" side are his buddies, boon companions in many a carefree revel—

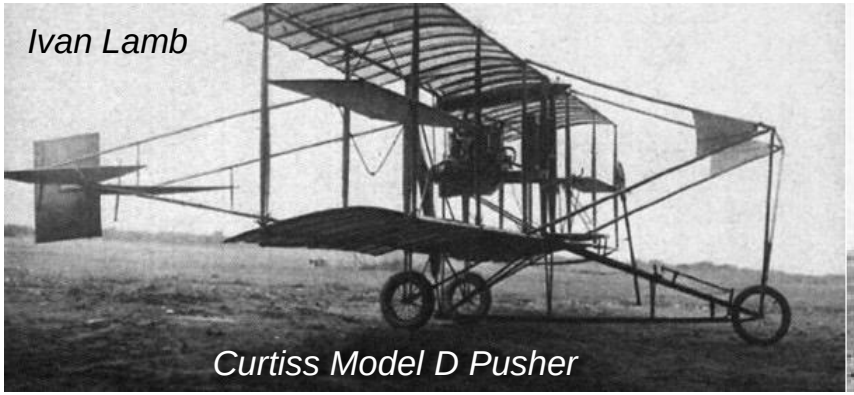
Then the stories he takes back home with him are likely to be highly humorous, as well as exciting.

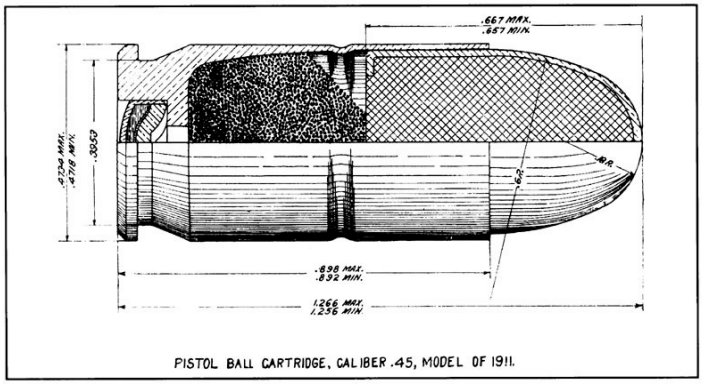
A case in point is that of Col. Dean Ivan Lamb, one of the most experienced of all present-day soldiers of fortune. For Colonel Lamb's experiences include all of the "ifs" mentioned above, and they make very amusing reading.

16 of 22

I. 1st Engagements

1st Gun Duel





The drawing above, from a 1918 "Manual of the Automatic Pistol Caliber .45 Model of 1911," illustrates components of the original military .45 ACP loading—a 230-gr. bullet traveling at 855 f.p.s.

Model 1906 .45 Revolver Ball cartridge

US Army Colt 0.45 1909

Image Source https://en.wikipedia.org/wiki/.45_ACP
http://www.cartridgecollector.net/45-colt-m1906

Image Source https://en.wikipedia.org/wiki/M1911_pistol

I. 1st Engagements

1st Air-to-Ground Bombardment from Heavier-than Air Craft

1st Air-Defense Gunnery

Box of Dynamite & Nails

I. 1st Engagements

1st Air-to-Ground Strafing:

US Customs House

Naco, Arizona

I. 1st Engagements

1st Air-to-Ground Strafing:

US Customs House

Naco, Arizona

"Customs people are always irritating." – Dean Ivan Lamb

II. Aerial Gunnery Ammo Evolution - WWI

Problems with the prop... From the start

July 28, 1914...

8mm Hotchkiss M1909 mounted on a Deperdussin Monoplane

1st Aerial Victory 5 October 1914, Joseph Frantz & Louis Quénault a German Aviatik

II. Aerial Gunnery Ammo Evolution - WWI

WWI Machine Gun Cartridges

Fokker Dr.I MG08/15 8mm machine guns

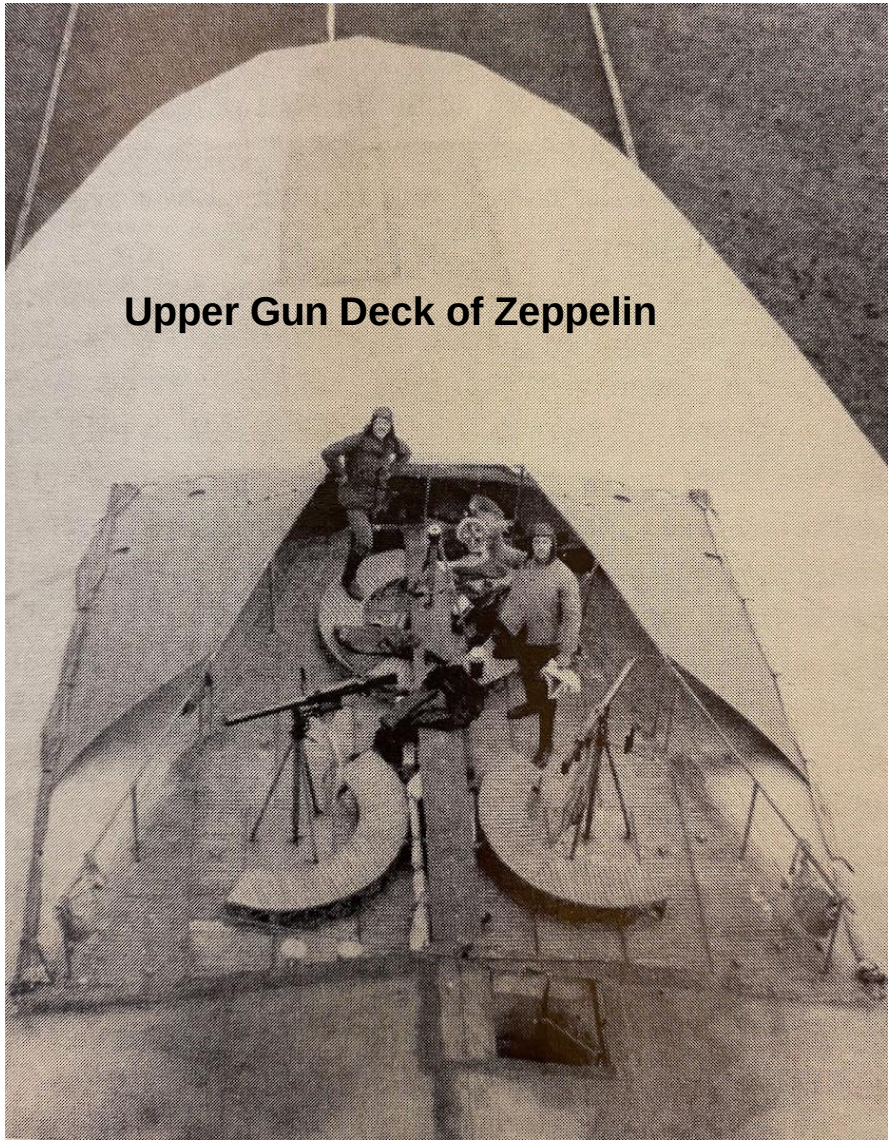
Lewis gun on a Bristol F.2.B. 1917

6.5 – 11mm Cal. Typical of the era

II. Aerial Gunnery Ammo Evolution - WWI

Airships...

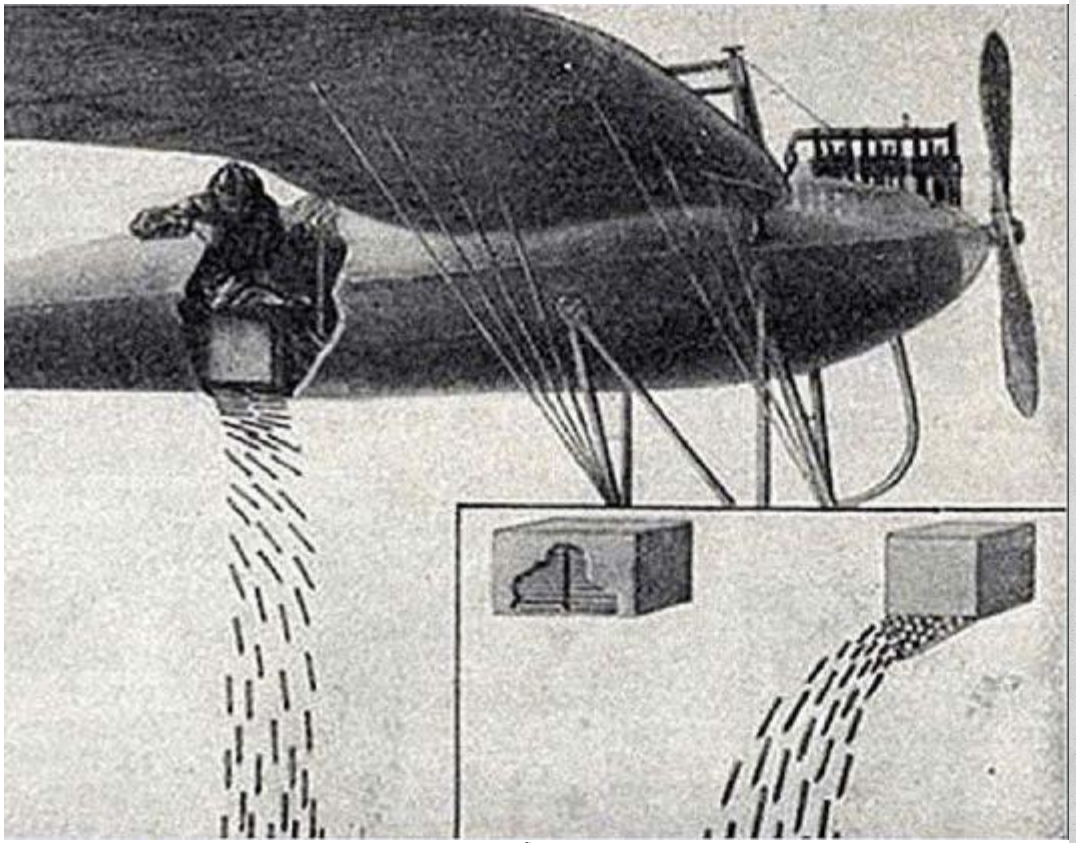
37 x 94 Hotchkiss
Incendiary Projectile



Upper Gun Deck of Zeppelin

II. Aerial Gunnery Ammo Evolution - WWI

Air-to-Ground Projectiles: Gravity Flechettes

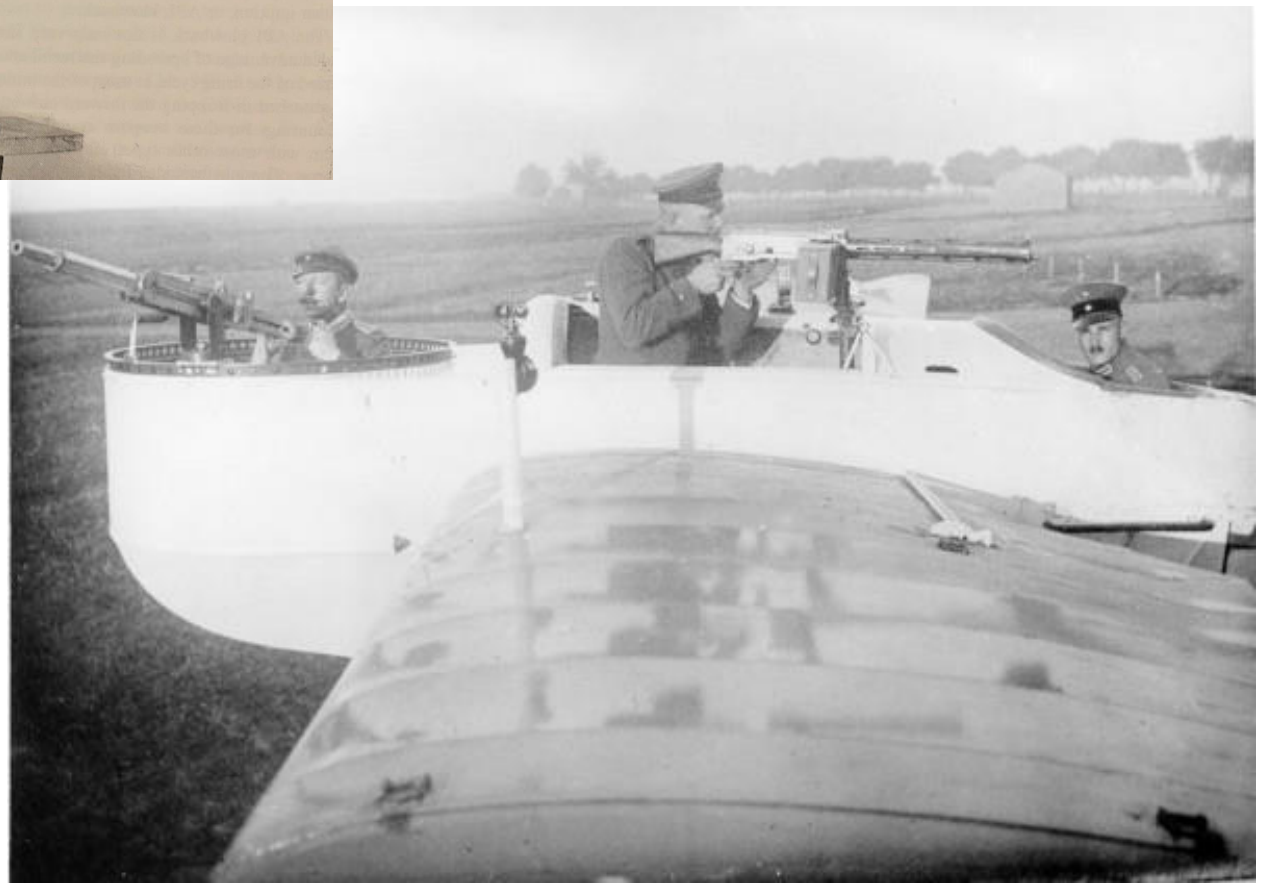


Source gallica.bnf.fr / Bibliothèque nationale de France

II. Aerial Gunnery Ammo Evolution - WWI

20mm Oerlikon (SEMAG) Type L

Cannon in the air

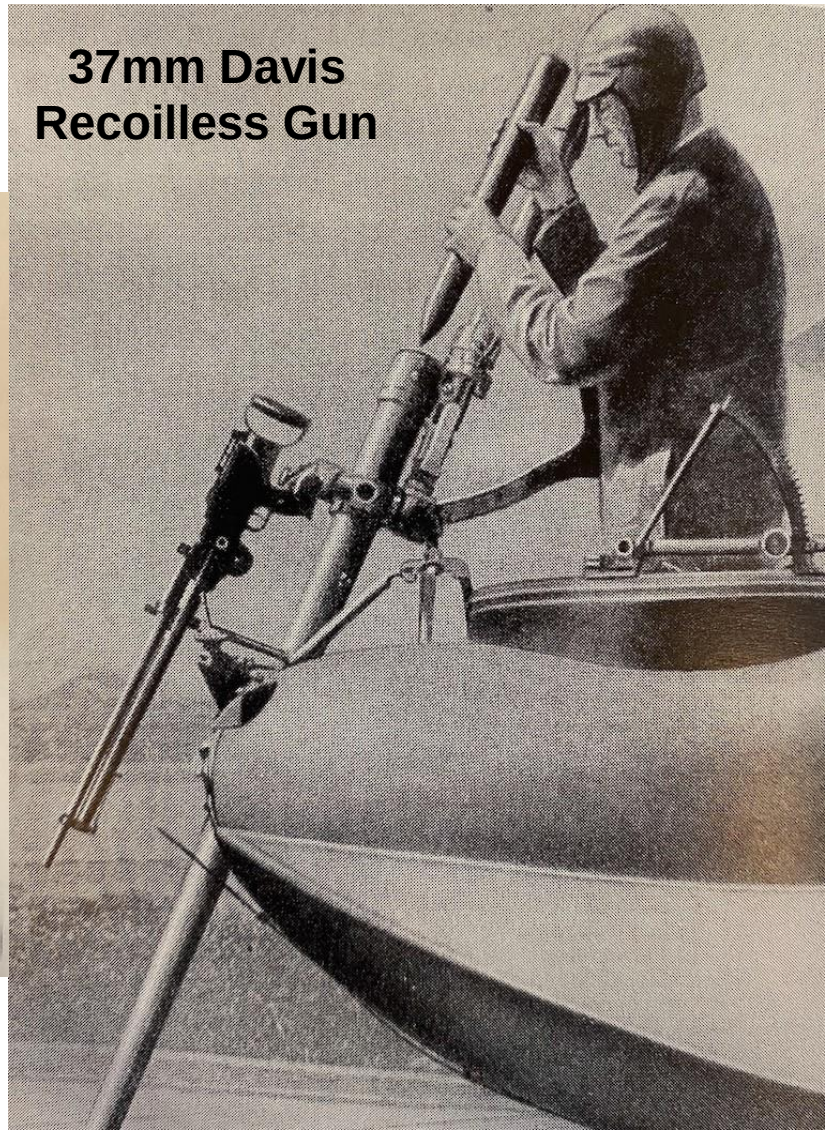


20mm Becker Autocannon in the Front of a Gotha G.1

II. Aerial Gunnery Ammo Evolution - WWI

Cannon in the air

20mm – 37mm WWI Aerial Gunnery Ammunition



II. Aerial Gunnery Ammo Evolution - Interwar

Interwar Aerial Gunnery

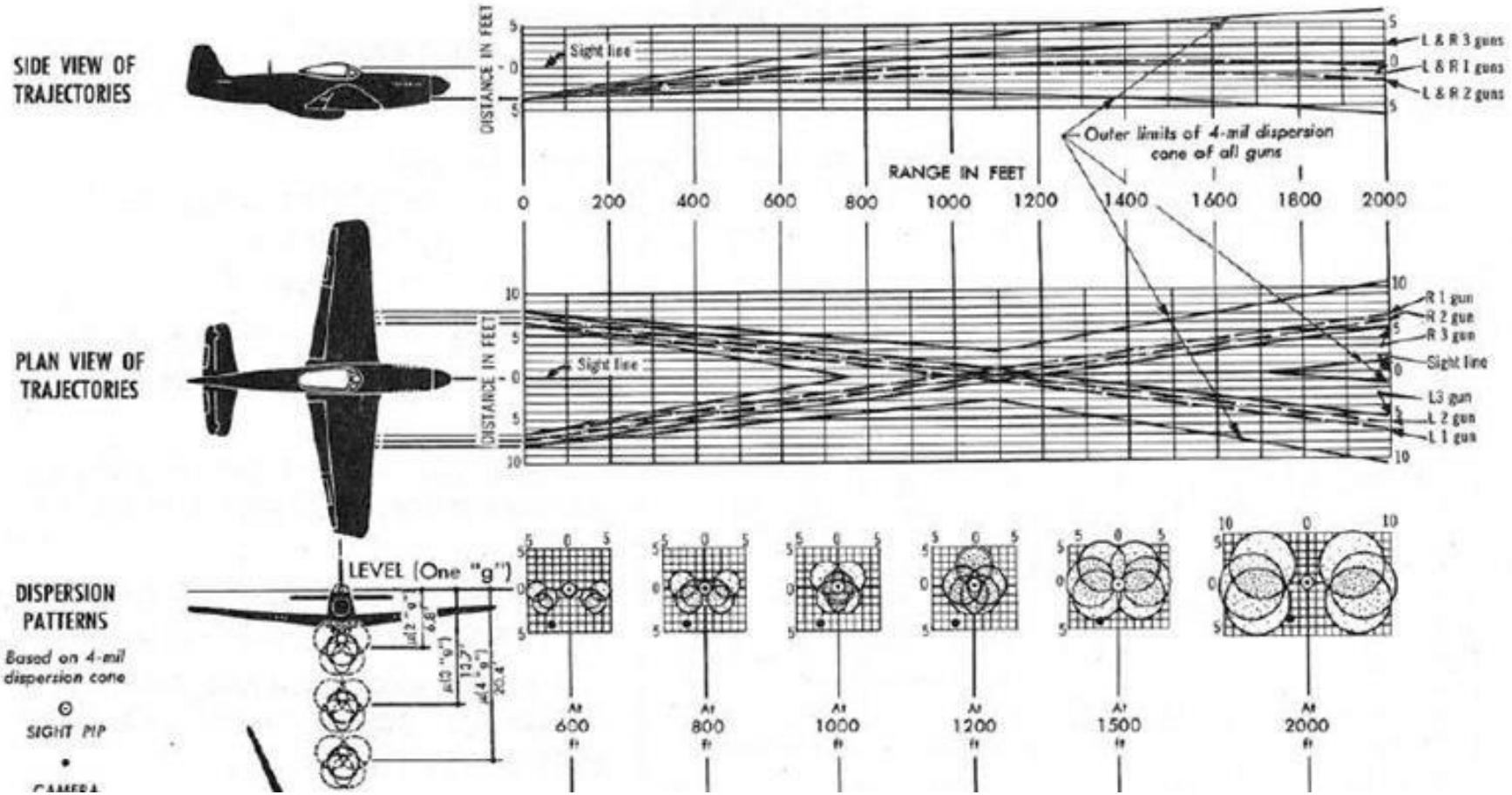
JU-87G-1 with 37mm Cannon (1937 – 1945)

II. Aerial Gunnery Ammo Evolution - Interwar

Bell XFM Airacuda "Heavy Fighter" with 37mm Cannon (1937 – 1945)

II. Aerial Gunnery Ammo Evolution - Interwar

The Convergence Problem

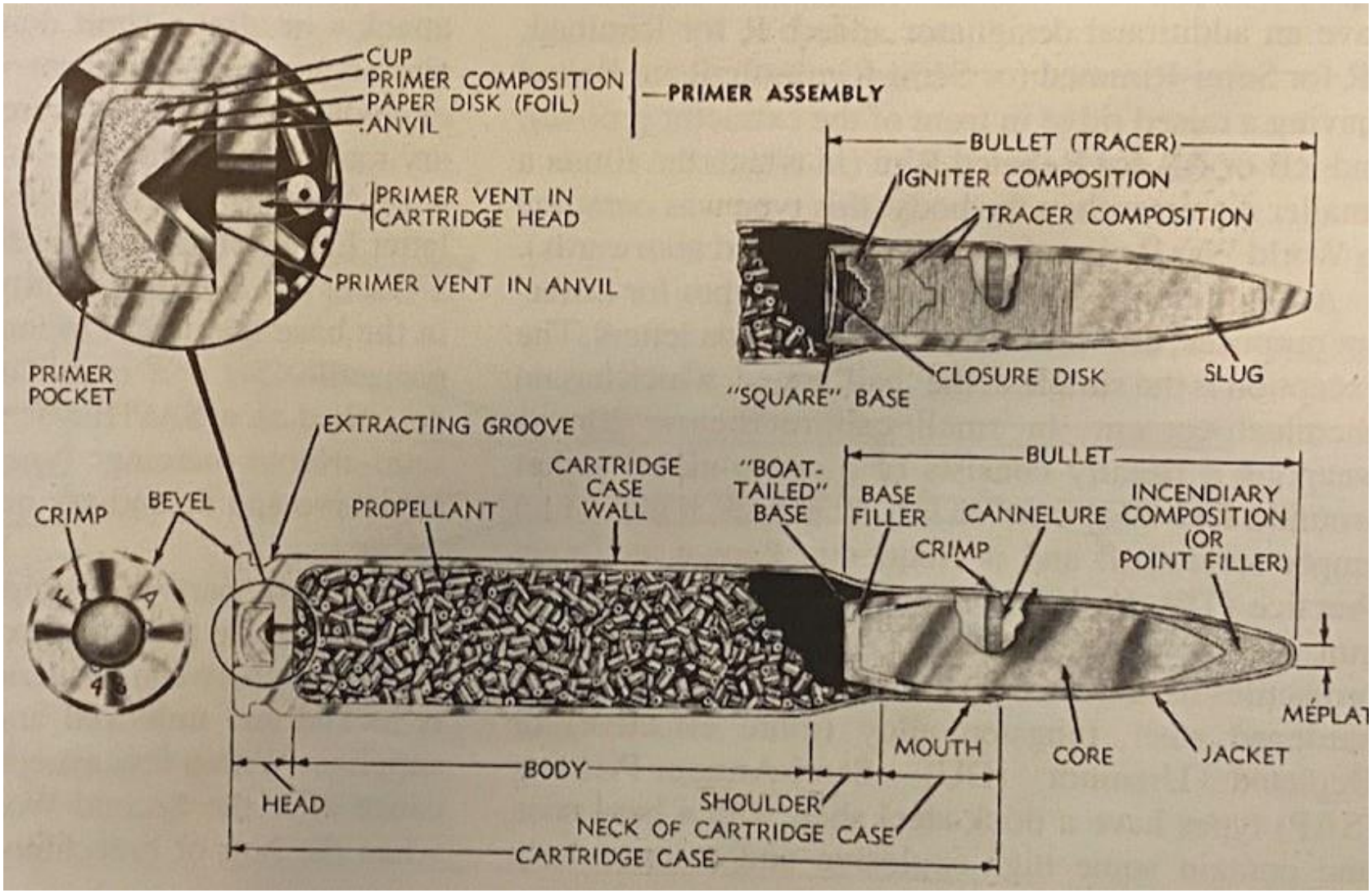


II. Aerial Gunnery Ammo Evolution - WWII

Convergence Problem Eliminated with Centerline Gun Pod (P-38/P-61/Me163/Me262)

7.62mm/0.50 cal/20mm/23mm/37mm

II. Aerial Gunnery Ammo Evolution - WWII



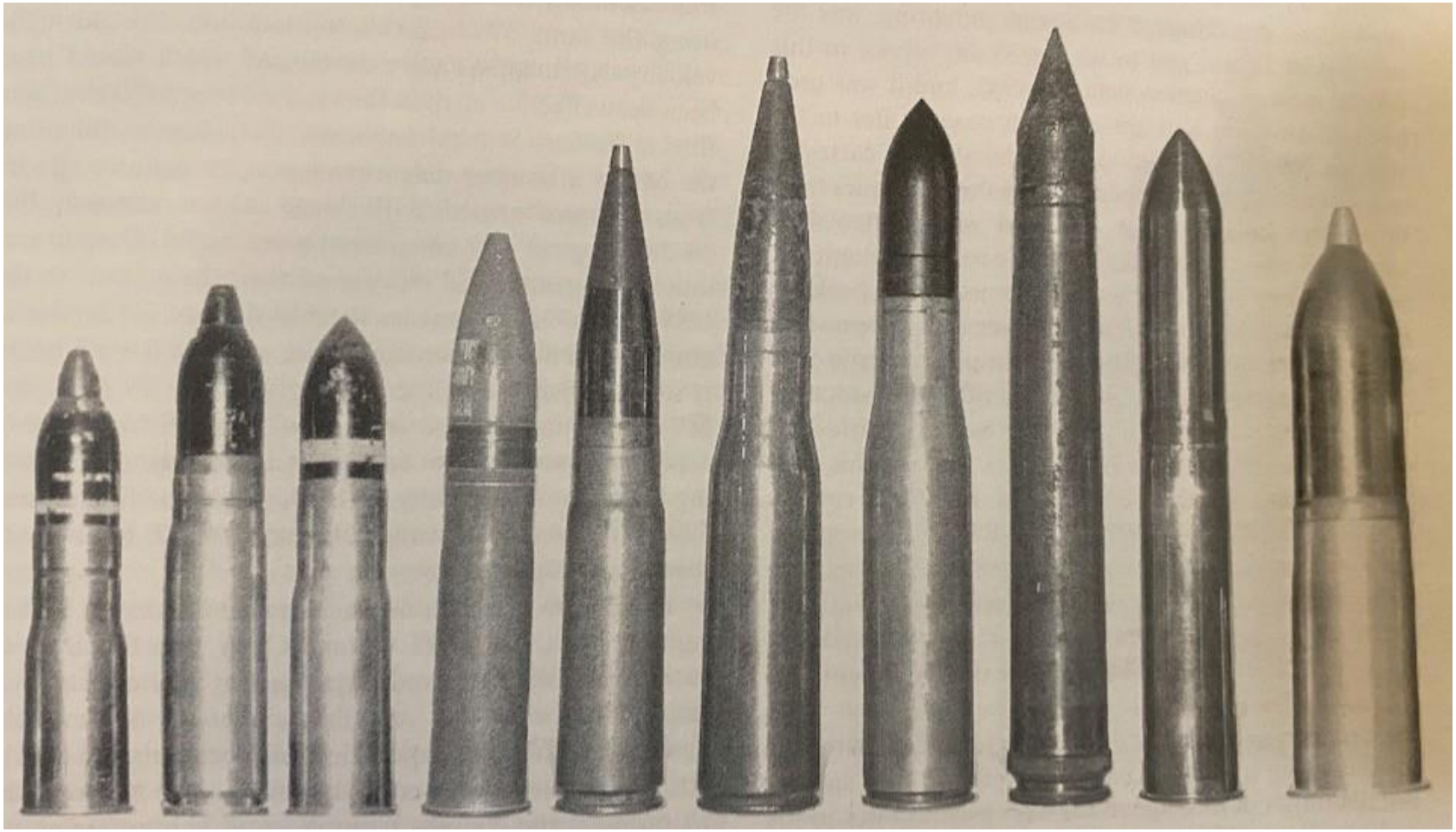
II. Aerial Gunnery Ammo Evolution - WWII

12.7mm Breda Ball, API, APIT, HEIT

II. Aerial Gunnery Ammo Evolution - WWII

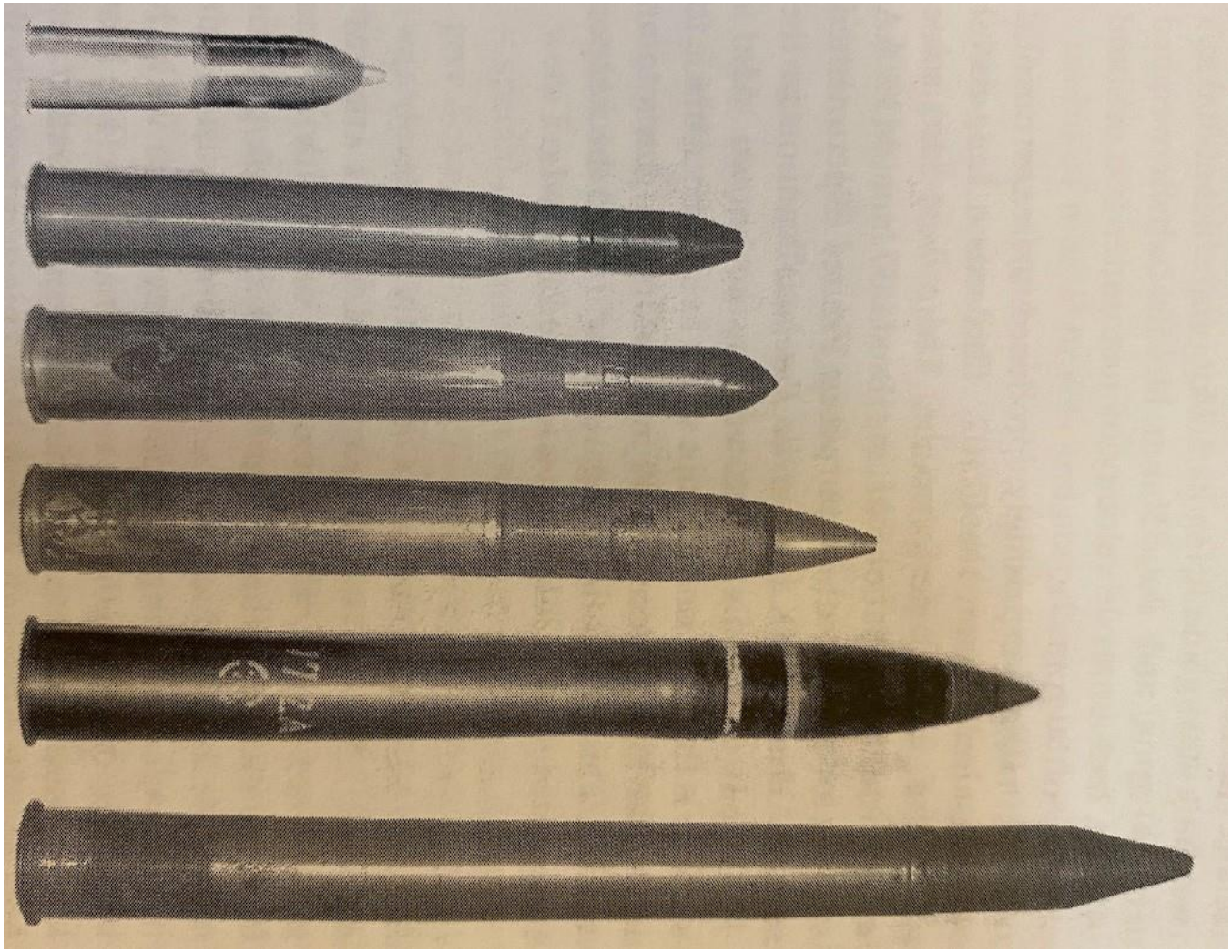
20 – 30mm Cannon Cartridges: 20 x 110 Hispano, 23 x 106 Madsen, 23 x 115 VYa-23, 30x90 Mk 108, 30x184 Mk 103, 30x114 IJA Ho0155, 30x122 IJN Type 5

II. Aerial Gunnery Ammo Evolution - WWII



37 – 40mm IJA Cannon Cartridges

II. Aerial Gunnery Ammo Evolution - WWII



50 – 75mm Cannon Cartridges

57x121 Ho-401, 50x419 BK5, 57x441 6pndr Molins, 75x350 Am.M4/M5/M10, IJA 75x497 Type 88

II. Aerial Gunnery Ammo Evolution - WWII

Eric Hartmann *1404 Combat Missions 352 Victories Bf 109*

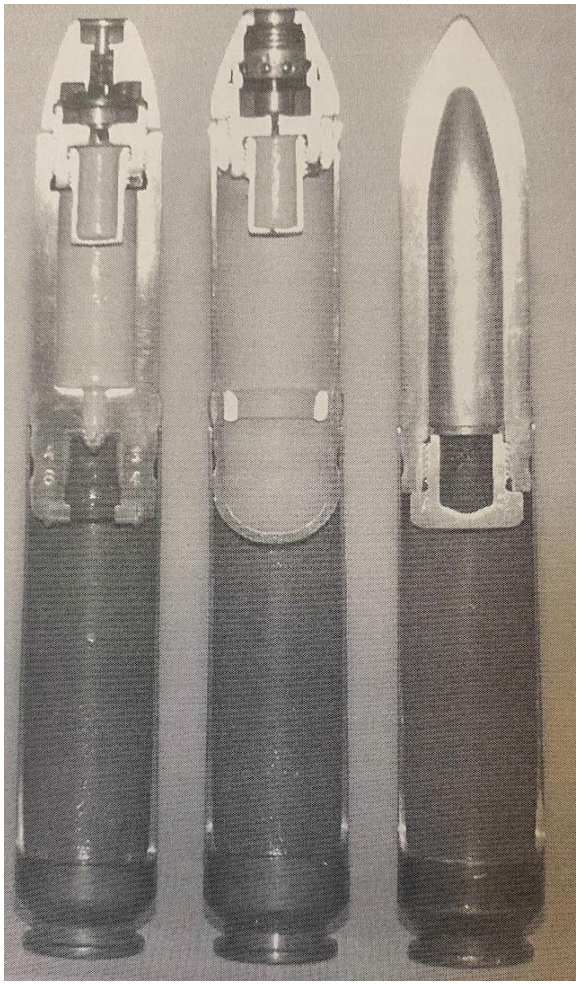
(20mm MG C/30 cannon + 7.92mm machine guns)

II. Aerial Gunnery Ammo Evolution - WWII

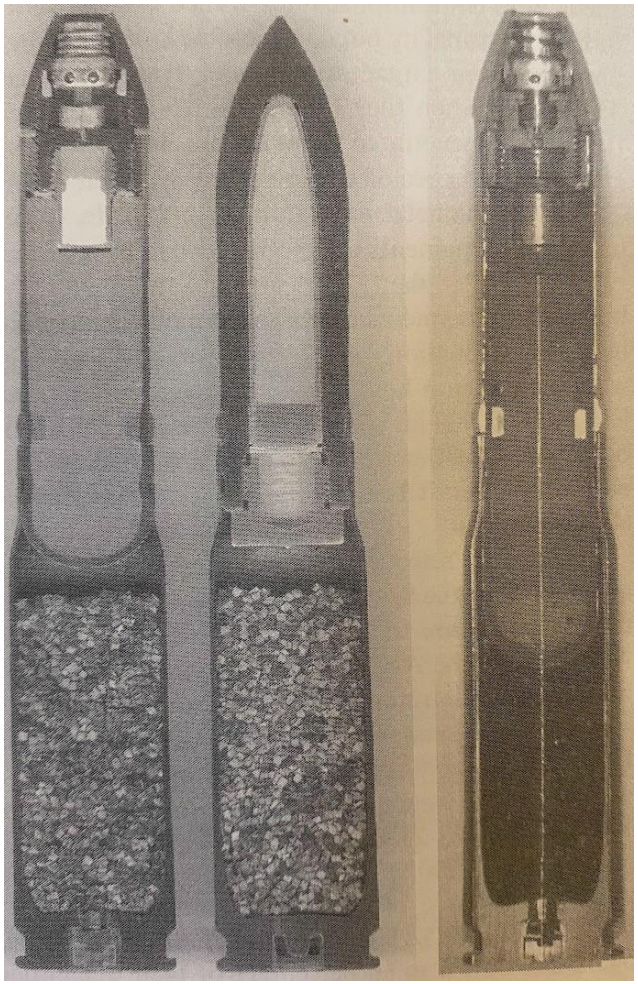
Hans-Ulrich Rudel *2530 Combat Missions 519 Tanks/1 Battleship/1Cruiser/70 Landing Craft/150 Artillery Pieces/51 Aerial Victories Ju 87 Stuka*

(37mm MG C/30 cannon + 7.92/13mmmm machine guns + 250/500kg bombs)

II. Aerial Gunnery Ammo Evolution - WWII



20mm M-Geshoss HEIT and API Cartridges



20mm M-Geshoss 151/120 & MX-Geschoss API

III. 40kft Combat

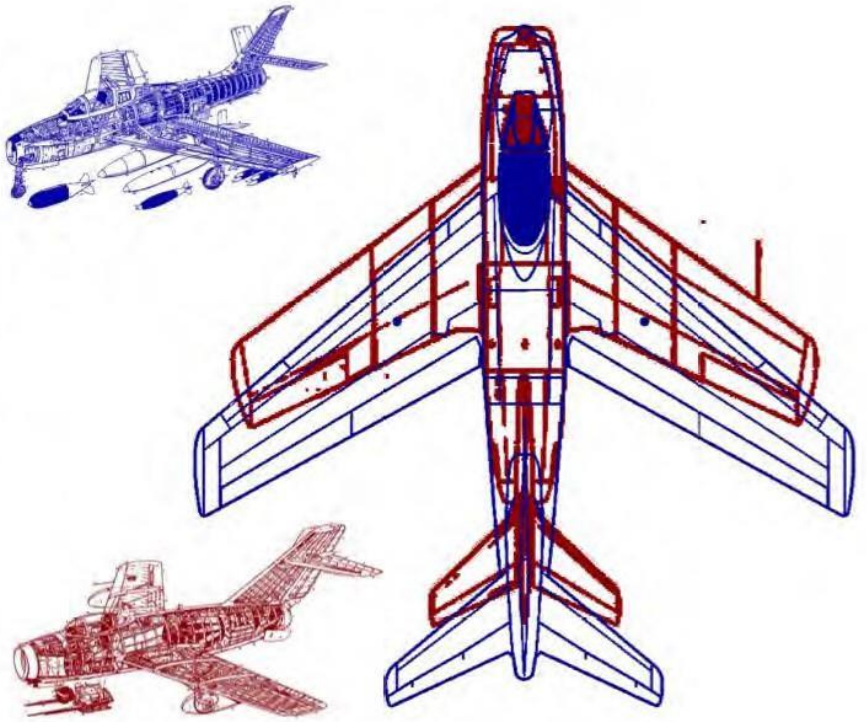
Ammunition for the First Jets

M-50 series 20 x 102mm ammunition

III. 40kft Combat

Ammunition for the First Jets

Characteristics	F-86	MIG-15
Wingspan (b, ft)	37.1	33.1
Max Takeoff Weight (WTO, lb)	20,650	14,240
Max Speed (V_{max}, mph)	690.5	670
Combat Radius (R, nm)	464.9	(~2 hr Endurance)
Armament	-6 0.50 Colt-Browning M-8 Machine Guns	-1 37mm Nudelman Cannon -2 NR-23 23mm Cannons
Max Ordnance (lb)	2,000	2,000



III. 40kft Combat

Korean War Victories

Aircraft \ Target	IL-10 -12	L-7 -9	PO-2	T-2	YAK-3 -9 -11 -15	Propeller no ID	MIG-15	Jet no ID	Total
F-80 	5	-	-	-	9	-	6	-	20
F-84 	-	-	-	-	1	-	10	-	11
F-86 	2	6	-	9	1	-	834	-	852
F-94 	-	-	-	-	-	2	1	1	4
F3D-2 	-	-	1	-	1	-	4	-	6
F9F 	-	-	-	-	2	-	5	-	7
Total	**7**	**6**	**1**	**9**	**14**	**2**	**860**	**1**	**900**

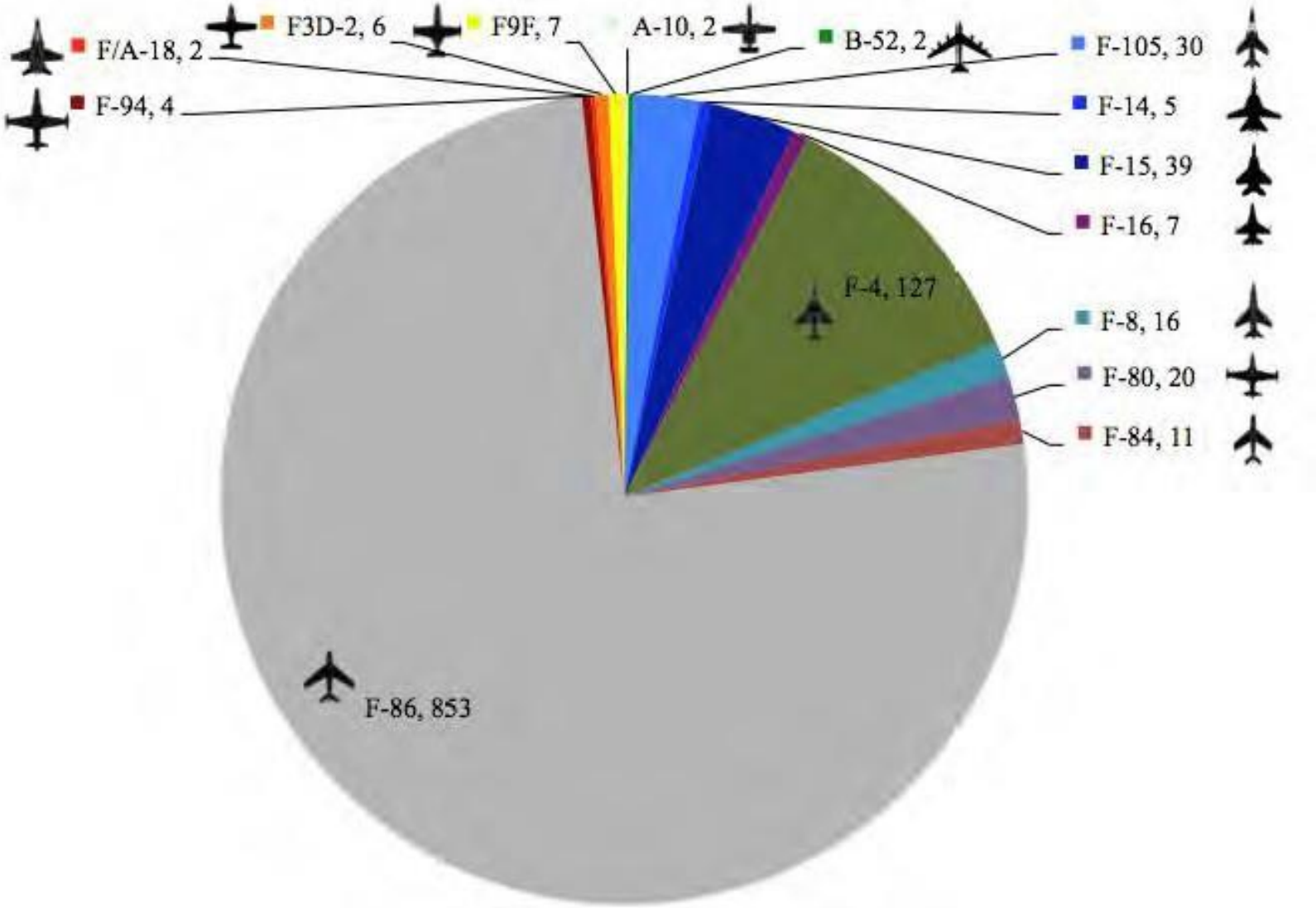
III. 40kft Combat

Viet Nam Victories

Weapon \ Target	An-2	MIG-17	MIG-19	MIG-21	Total
B-52D 	-	-	-	**2**	**2**
Guns	-	-	-	2	2
F-105 	-	**30**	-	-	**30**
Guns	-	27	-	-	27
AIM-9	-	2	-	-	2
AIM-9+Guns	-	1	-	-	1
F-4 	**1**	**43.5**	**9.25**	**73**	**126.75**
Guns	-	7	1	7	15
AIM-4	-	4.5	-	1	5.5
AIM-7	1	9.5	4	39.5	54
AIM-9	-	20.5	3	22.5	46
AIM-9+Guns	-	-	-	1	1
Maneuver	-	2	1.25	2	5.25
F-8 	-	**12.5**	-	**3.5**	**16**
Guns	-	0.5	-	-	0.5
Guns+Zuni Rockets	-	1	-	-	1
AIM-9	-	9	-	3.5	12.5
AIM-9+Guns	-	2	-	-	2
Totals	**1**	**86**	**9.25**	**79**	**174.75**

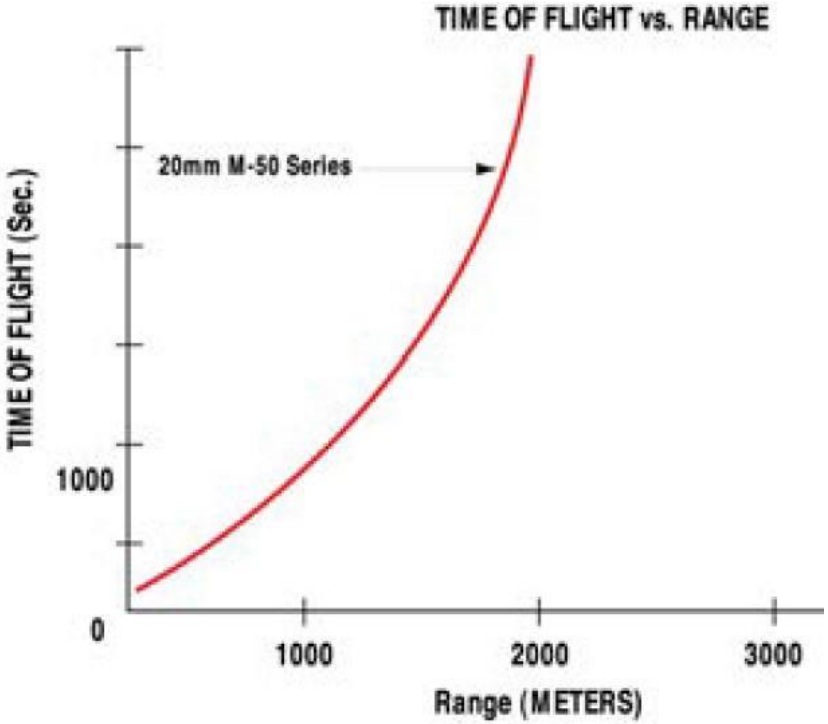
III. 40kft Combat

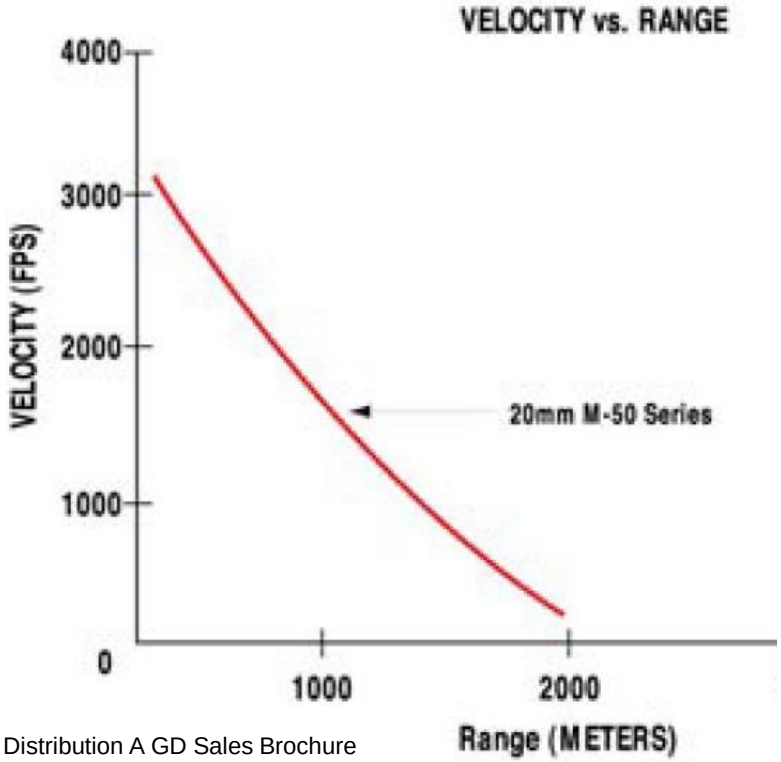
Total USAF Victories Since 1950



III. 40kft Combat

Ammunition for the First Jets



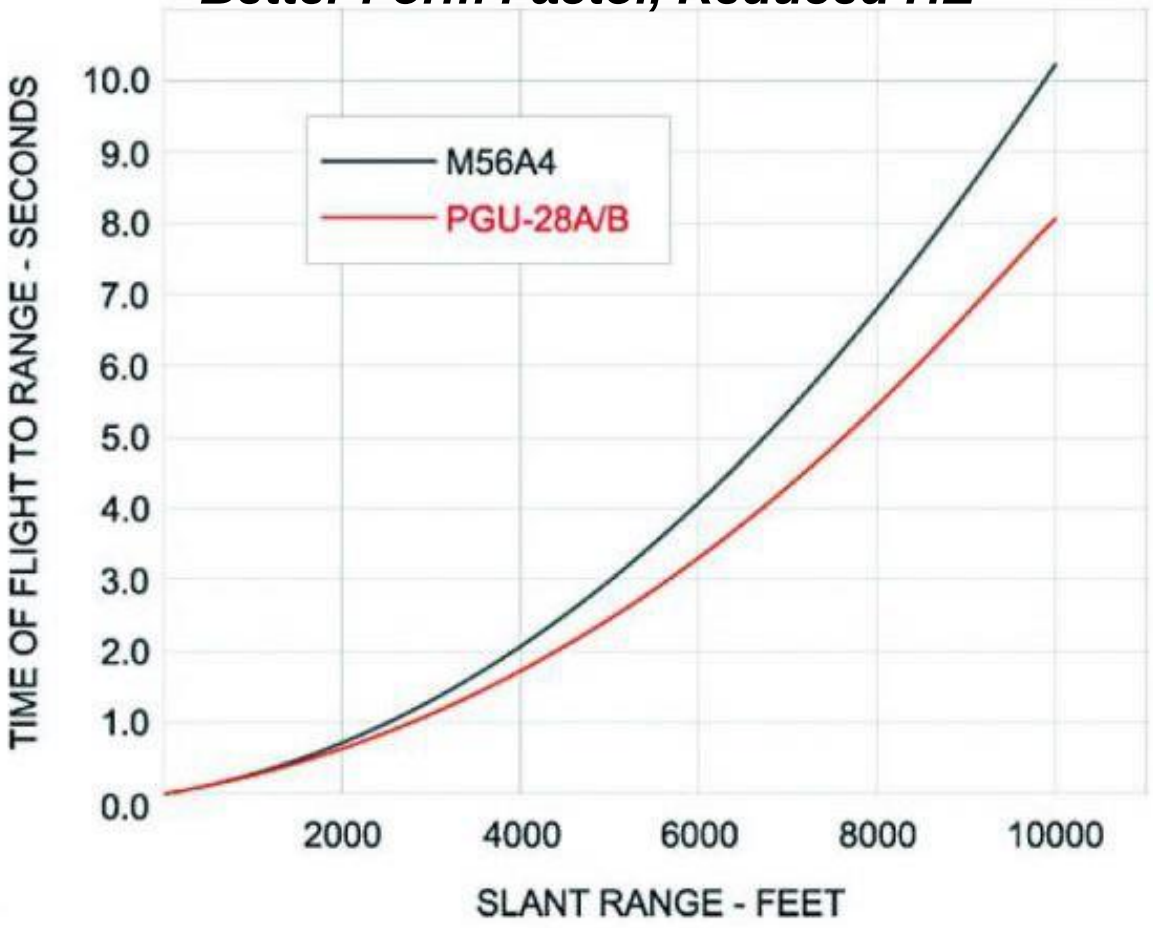


M-50 series 20x102mm ammunition

Source: Distribution A GD Sales Brochure

III. 40kft Combat

Ammunition for the More Modern Jets: Better Form Factor, Reduced HE



M-50 series 20x102mm vs PGU-28

Source: Distribution A GD Sales Brochure

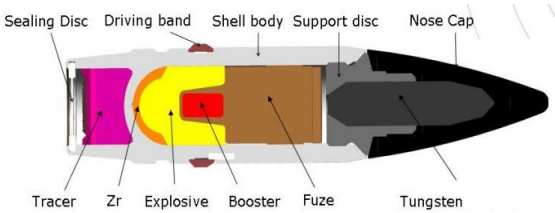
III. 40kft Combat

Ammunition for the More Modern Jets: Better Form Factor, Reduced HE

Today

F-35

Image Source: https://www.youtube.com/watch?v=69Nv3FIHNK0



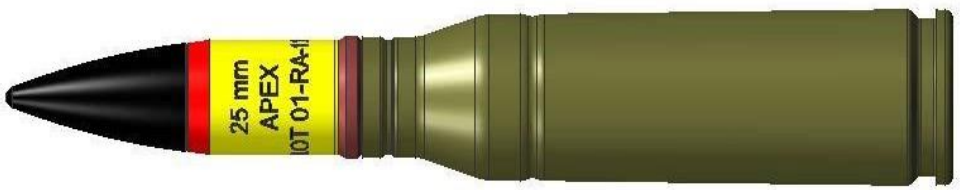


Image Source:
McConkie, Jim, "Qualification Testing of the PGU-47 Armor Piercing High Explosive Incendiary-Traced 25mm Cartridge," NDIA Armament Systems Forum 27 April 2016

III. 40kft Combat

Aerial Gunnery Ammunition has Barely Evolved

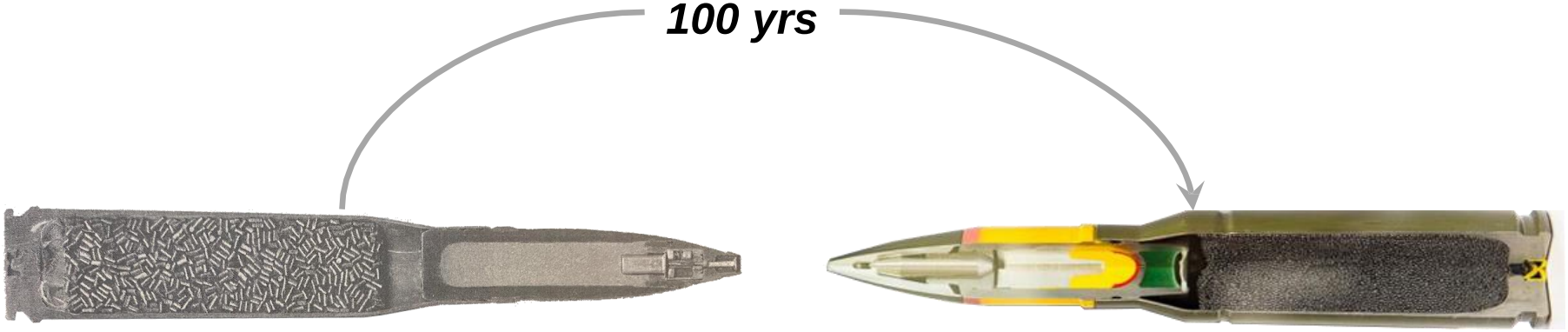
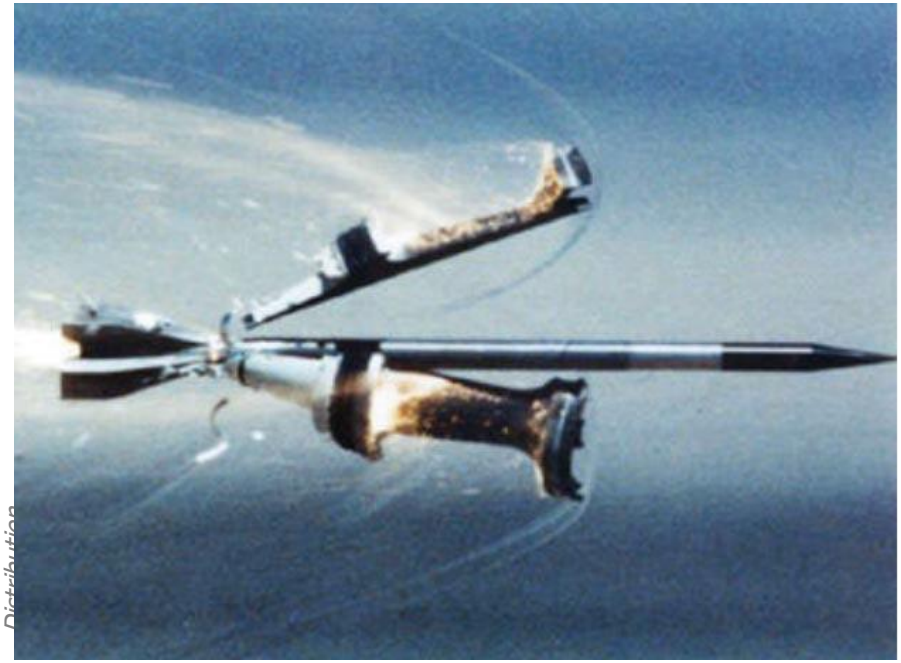


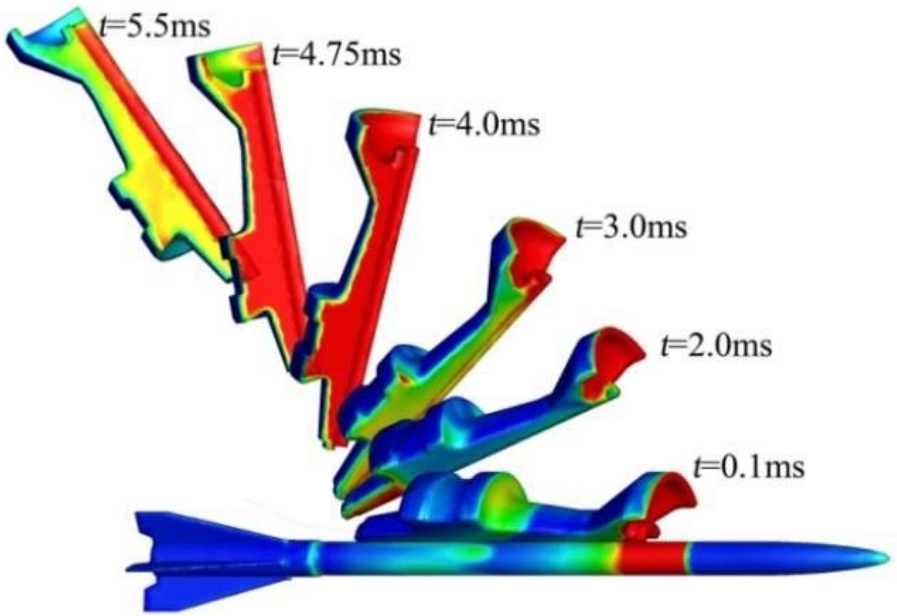
Image Source:
Williams & Gustin, Flying Guns

Image Source:
https://www.f-16.net/forum/viewtopic.php?f=54&t=52628&start=75

IV. USAF High Performance Ammo. Efforts

Conventional Discarding Sabot Design Philosophy and Aeromechanics





IV. USAF High Performance Ammo. Efforts

Conventional Discarding Sabot Design Philosophy and Aeromechanics

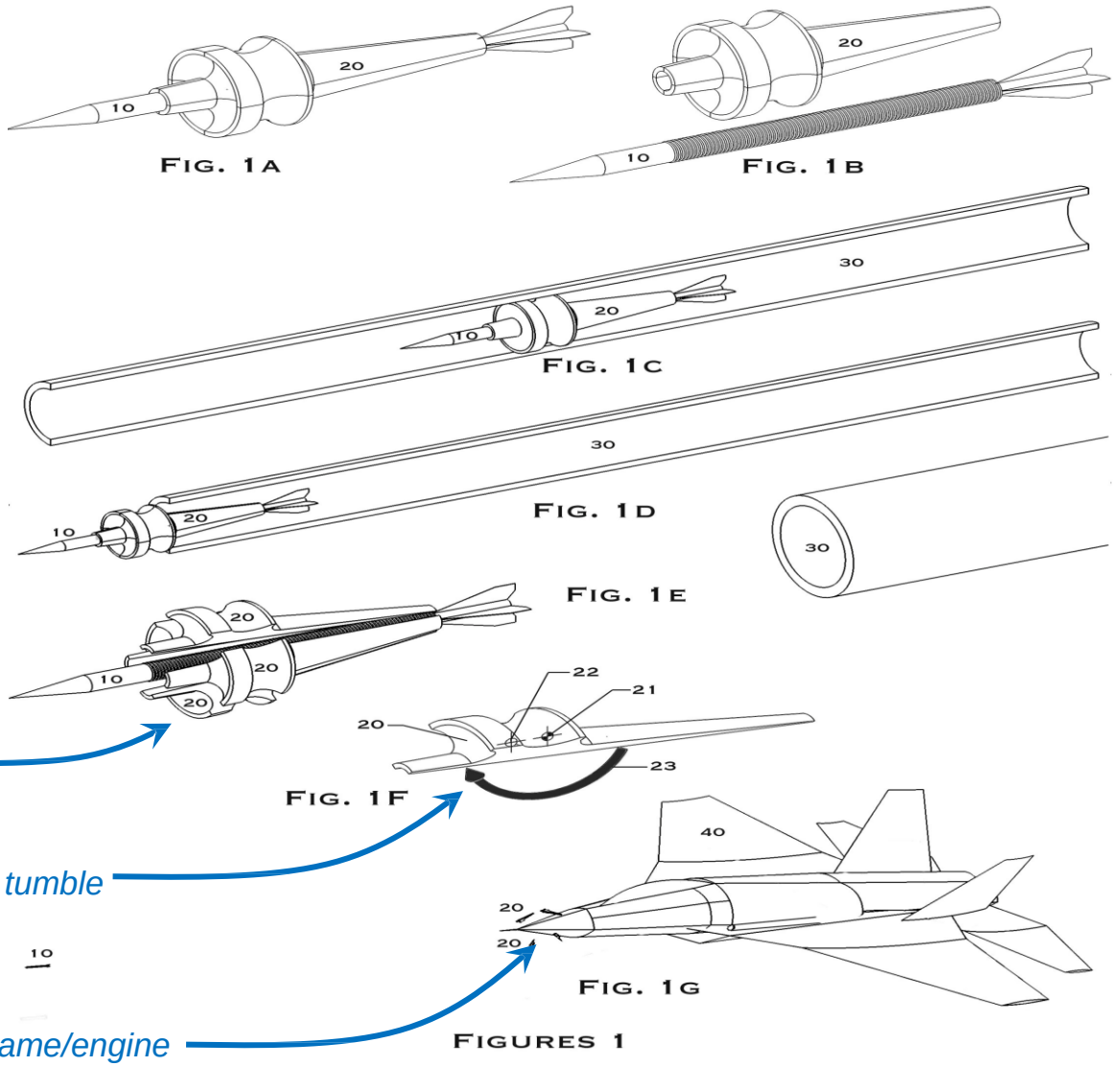
Flechette ammunition by its nature must be sabot launched. Herein lies another advantage and its major disadvantage. The advantage of sabot launch is, of course, that the projectile has a low sectional density while in the gun bore and can be easily accelerated to velocities not readily attainable with conventional shot. The disadvantage of sabots is that they must be discarded at muzzle exit, and these rapidly decelerating sabots pose an unacceptable hazard to launching aircraft.

*-**Dale Davis**, Director, USAF Munitions Directorate 1984*

IV. USAF High Performance Ammo. Efforts

Why a conventional sabot won't work for aerial gunnery

Dale Davis' Observations:



FIGURES 1

Conventional sabot pieces are designed to be aeromechanically unstable, by necessity, to separate from projectile

Aeromechanically unstable sabot pieces tumble

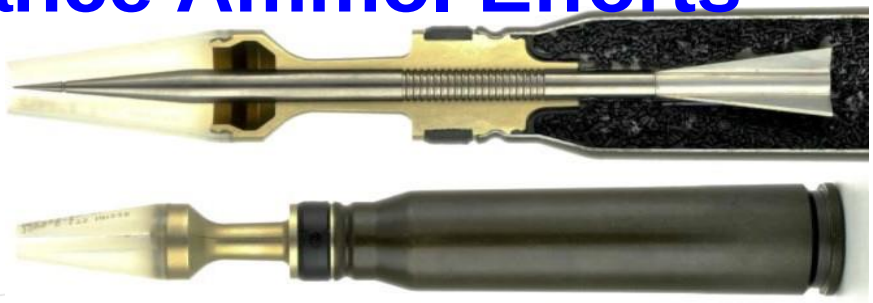
...and strike airframe/engine

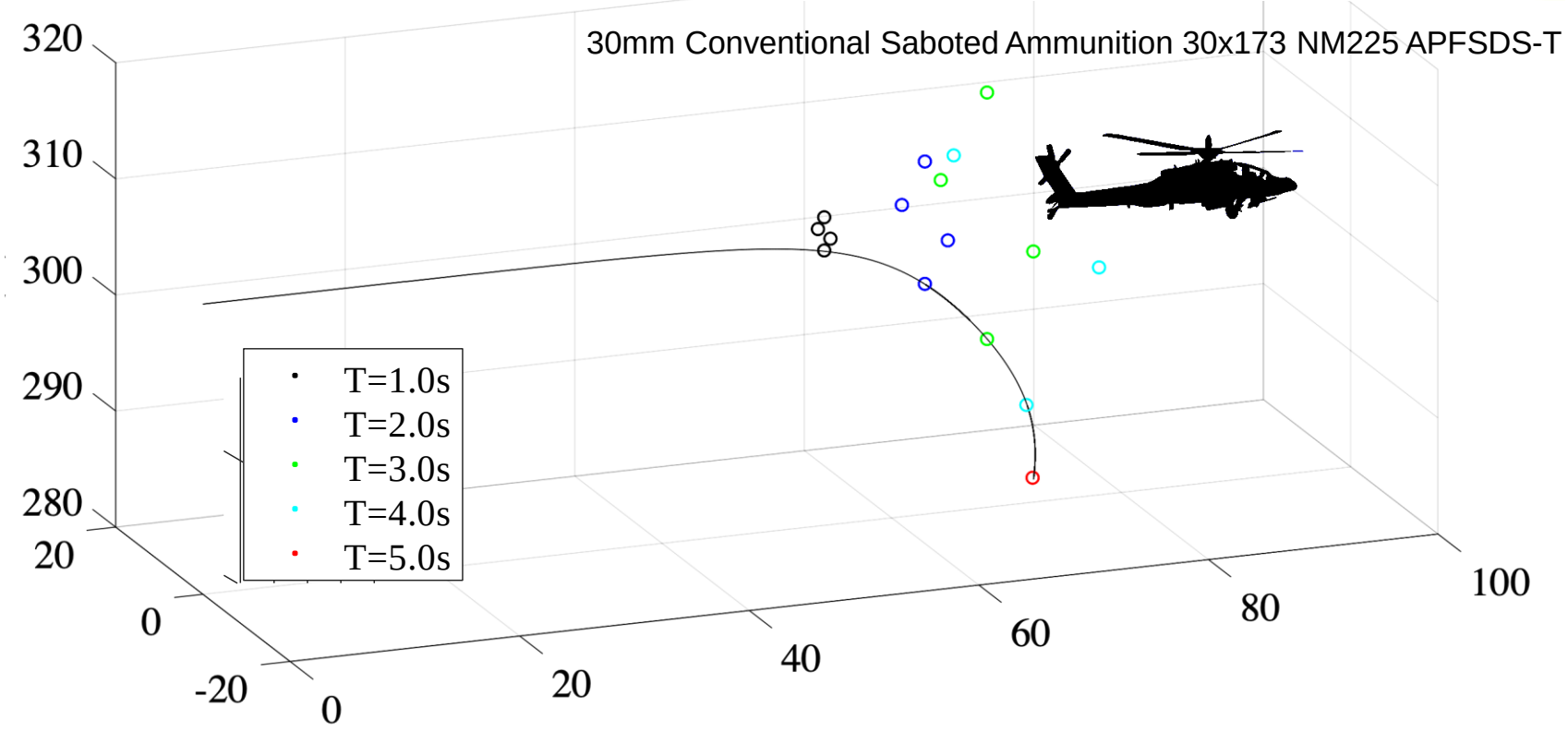
Image Source: PCT/IB2020/053899

IV. USAF High Performance Ammo. Efforts

The Great Show Stopper:

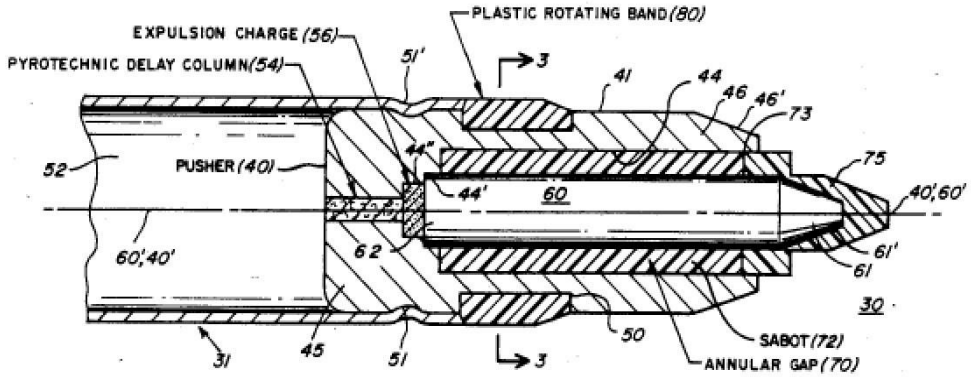
Flight Safety

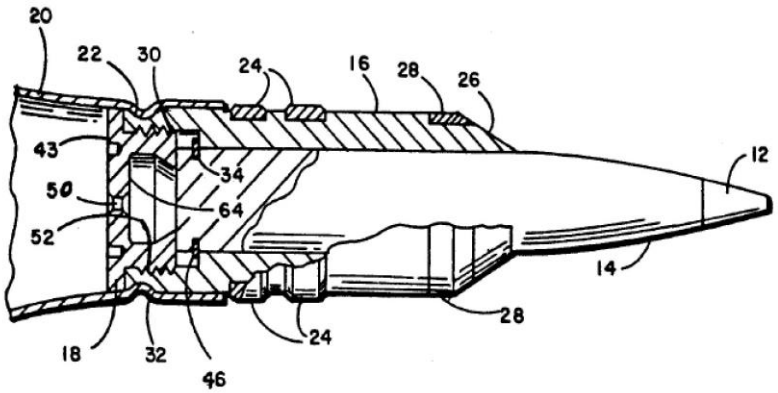




IV. USAF High Performance Ammo. Efforts

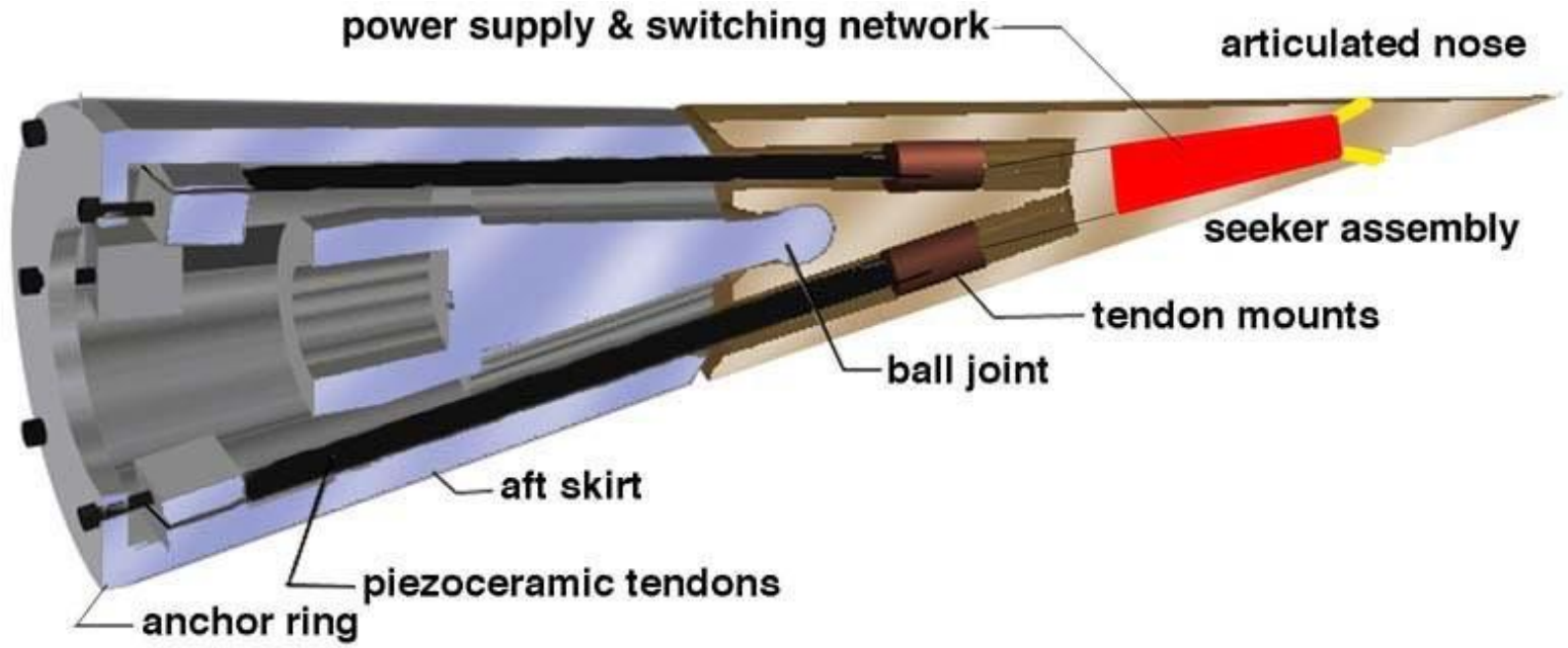
- ***Tremendous Activitiy 1952 – 1998***
- *Sabot Diverters*
- *Hybrid Rocket-Assisted Projectiles*
- *Drag Fumers*
- *Rotating Bands*
- *Tubular Projectiles*
- *Disentegrating Sabots*
- *Meyer & Burnette Sabots*





IV. USAF High Performance Ammo. Efforts...

- ***Barrel-Launched Adaptive Munition (BLAM) Program 1995 - 1998***



IV. USAF High Performance Ammo. Efforts...

- ***Advanced DoD Aerial Gunnery Ammunition Programs 1998 - Present***

IV. USAF High Performance Ammo. Efforts...

- ***Advanced DoD Aerial Gunnery Ammunition Programs 1998 - Present***

"The AFRL does not have an S&T portfolio in ammunition."

*-**David Lambert** AFRL Chief Scientist November 2021*

V. Ballistic Aeromechanically Stable Sabot (BASS) Rounds

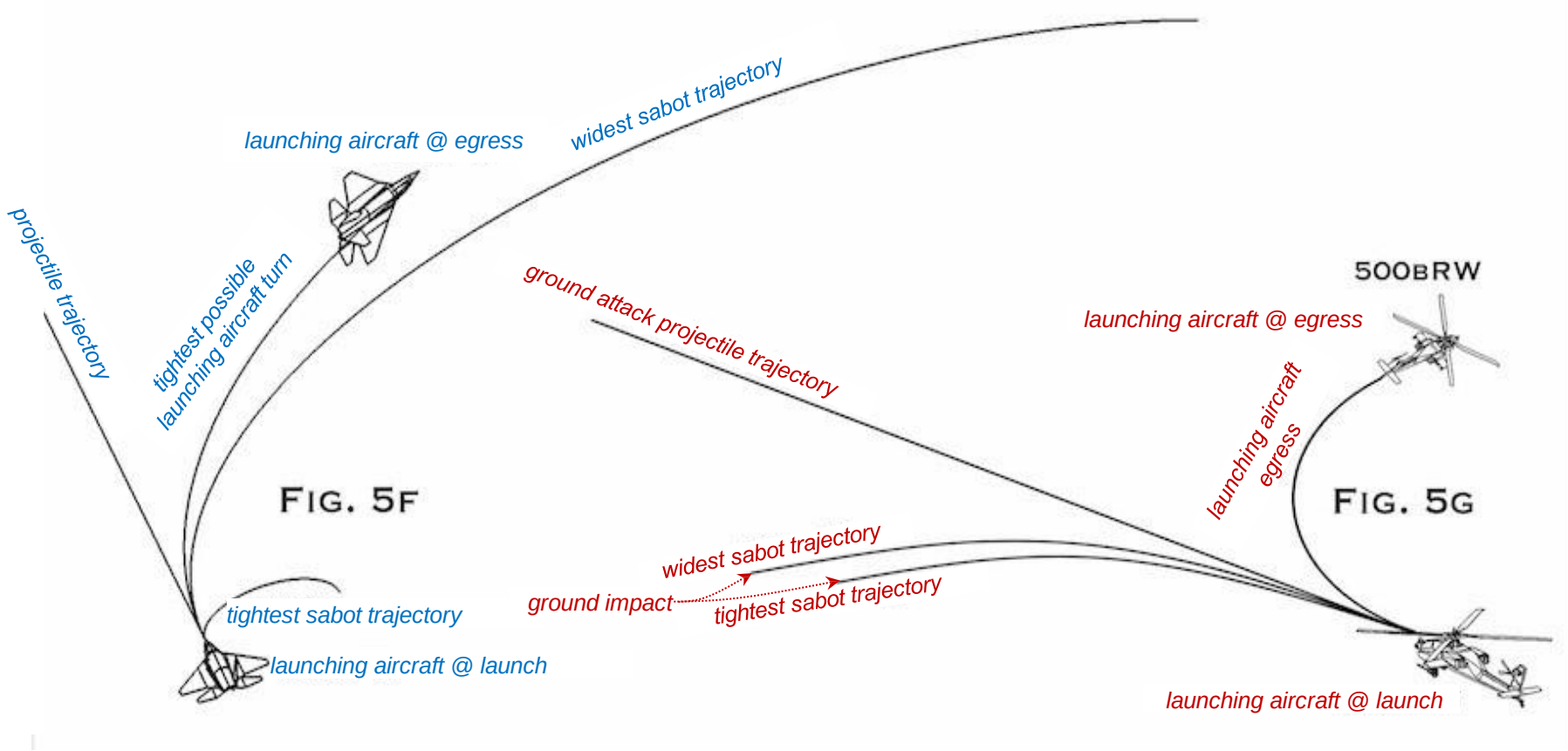
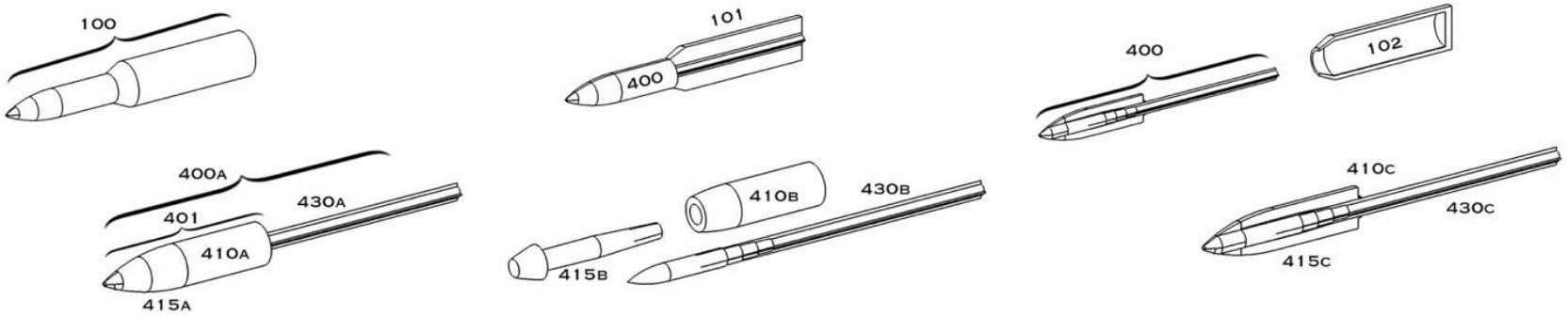


Image Source: PCT/IB2020/053899

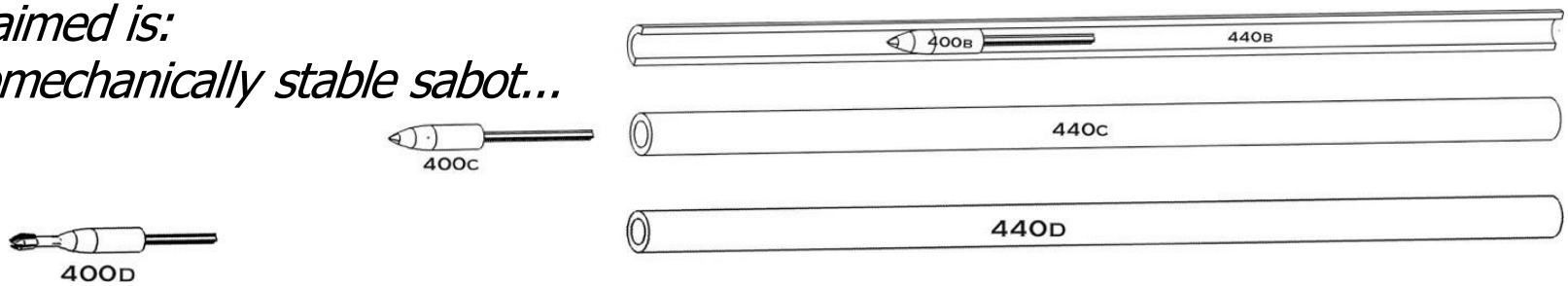
Invented 2016
Modeled computationally & analytically 2017
Reduced to practice 2018
US & international patent priority date: 4/26/2019

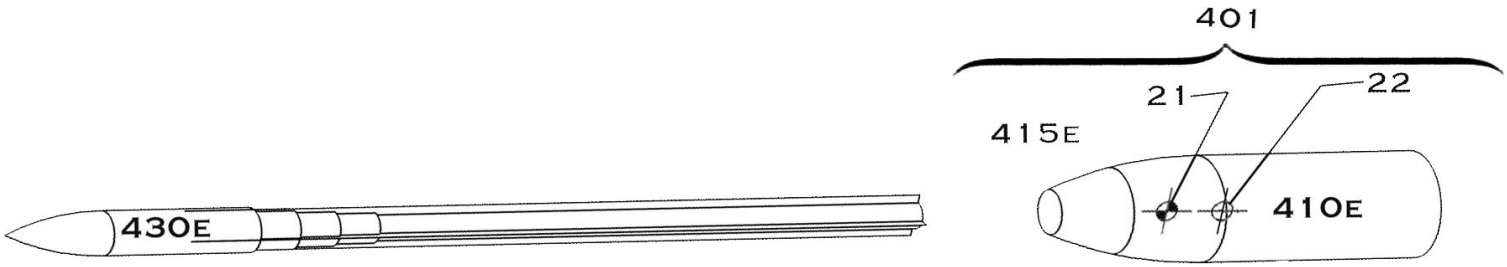
V. Ballistic Aeromechanically Stable Sabot (BASS) Rounds



What is claimed is:

1. An aeromechanically stable sabot…





54 major families, >1,000 species covered in multiple expansive patent filings


Questions?