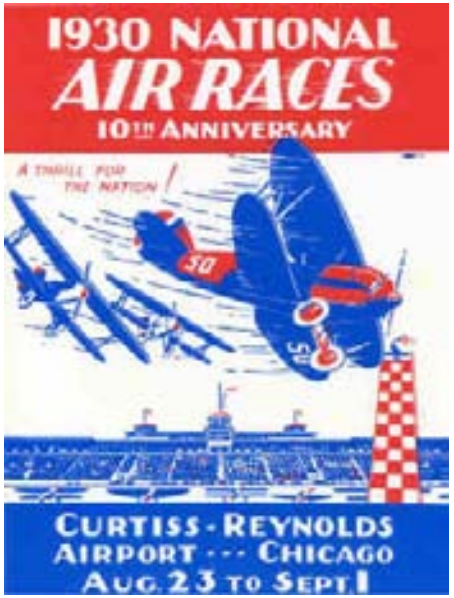


History of Aviation

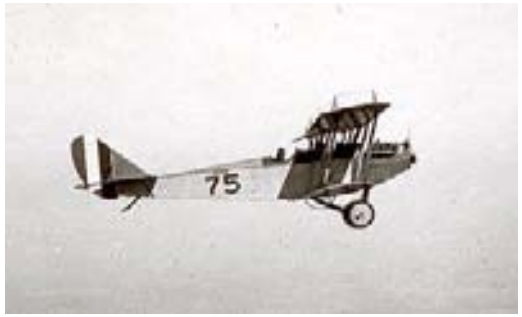
Session 3

Between the Wars 1919-1938


Pre WB-1911
WWI 1911-1918
1919-1937
WWII 1938-1941
WWII 1942-1945
K/V 1946-1980
ME 1981-2000
ME 2001-2012
Early Aviation
1909 WB-F
WW I
Europeans
US
Growth and Expansion
WW II
B of B
Pearl Harbor
Eur. Theater
Pac. Theater
Atomic Bomb
Commercial Aviation
Jet
Military Jet Aviation

Session 3 Between the Wars

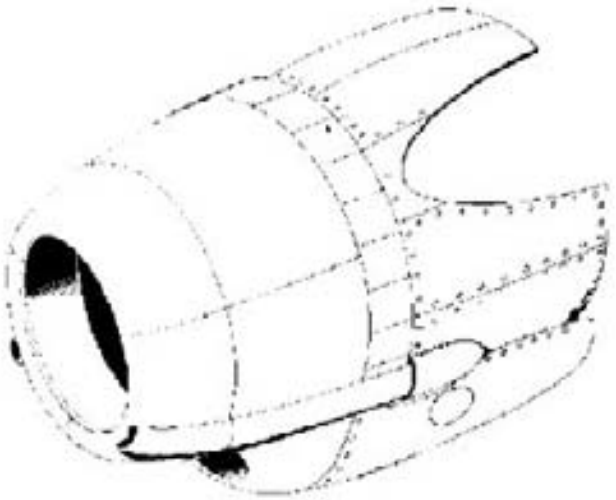
- Aviation Operational Advances
- Technology
- Air Races/Prizes/ Challenges
- Aeronautical Engineering/ Manufacturing Advances
- Commercialization [Later in Commercial Aviation]
- Politics/Policy
- Jet Engine Development
- Pre-World War II build up



20 Years

Aviation Operational Advances: 1920s through 1930s

- National Advisory Committee on Aeronautics (NACA), 1915
  - Wings, propellers, cowlings, instrumentation
- Instrument flying, autopilots
  - Sperry Gyroscope, Jimmy Doolittle
  - Better weather forecasting
- Navigation aids along the airways
  - Radio direction finding ground transmitters and airborne receivers
- Aeronautical engineering programs, first beginning in 1914 at University of Michigan. There are 84 degree programs in the US alone. Now taught in 54 nations.
- Pressurization designs and advances
  - Wiley Post's early pressure suit experiments
  - Boeing 307



National Advisory Committee on Aeronautics
A low drag cowling

Wiley Post's first High Altitude pressure suit

Boeing 307, first pressurized Production aircraft

Technology/Manufacturing Advances

- **Metallurgy, lighter weight and stronger alloys**
  - **Duralumin, Magnesium**
    - **Improved and consistent metal working, precession forging and machining**
    - **Ball Bearing improvements**
- **Thompson Products – Sodium cooled valves**
  - **Thompson Products > TRW**
- **Shell oil - developed High Octane fuel**
  - **Jimmy Doolittle's impetus and its impact on the Battle of Britain**
    - **Ethylene glycol - "Prestone ™ " coolant**
    - **Aircraft engine components: Turbo chargers, Fuel Injection, Liquid coolant pumps and high pressure hoses, engines seals, better air filters**
    - **Variable pitch propellers**

Aviation Fuel Advances
High Octane Rated Fuel

- When engine designers tried to build motors with greater power through higher compression, they ran into the problem of pre-ignition or "knock."
- An air and fuel mixture is intended to burn very rapidly and in a controlled manner, but often the mixture exploded early, which damaged engines - "knock."
- Poor-grade fuels avoided knock but produced little power.
- In 1924, an American chemist, Thomas Midgely determined that small quantities of a suitable chemical added to high-grade gasoline helps it burn without knock, the best was tetraethyl lead.

Aviation Fuel Advances
High Octane Rated Fuel

- Leaded gasoline became standard as a high-test fuel, used widely in automobiles as well as in aircraft.
- Leaded gas improved an aircraft engine's performance by enabling it to use a supercharger more effectively while using less fuel.
- The Liberty Engine, best WW I engine developed 400 HP. In WW II, the Rolls-Royce Merlin engine about the same size/weight — but output was 2,200 HP. Half the gain is attributed to use of higher octane fuel.
- Shell Oil was the only refiner in the1930s.
  
  ed by Jimmy Doolittle - Army pilot, Air Race winner, PhD in aeronautical engineering.

Superchargers & Turbosuperchargers

NACA Roots-Type Model 2

Centrifugal Supercharger Daimler-Benz DB 605

Type C-Series Turbosupercharger Cutaway General Electric

Curtiss-Wright [NYSE CW]
109 Years in Continuous Operation

- Curtiss-Wright came into existence on July 5, 1929, the result of a merger of 12 companies associated with Curtiss Aeroplane and Motor Company [aircraft] of Buffalo, New York, and Wright Aeronautical [engines] of Dayton, Ohio, and was headquartered in Buffalo, New York. With $75 million in capital, it was the largest aviation company in the country.
- The company was a major manufactures of engines and aircraft through WWII.
- The company did not make a successful transition to jet aircraft after WWII.
- Curtiss-Wright's flight research laboratory, founded in 1943 was given to Cornell University along with a cash gift to finish construction of a transonic wind tunnel; it is now Calspan.
- During the 1960s CW shifted to aircraft components and other types of equipment, used in nuclear submarines, a business that was still being conducted in 2009.
- NYSE: CW still operates out of NJ manufacturing Valves, Pumps, Motors, Generators
  Instrumentation, Controls, Actuation, Drive Sensors, Embedded Computing and Metal Treatment.

Challenges/Prizes/Races

Challenges/Prizes

- **Transcontinental US flights**
- **Trans-Atlantic**
- **Round the World**

Races

- **Bendix**
- **Schneider**
- **Thompson**
- **Hughes H1**

Early and Record Setting Trans - Continental and Trans –Atlantic Flights

Prizes/Challenges
First Trans-Continental US flights

1911 Hearst $50,000 prize for first trans-continental US flight completed in 30 days.

Wright Model B, Vin-Fiz, 84 days - 70 landings, 19 crashes; 84 hours in the air Cal Rogers, pilot.

- **First air mail**
- **First air freight**

1923 US Army Fokker T-2, non - stop from Brooklyn NY to San Diego CA in 27 hours.

- **Saves Army Air Service from being dropped from the Budget**
- **Uses a Liberty engine**

Current Record Holder: US Trans-continental flight, Lockheed SR-71, 1990, LAX to IAD a distance 2,299.7 miles, average speed 2,144.8 miles per hour in an elapsed time of 64 minutes 20 seconds.

Pilot Training in the 1920s and 1930s

US Wartime/Peacetime Air Unit Build Up-Draw Down

- **Size (1914): 268 men; 23 aircraft in US**
- **Size (1918): 195,024 men; 7,900 aircraft in US/Overseas**
- **Size (1926): 9,954 men; 1,451 aircraft in US**

A lot of aircraft per size of the service, but few dollars for fuel and maintenance of an already obsolescent fleet.

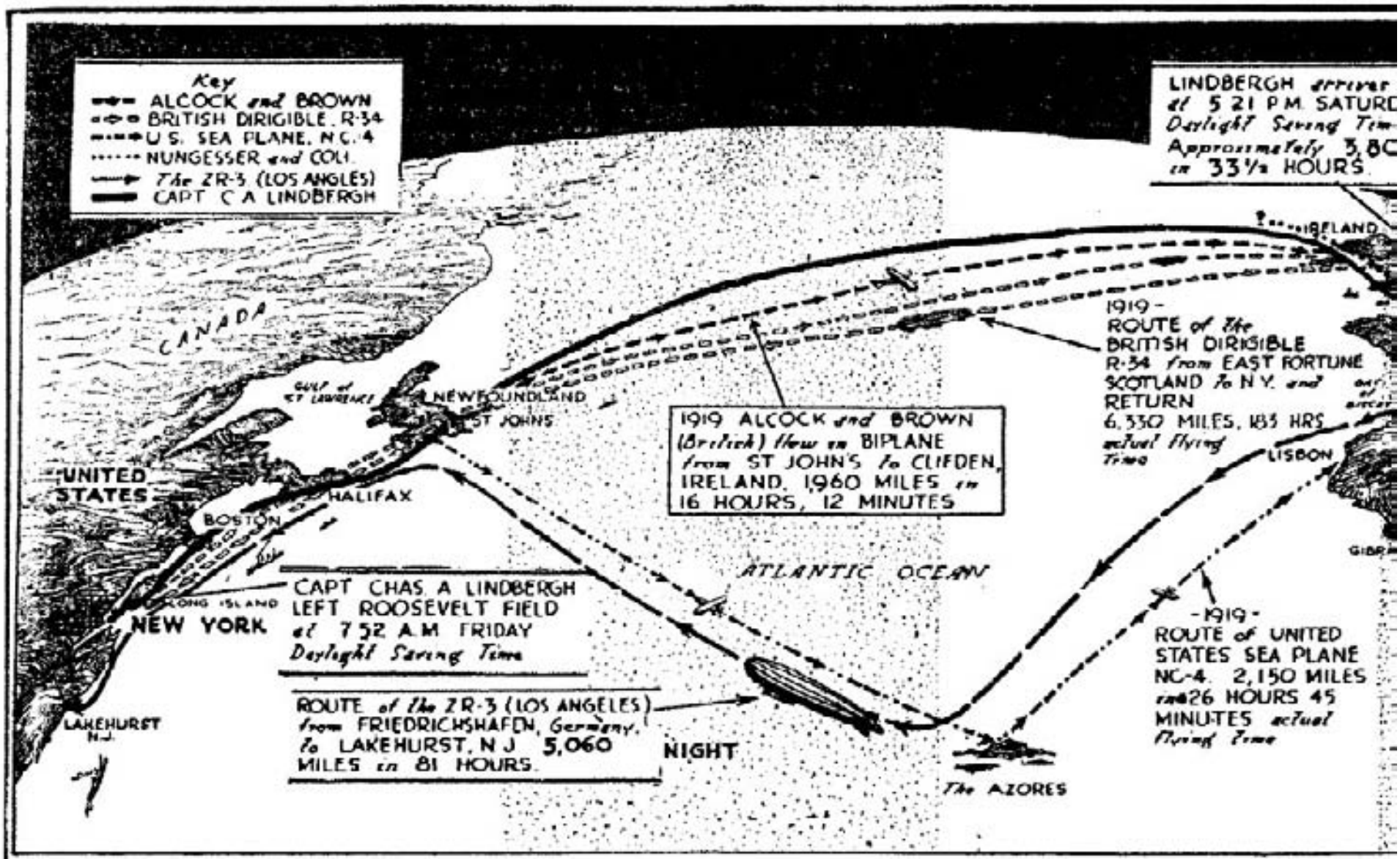
Charles Lindbergh and Reserve Pilots

- Learns to fly in 1920
- In 1924, Lindbergh enlisted in the Army for training as an Army Air Service Reserve pilot.
- In 1925, he graduated from the Army's flight-training school at Brooks and Kelly fields, near San Antonio, as the best pilot in his class.
- After Lindbergh completed his Army training, the Robertson Aircraft Corporation of St. Louis hired him to fly the mail between St. Louis and Chicago.
  - He gained a reputation as a cautious and capable pilot.
  - Weekends he manages a flying club
- Joins the Missouri Air National Guard

Charles Lindbergh

1927 Spirit of St. Louis on Display at the Smithsonian Air and Space Museum

$25,000 Ortiz Prize for the first solo flight from New York to Paris, 1927



THE CONQUEST OF THE NORTH ATLANTIC BY AIRPLANE AND DIRIGIBLE

The various crossings that have been made by airplane from Portugal, Spain, and Italy, across the South Atlantic to South America, co- series of comparatively short "hops." These flights began in 1922, when Cabral and Coutinho flew from Lisbon to Rio de Janiero. E Commander Ramon Franco flew from Palos, Spain, to Buenos Aires, a distance of 6,230 miles, and since then Colonel De Pinedo has neg

Government subsidized Pilot Training

- Observing world military and commercial events
- Civilian Pilot Training Act of 1939
  - Private pilot training schools to train thousands of pilots
  - "… a program will increase the purchase of planes. It will increase employment in manufacturing plants, service depots, and airports. It will increase passenger traffic on the transport lines. This increase in private or peacetime flying activities will make possible an improved system of aeronautical research which will be accompanied by improved safety conditions. The manner in which we propose to carry on the program will increase safety factors above and beyond anything heretofore achieved by either private or public agencies." (1)

1. From Congressional hearing

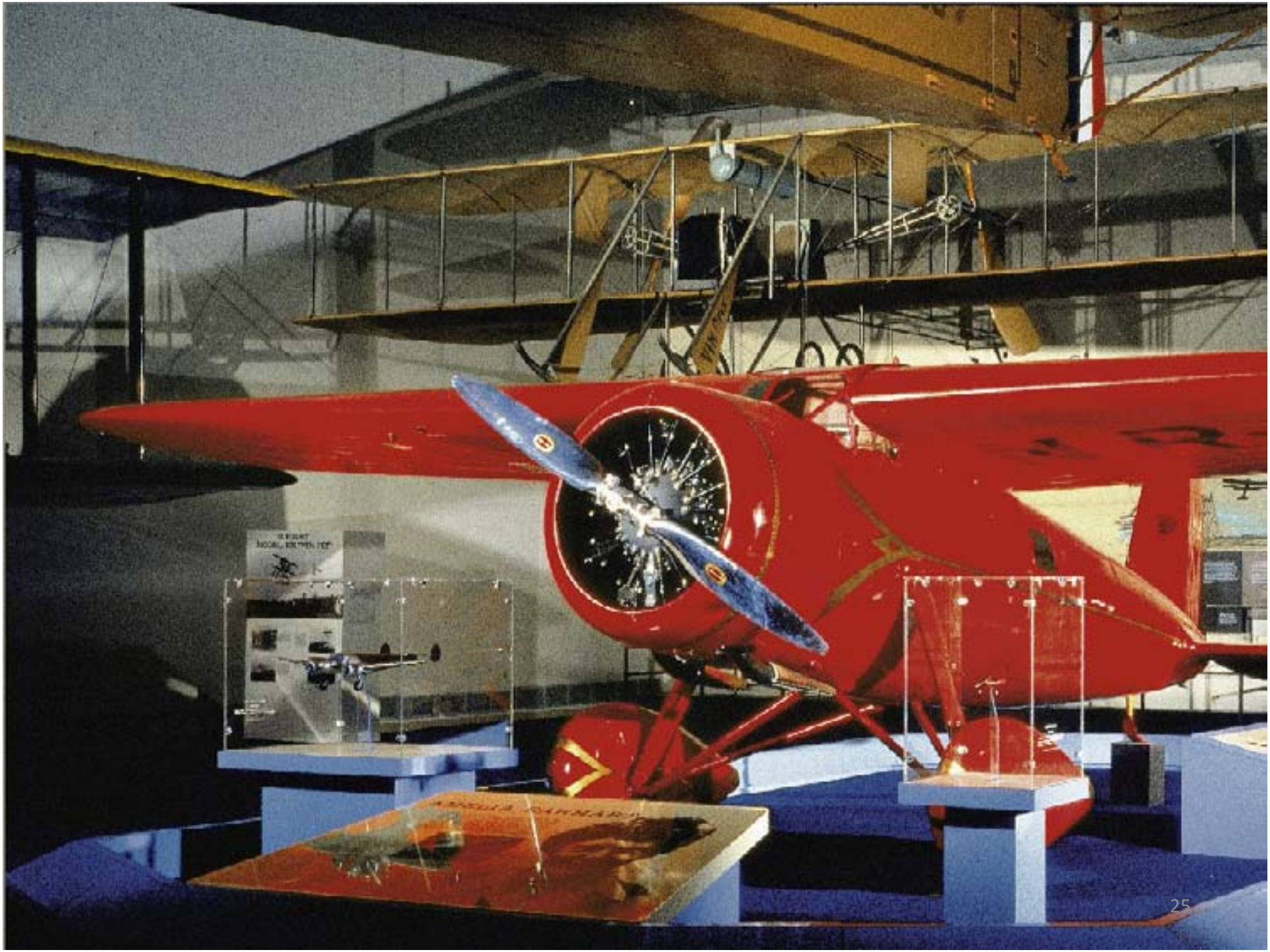
Segregated Pilot Training

- **The CAP was opened to black pilots students on a segregated basis, hundreds were trained**
- **Formed the nucleus for the Tuskegee Air man program**
- **US Army allocates $1,000,000 for the Tuskegee experiment in 1940**

Amelia Earhart

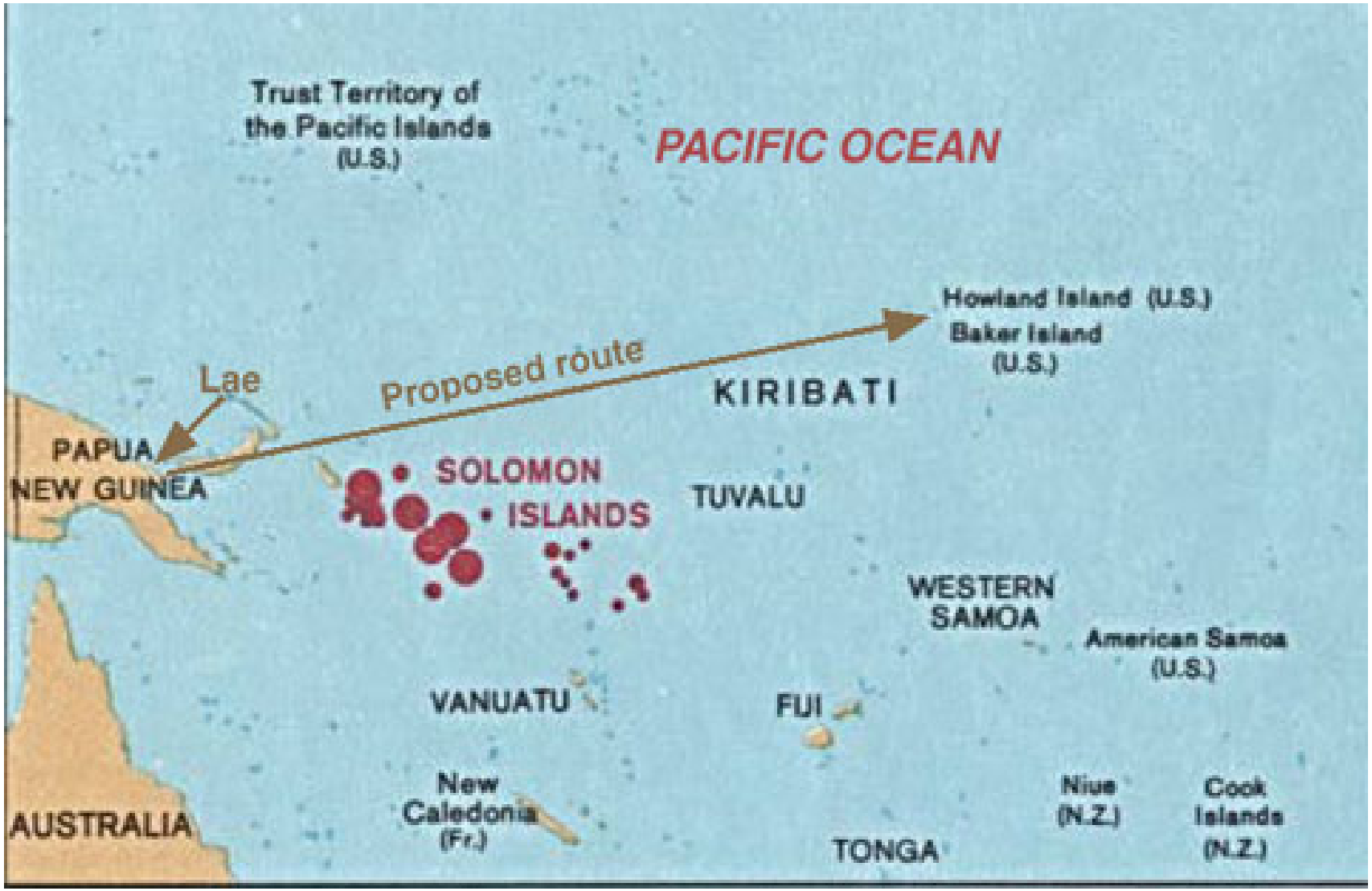
- **First woman to fly across the Atlantic, 1928.**
- **First Woman to solo across the Atlantic and only the second person to do so, 1932, five years to the day the Lindbergh flew.**
- **First woman to fly non-stop across the US, 1932.**
- **First person to fly solo from Hawaii to the US mainland, 1933**
- **Married to George Putman and earned her living on the lecture circuit.**
- **1937 needed a new goal - a flight around the world near the equator.**

Amelia Earhart



Lockheed Electra

Last Leg of Amelia Erhardt's 1937 Round the World Flight- 2600 Miles at 200 MPH, 13 Hours



Still missing

- **Calculations made against Coast Guard radio signal strength and the radios on Amelia's Electra lead to the conclusion that she was about 60 miles west of Howland Island, when she ran out of fuel.**
- **Debris found on Nikumoro Island, also called Gardner's Island, about 450 miles west of Howland lead to belief that she made it to the island or very near by.**
- **Fuel calculation differences**
- **Recent expedition this summer failed to find any evidence on either the island or in the nearby waters that she had landed or swam ashore.**

Howard Hughes and the H-1 Racer

HUGHES
HUGHES AIRCRAFT COMPANY

The H-1 first flew in 1935 and promptly broke the world landplane speed record with Hughes at the controls, clocking 352 mph (566 km/h) averaged over four timed passes.

On January 19, 1937, a year and a half after his previous landplane speed record in the H-1, Hughes set a new transcontinental speed record by flying non-stop from Los Angeles to New York City in 7 hours, 28 minutes and 25 seconds

Air Racing

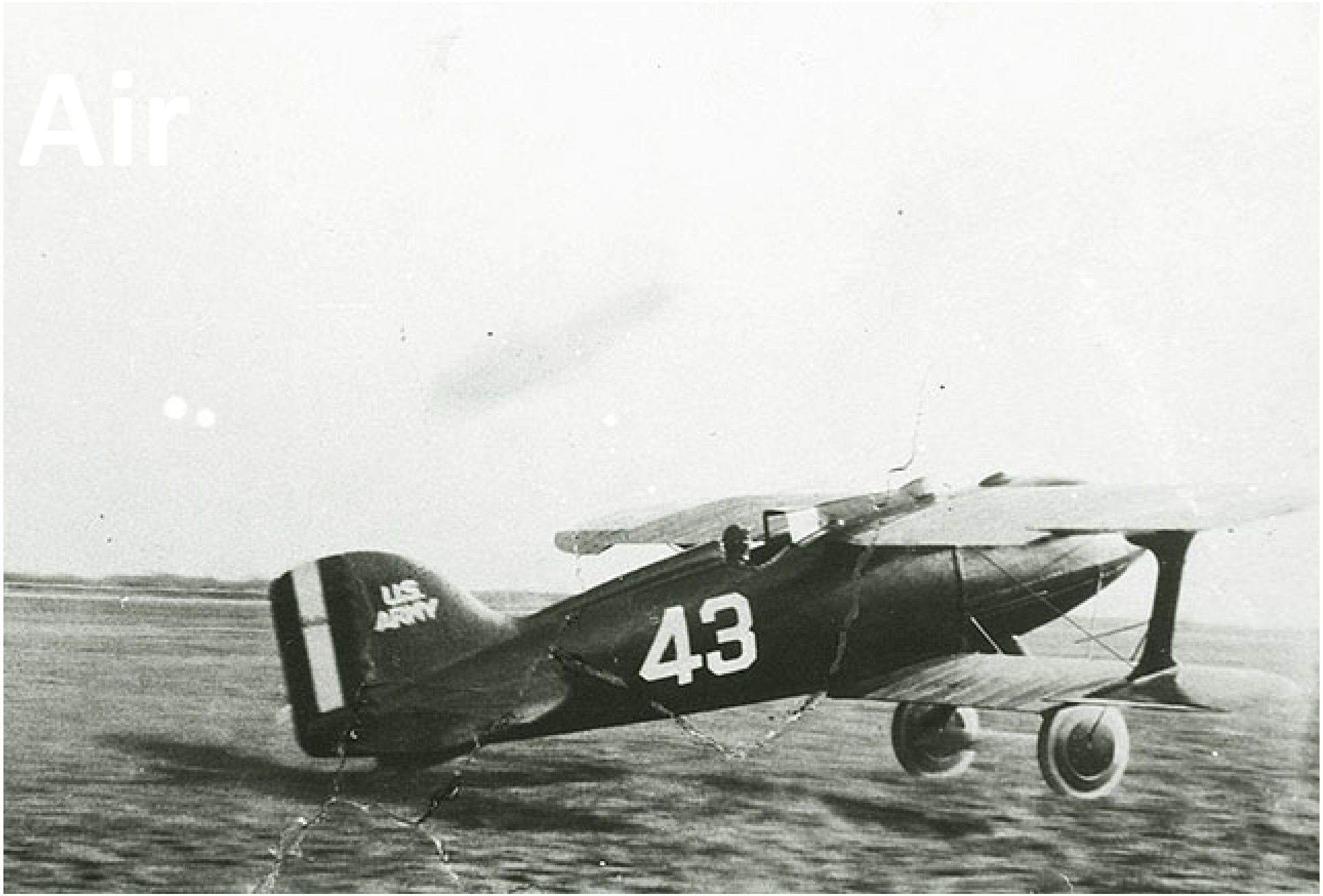
Races

- **Bendix**
- **Schneider**
- **Thompson**

- **Drove aviation – look at the racing aircraft that came not many years after WWI**

Air Racing's Four Eras

- Aerial Sportsmen, 1909-1914, 1919-1922
- Institutionalized Military Air Racing, 1920-1931
- Aerial Populism in the U.S., 1920-1939
- Aerial Motorsport, 1946-1949 and 1964-Present

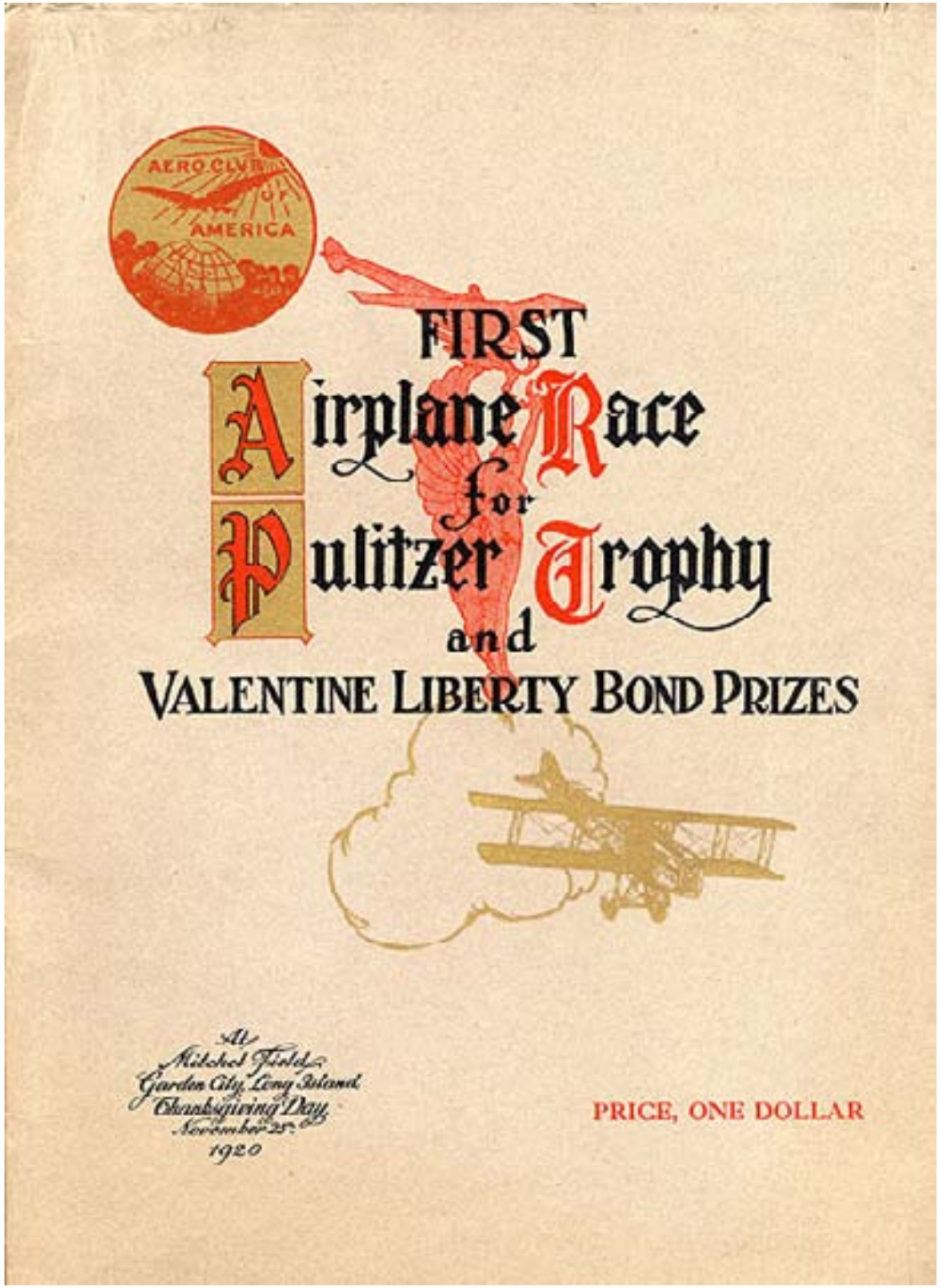

Air
U.S.
ARMY
43

"…a situation or place for testing new equipment or ideas"

- Interwar military aviation
- Broader contextual format
- Aerial publicity campaigns

Historiography of Military Air Racing

- Influence of the technology?
- A “Golden Age”?
- Technological progress?
- Includes socially-constructed and non-technical influences
- Enthusiasts


AERO CLUB OF AMERICA
FIRST
Airplane Race
for
Pulitzer Trophy
and
VALENTINE LIBERTY BOND PRIZES
At
Mitchel Field
Garden City, Long Island
Thanksgiving Day
November 25
1920
PRICE, ONE DOLLAR

Brig. Gen. William “Billy” Mitchell

Lt. ALEX PEARSON Jr.

WORLD'S OFFICIAL SPEED RECORD

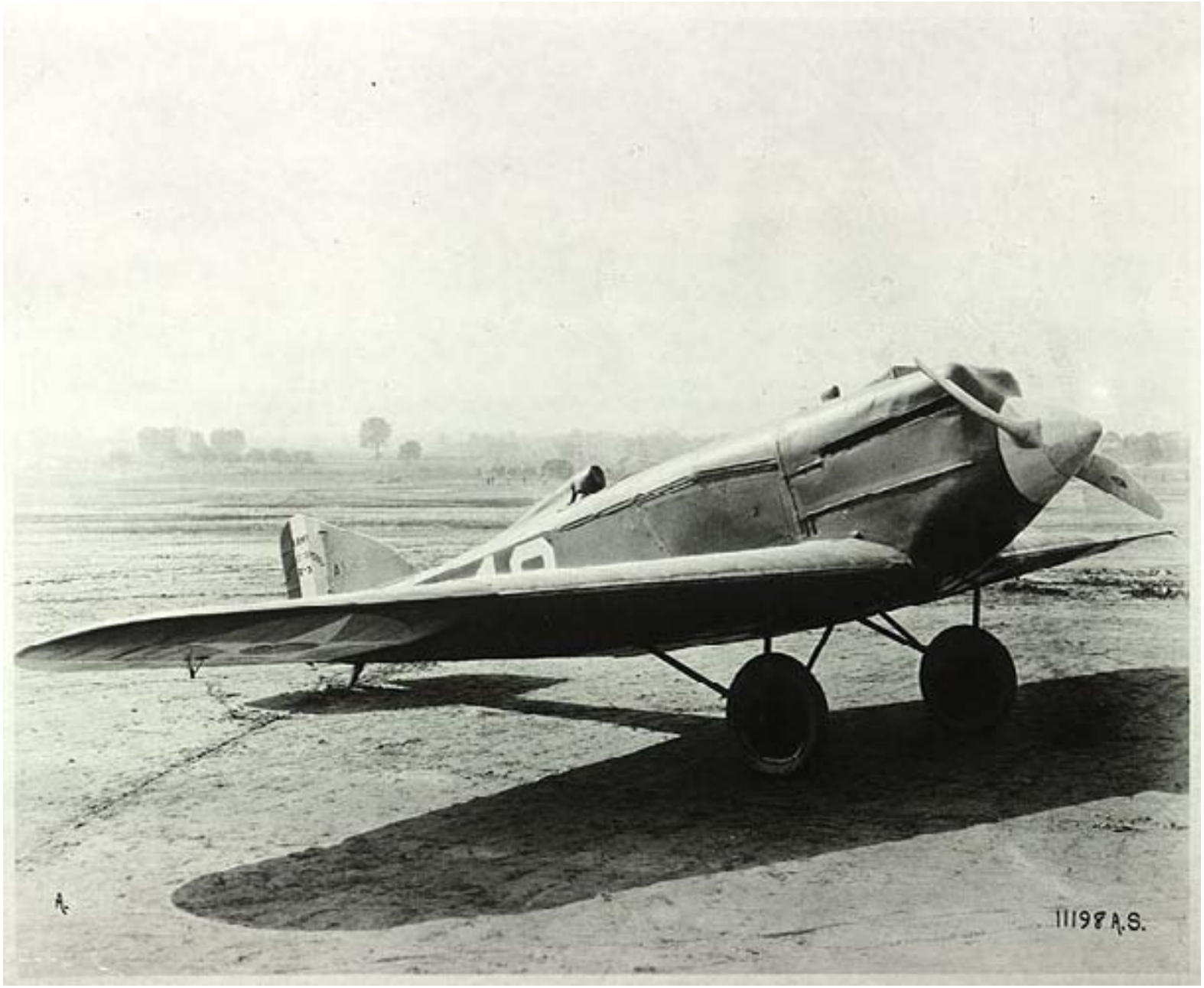
F.A.I.

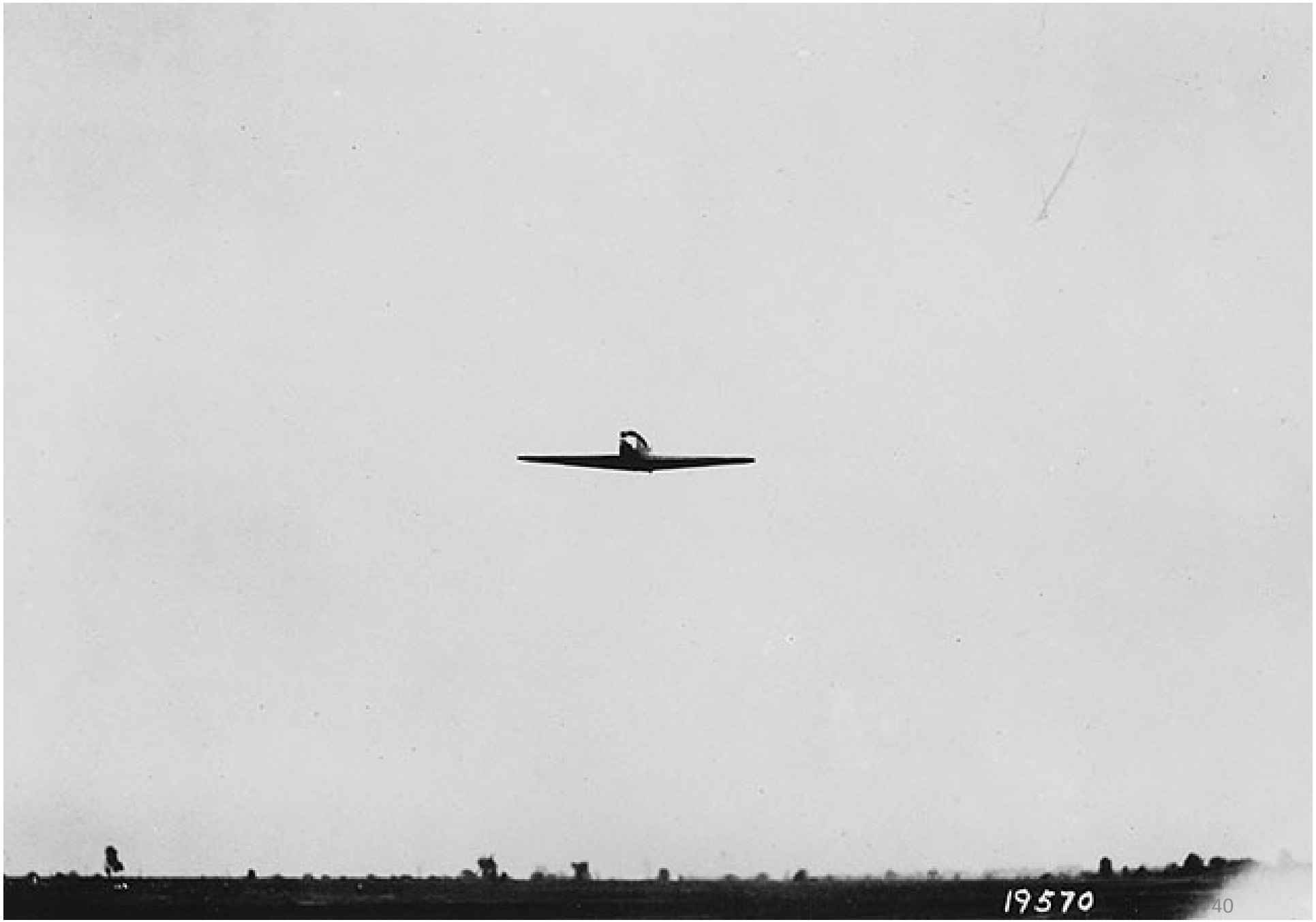
for

500 KILOMETERS at 167.73 M.P.H.

VERVILLE SPERRY R-3 RACER

The American Racing System

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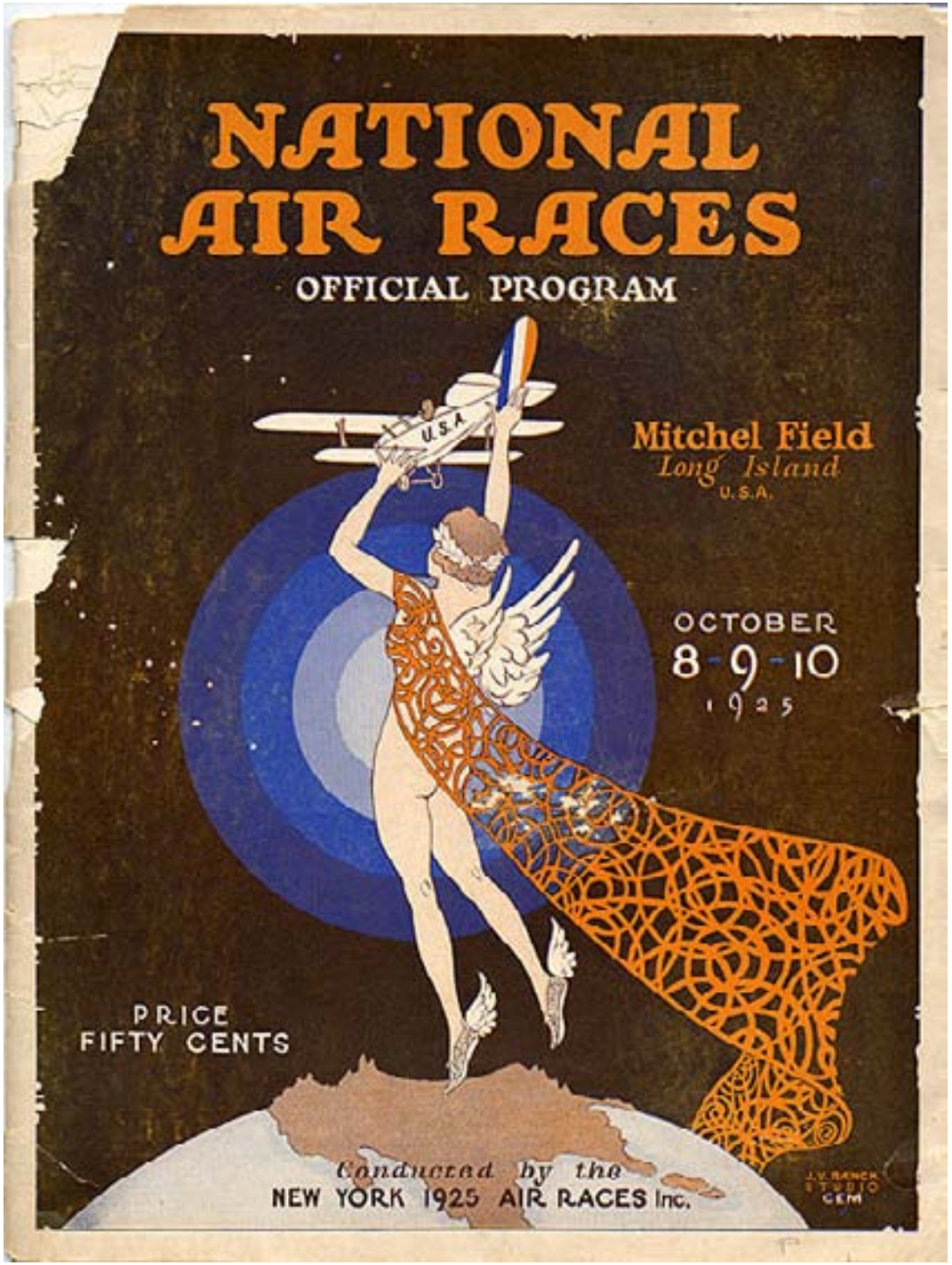
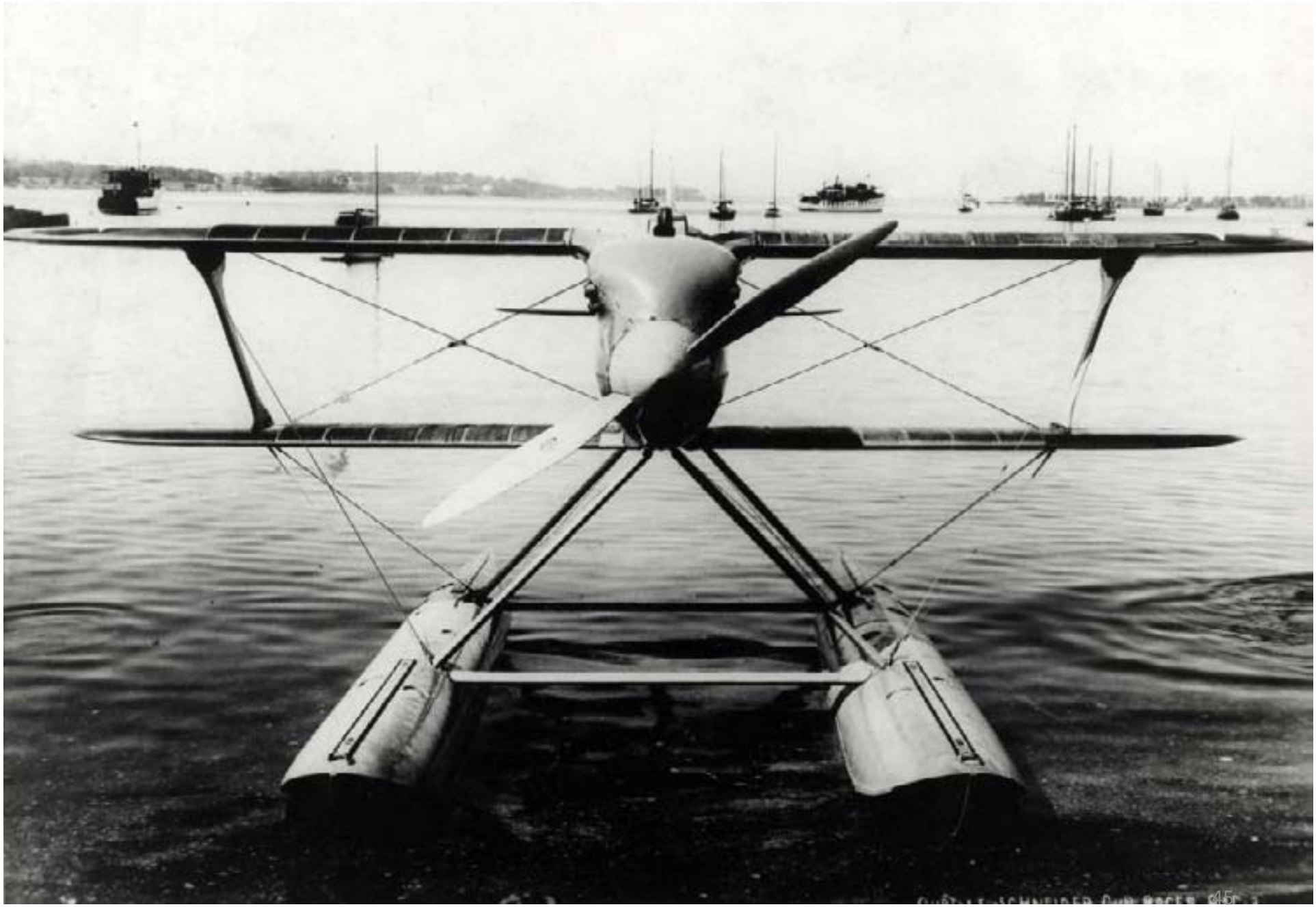
The Curtiss Racing System

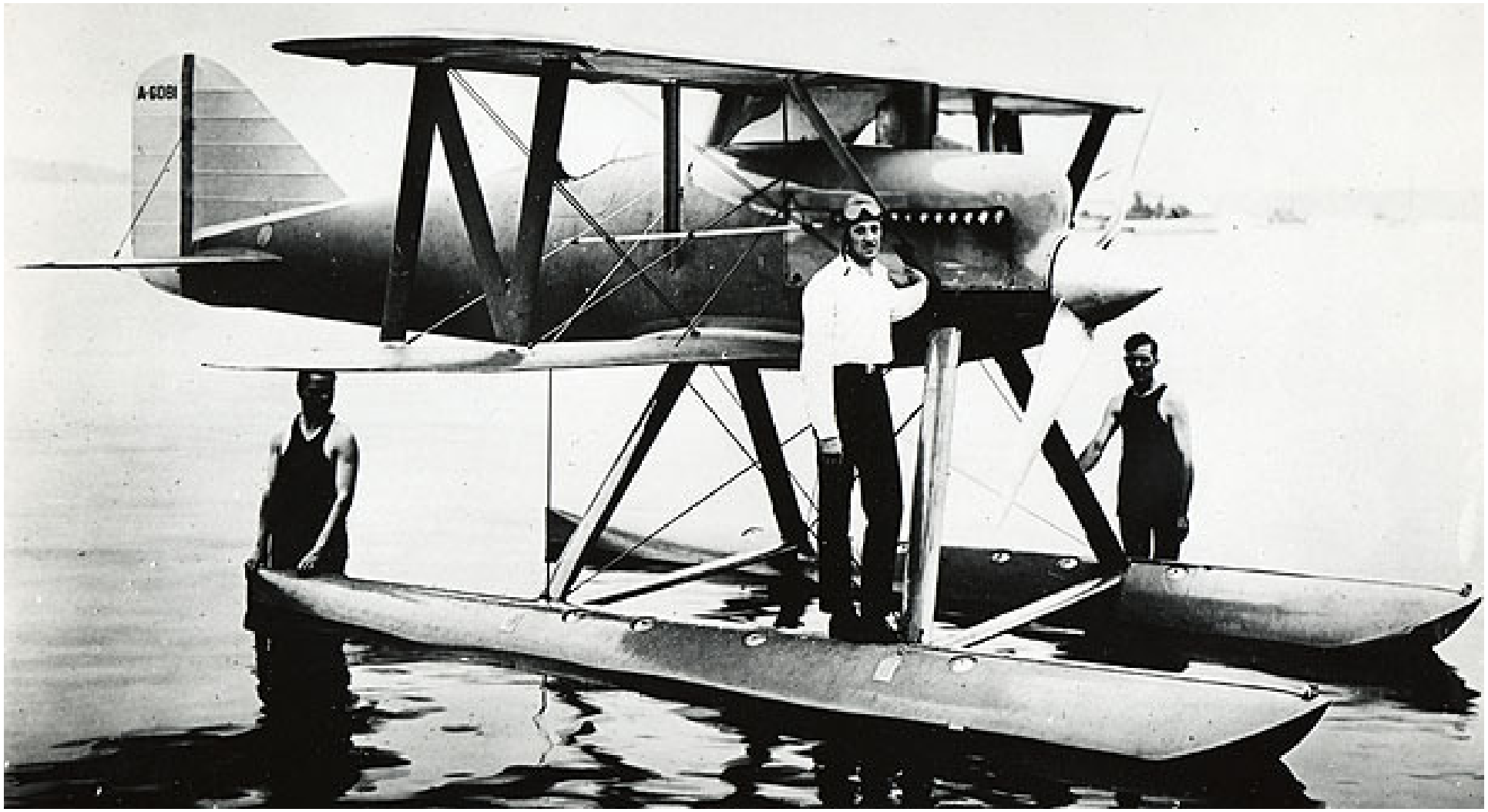
1923 Pulitzer Race


NATIONAL
AIR RACES
OFFICIAL PROGRAM
U.S.A.
Mitchel Field
Long Island
U.S.A.
OCTOBER
8-9-10
1925
PRICE
FIFTY CENTS
Conducted by the
NEW YORK 1925 AIR RACES Inc.


International
JACQUES SCHNEIDER CUP
RACES
BALTIMORE OCT. -24- 1925 U.S.A.
BAY SHORE PARK



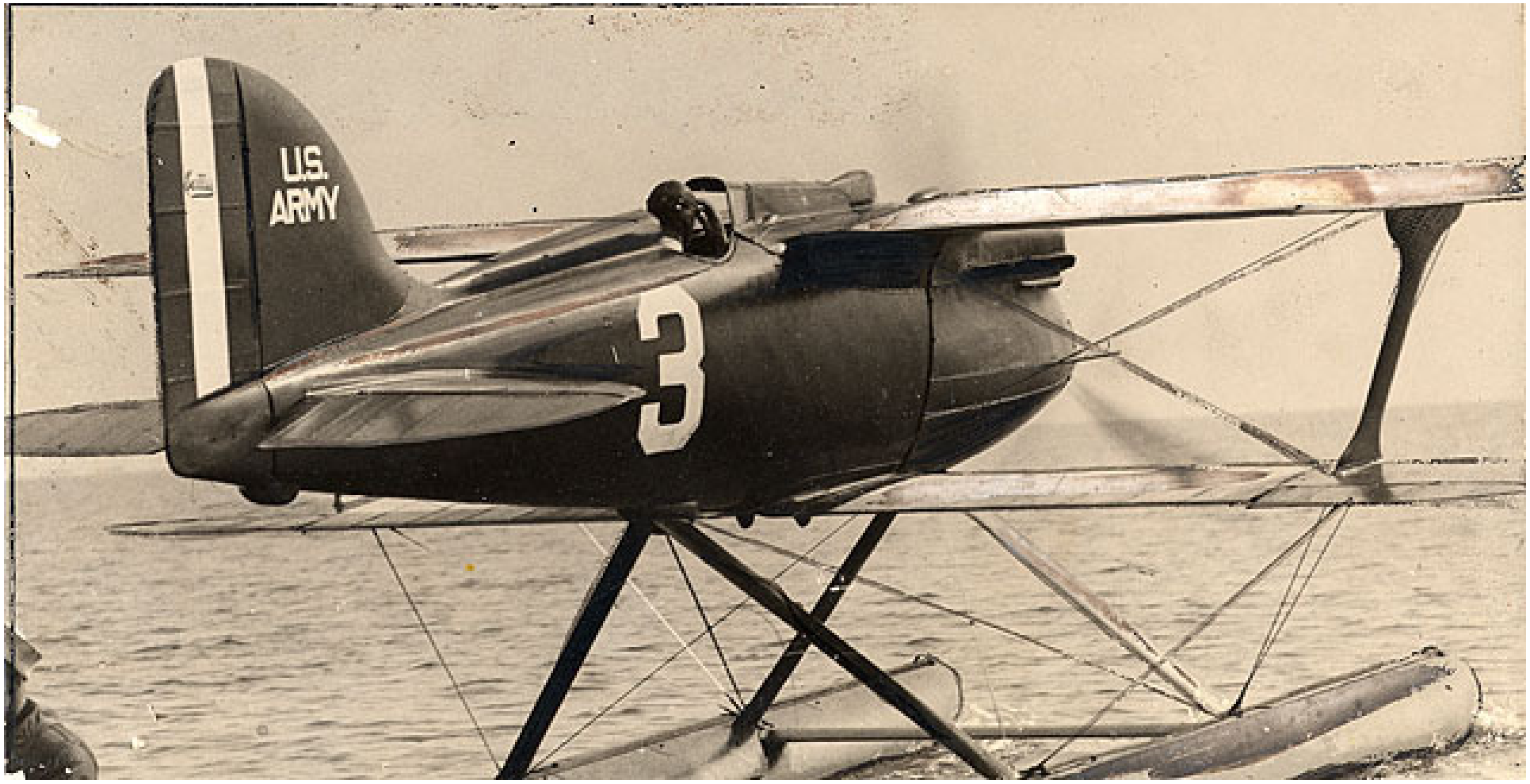
1923 Schneider Competition: A “Revolution in Design”



1925: The Culmination of American Military Air Racing

- Curtiss R3C
- Pulitzer Race
  - Lt. Cyrus Bettis
- Schneider Contest
  - Lt. James H. "Jimmy" Doolittle
  - World Speed Record

1925 Schneider Competition, Bay Shore Park, Baltimore, Maryland




U.S.
ARMY
12279 A.S.

Lt. Bettis Rounding the Pylon at the 1925 Pulitzer Race, Mitchel Field, Long Island, New York

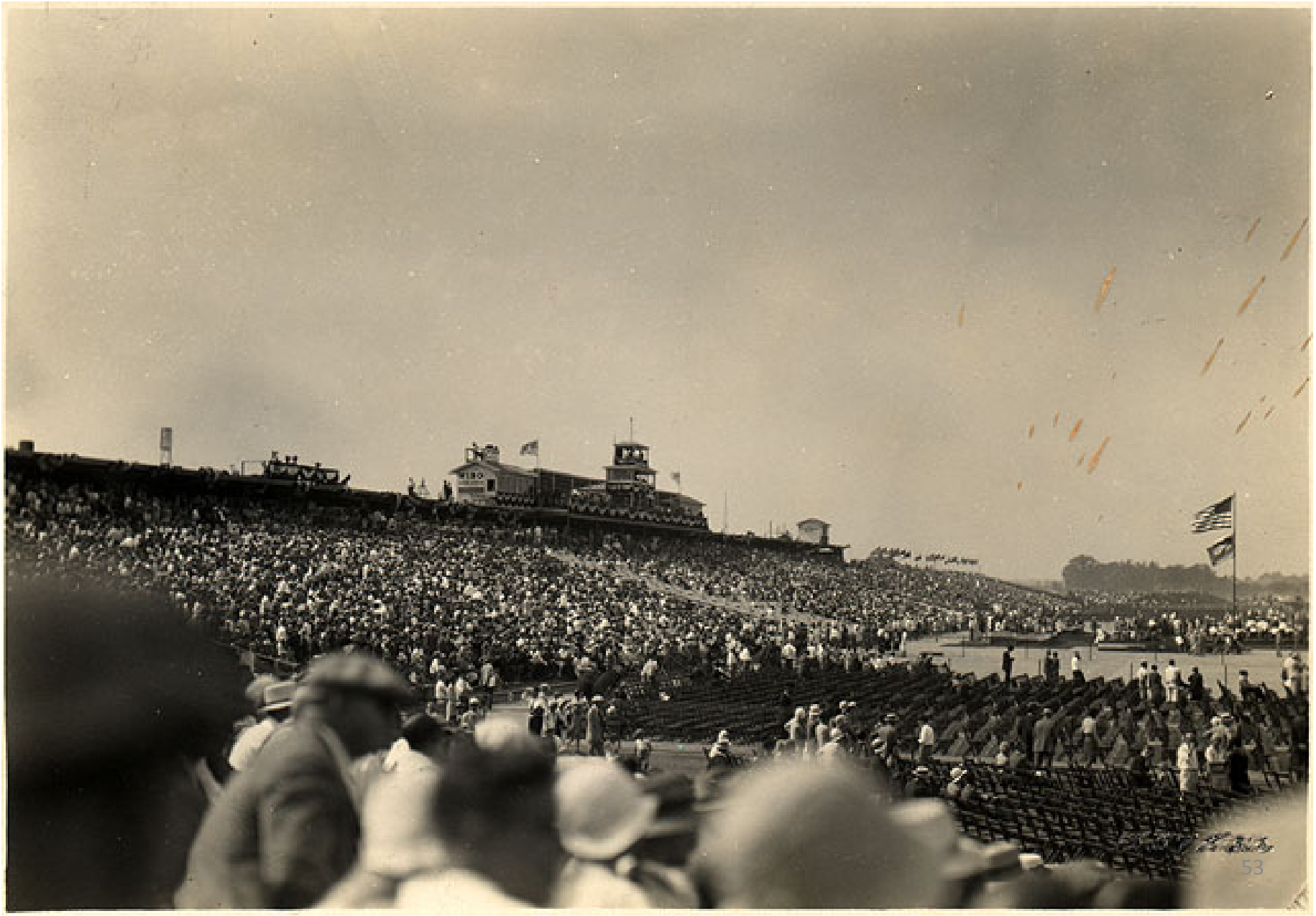

NATIONAL
AIR RACES
AUG. 27 to SEPT. 5
CLEVELAND
HIGHER SPEEDS • GREATER THRILLS
GIGANTIC NIGHT SPECTACLE
Seat Prices Greatly Reduced

American military aviation can “stand on its own real worth and dignity.”

- Patrick
- Kimball Committee
- Moffett
- Cancellation of 1927 racing programs
- Continued participation

Patrick Mitchell

1930 National Air Races, Chicago



1932 Gee-Bee
Thompson Trophy Winner

“I am a speed merchant.”: Bendix Trophy

- 1933
- New York-to-Los Angeles
- 11 hours, 30 minutes
- 2 time winner

Turner RT-14 1934

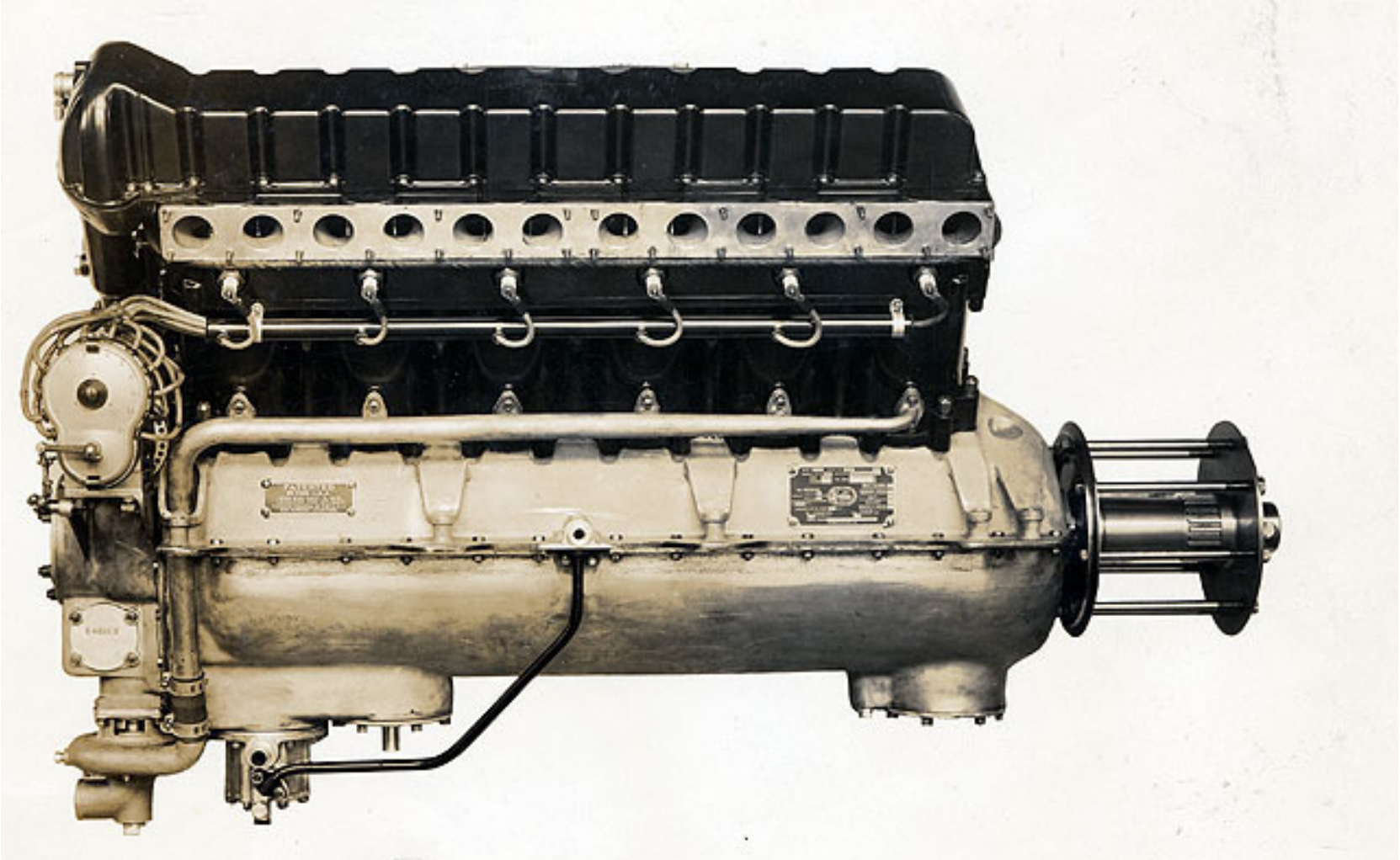

1936
NATIONAL
AIR RACES
LOS ANGELES
SEPT·4
5·6·7

Aerospace Engineering
Manufacturing Advances

Aviation Advances

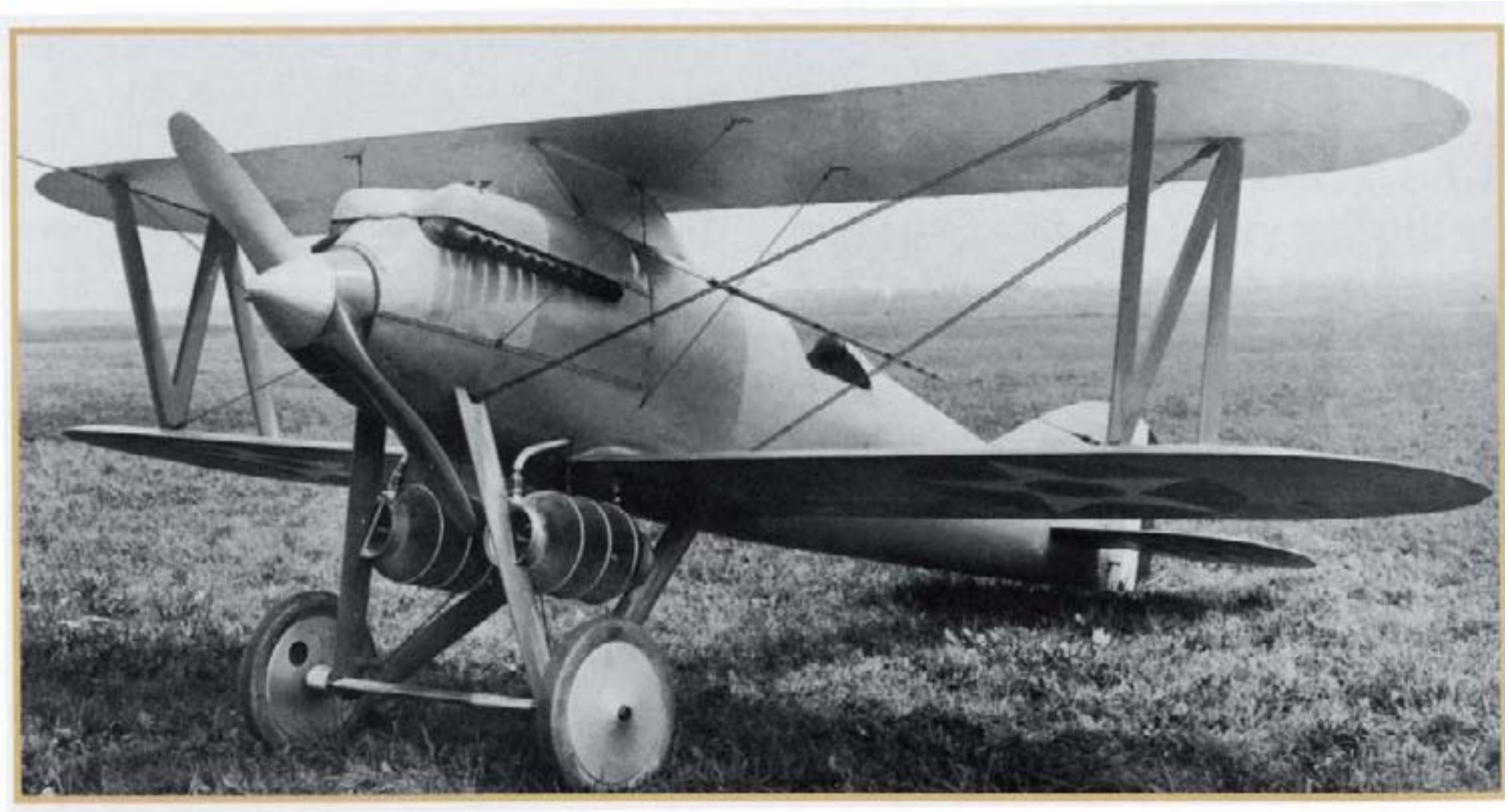
Reed Duralumin Propeller

Curtiss Racing Engines: D-12



Power rating: 242 kW (325 hp) at 1,800 rpm
Displacement: 18.8 liters (1,145 cu. in.)
Weight: 309 kg (680 lb.)
Manufacturer: Curtiss Aeroplane and Motor Company

Lamblin Radiators

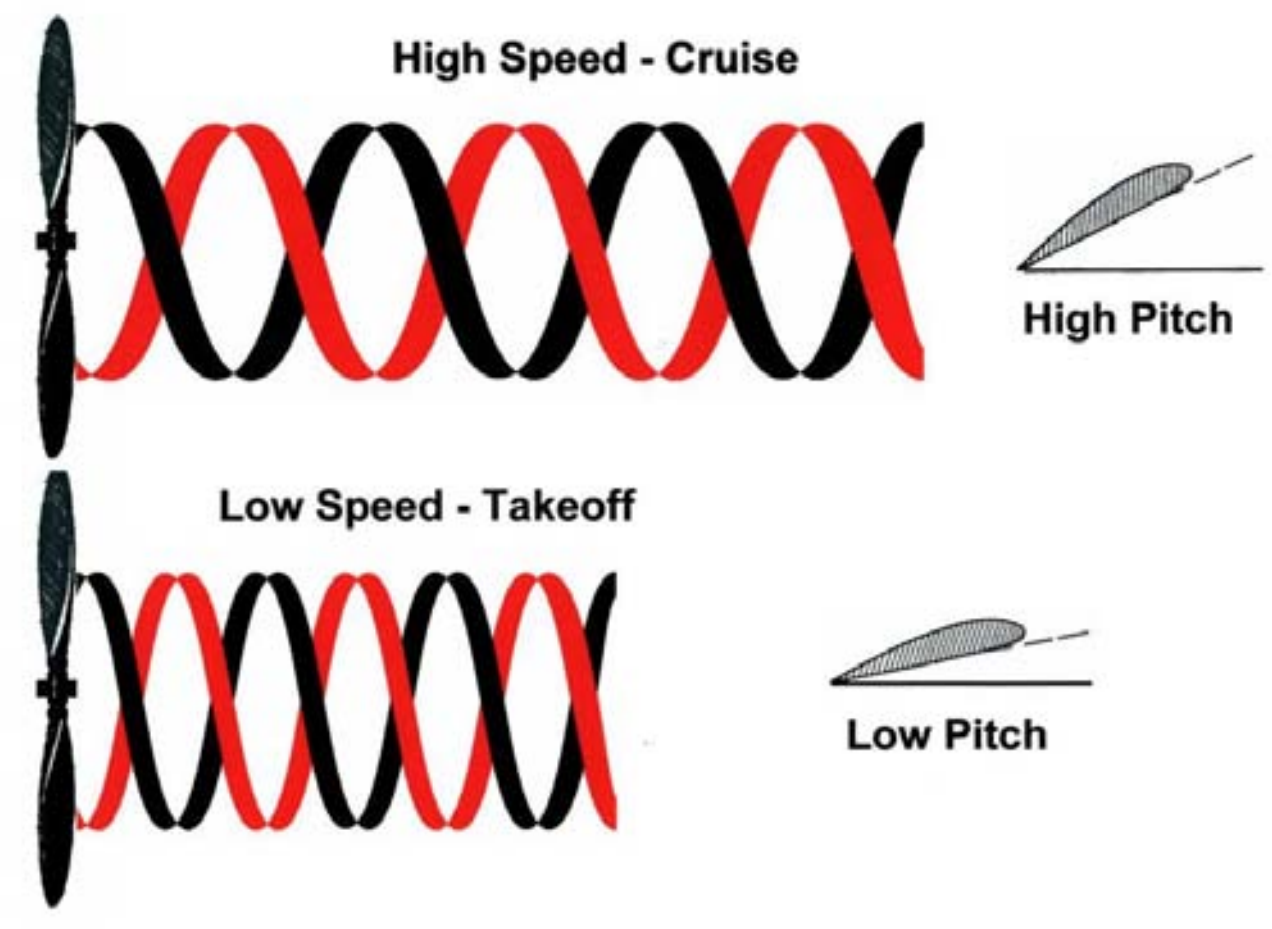


Flush Wing Radiators

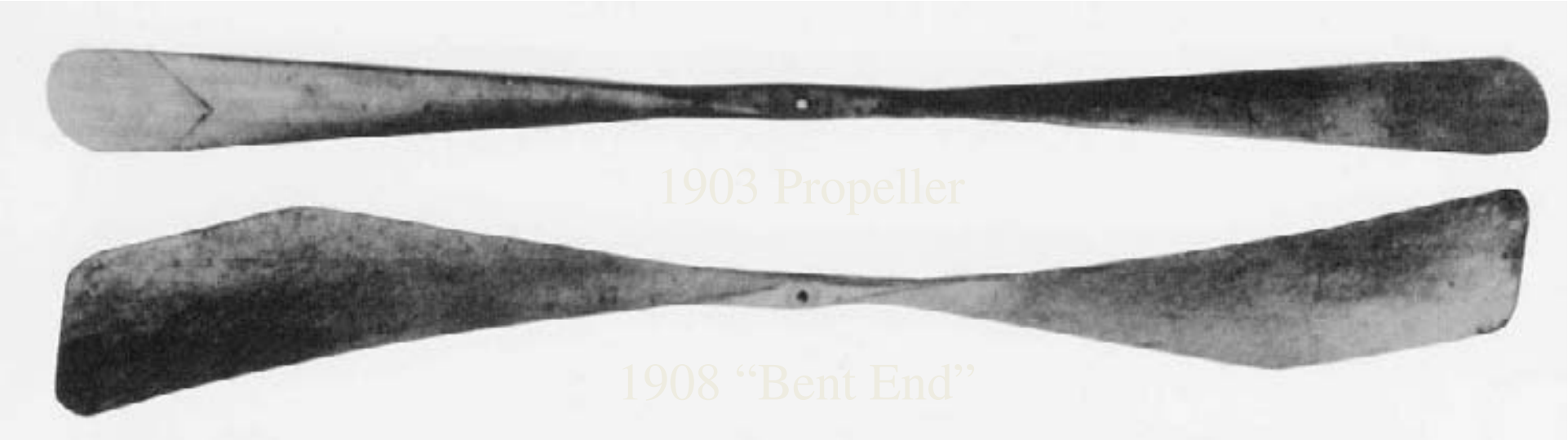
Aerial Propellers

"…a rotating wing in a helical path…" How do we do these?

- Through WWI, a compromise with a fixed propeller
- Then thru extensive development, variable pitch and reversible



The World's First Propellers

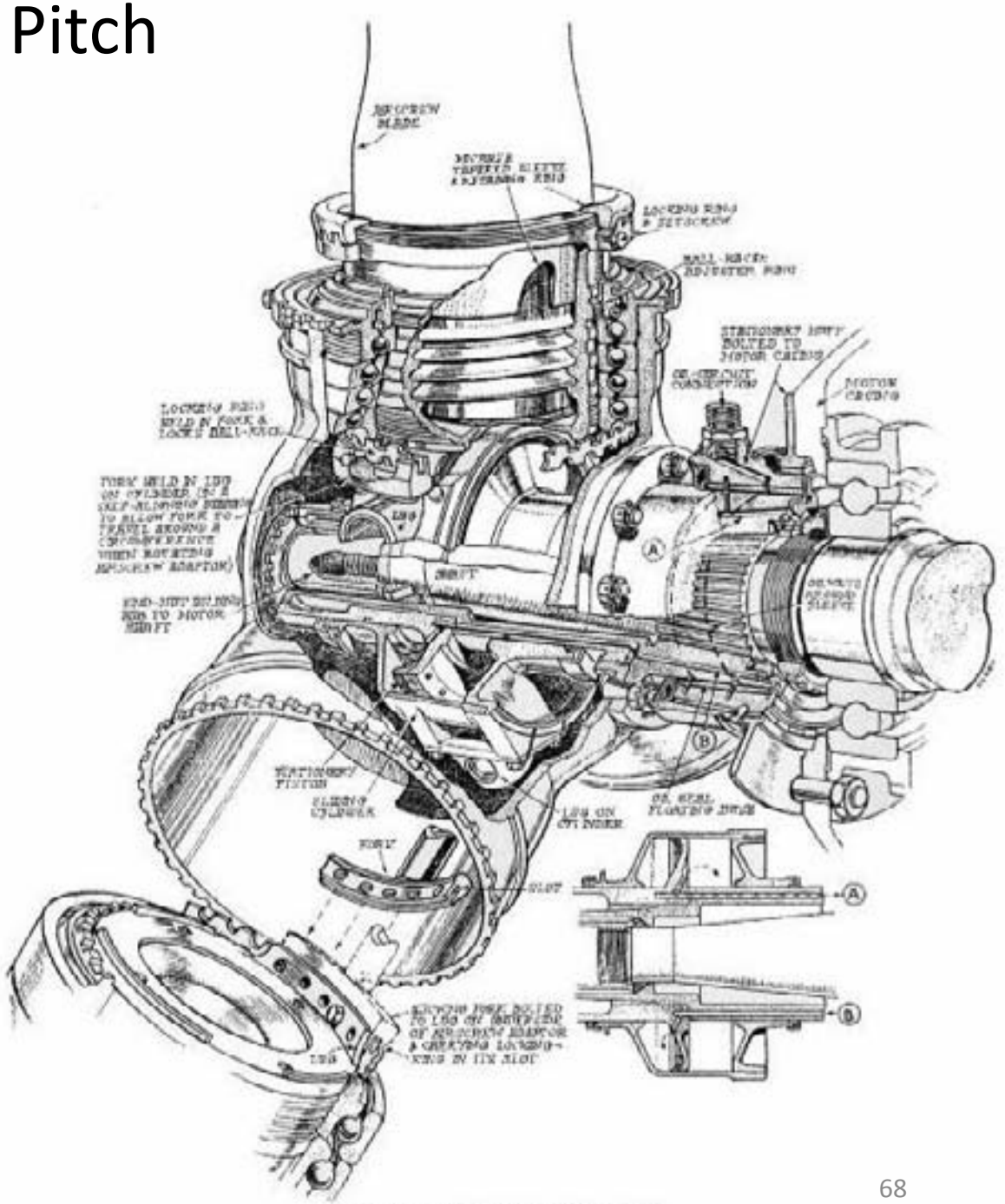


- Propulsion System =
  - Engine + Propeller + Support Equipment

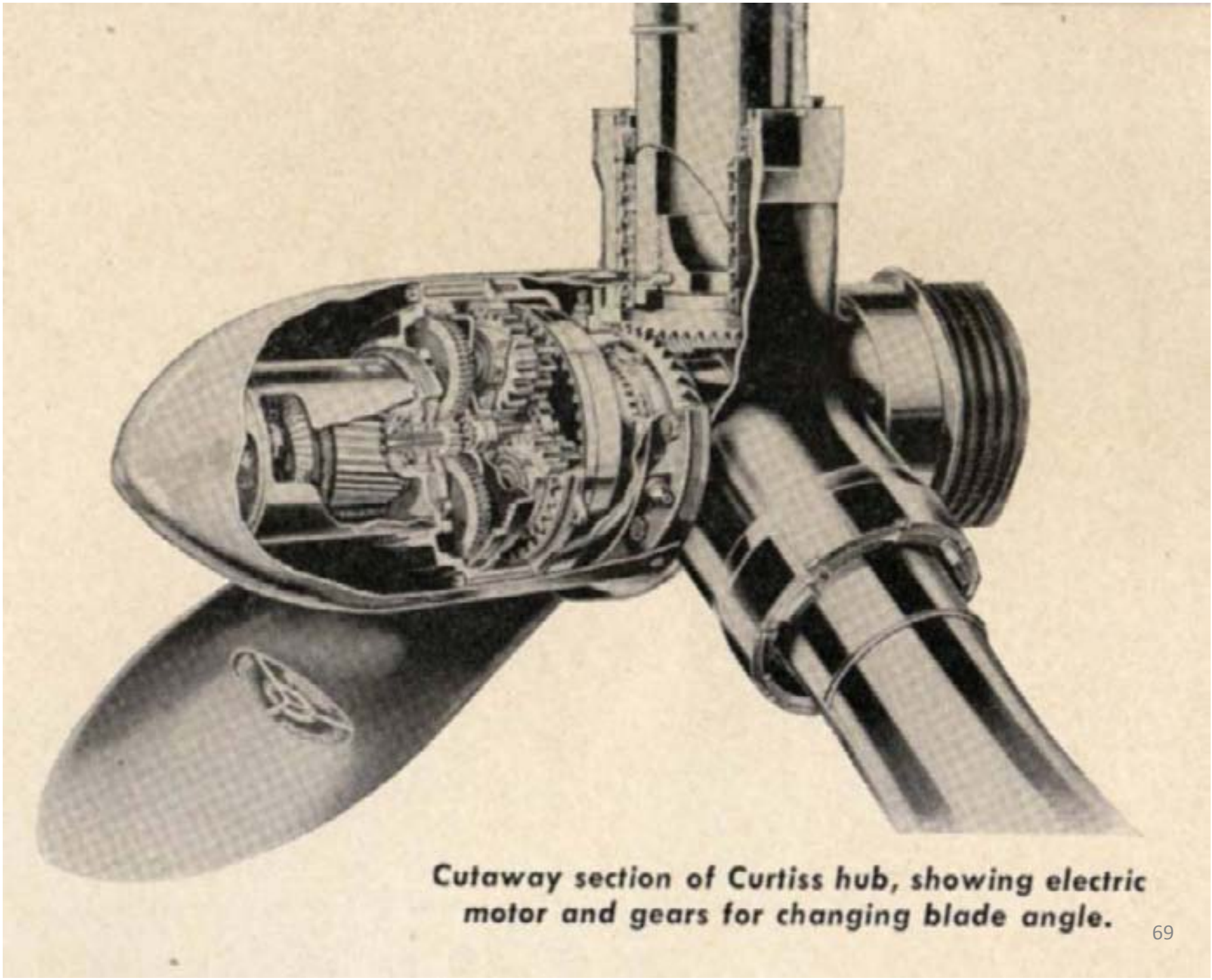
Era of the Wood, Fixed-Pitch Propeller

The First Variable Pitch Propeller

- 1924
- H.S. Hele-Shaw
- T.E. Beacham
- Constant-Speed
- Hydraulic
- Governor
- Gloster
- Resistance
- “Pop” Milner
- Bristol



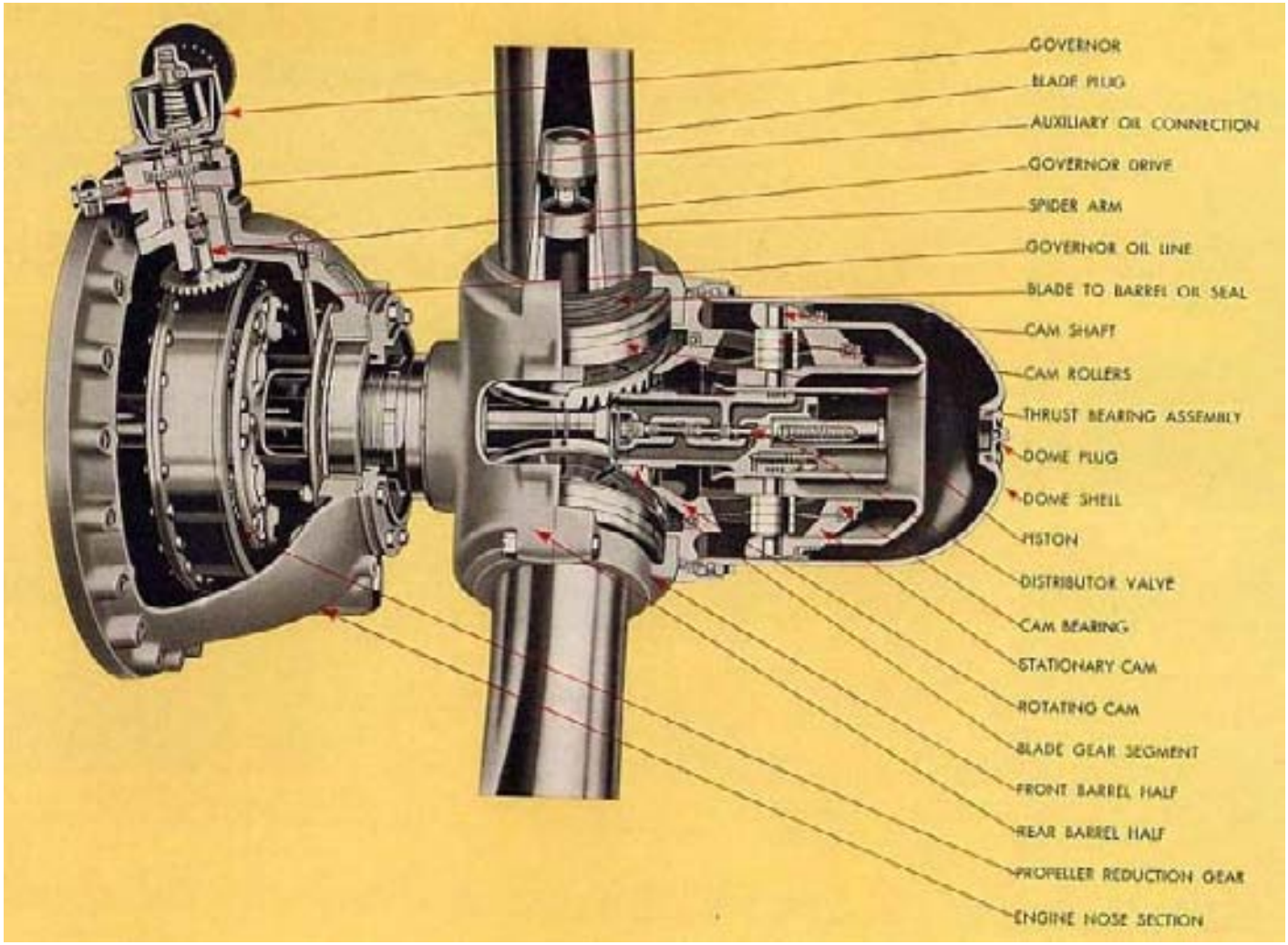
By Courtesy of "THE AEROPLANE"



Cutaway section of Curtiss hub, showing electric motor and gears for changing blade angle.

Hamilton Standard Hydromatic Propeller

- **Boeing 307 Stratoliner Clipper Flying Cloud**
- **Grumman F6F-3 Hellcat**
- **North American P-51C Mustang *Excalibur III***
- **Vought F4U-1D Corsair**



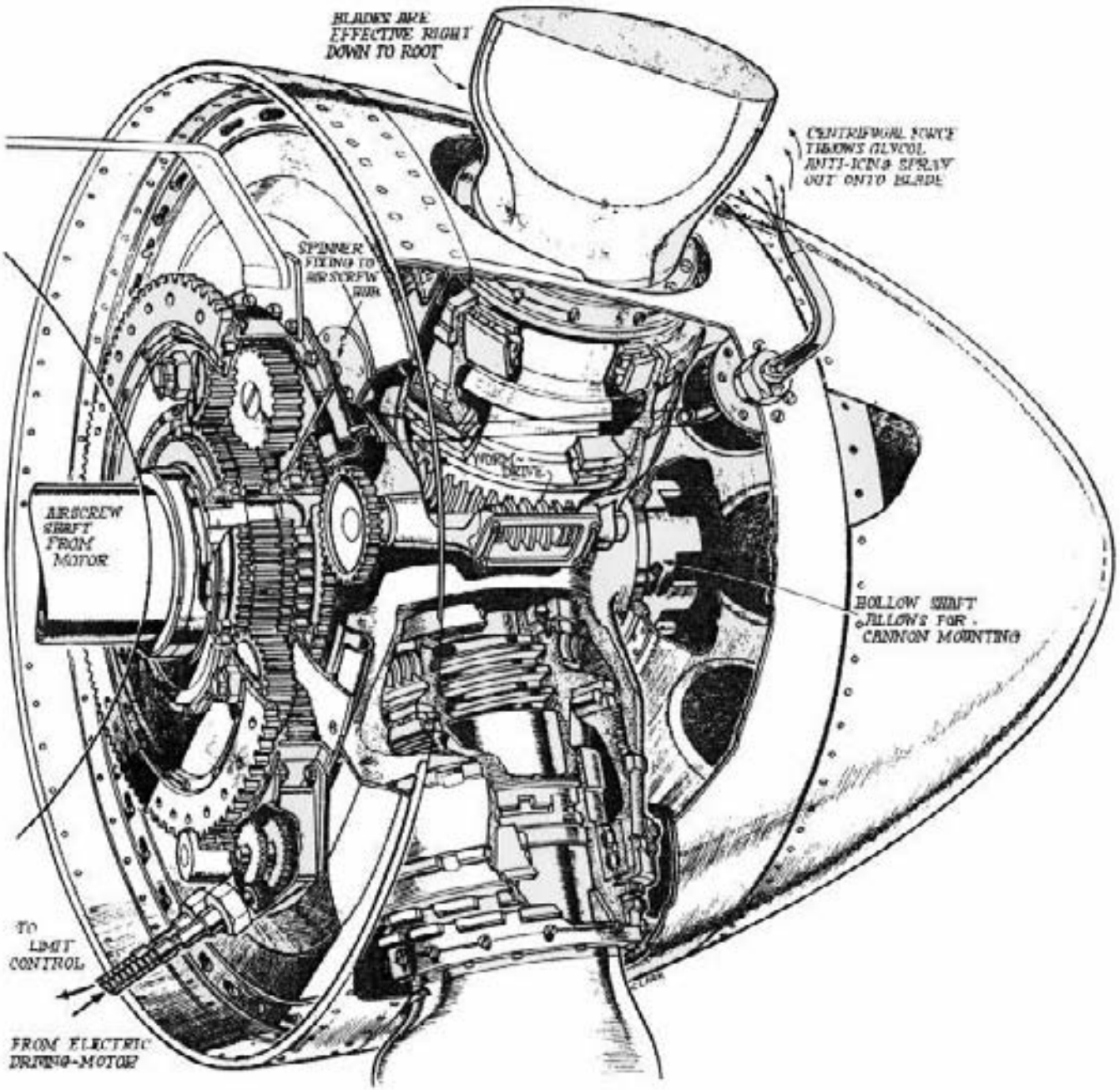
World War II & the Variable-Pitch Propeller

- Feathering
- Hamilton Standard
  - 530,135 Hydromatic propellers
- Curtiss Propeller Division
  - 144,863 Curtiss Electric propellers
- Aeroproducts Division of GM
  - 20,773 Aeroprop constant-speed propellers

Vereinigte Deutsche Metallwerke (VDM)

- 1937
- Electric-Mechanical
- Feathering
- Metal or Composite Blades
- Hollow Shaft
- 90% of the Luftwaffe's front-line aircraft used VDM propellers

- Dornier Do-335A-1 Pfeil (Arrow)
- Focke-Wulf Fw 190 F
- Heinkel He 219


BLADES ARE EFFECTIVE RIGHT DOWN TO ROOT
CENTRIFUGAL PUMPS THROWS GLYCOL ANTI-ICING SPRAY OUT ONTO BLADE
SPINNER FIXING TO AIRSCREW HUB
AIRSCREW SHAFT FROM MOTOR
HOLLOW SHAFT ALLOWS FOR CANNON MOUNTING
TO LIMIT CONTROL
FROM ELECTRIC DRIVING-MOTOR

Post-War Aviation, 1945-Present

Dowty R391 Advanced Propeller System

- Lockheed Martin

  C-130J Hercules
- Hydraulic constant-speed, counterweight
- Reversible
- Full-feathering
- Composite materials
- Serial #0001

Institutionalized Air Traffic Control

- **1930s Commercial Air traffic builds up to the point that airways controls are instituted for safety concerns initially on major routes in the continental US and then internationally**
- **Details are in the section on Commercial Aviation**

The Jet Engine Appears on the Scene
1930

Way back when - First Jet Engine

An aeolipile (or aeolipyle, or eolipile), also known as a Hero engine, is a rocket style jet engine which spins when heated.

In the 1st century AD, Hero of Alexandria described the device, and many sources give him the credit for its invention.

Jet Technology Paths

Inventor: Frank Whittle, English

- **Patent, 1930**
- Single-sided centrifugal compressor
- Less flexible design
- Retained control of design longer
- Delivered an engine
- Later implemetation

Inventor: Hans Von Ohain, German

- **Patent, 1936**
- multiple axial flow in-line compressors
- More flexible design
- Worked as a senior designer
- First engine to power an aircraft
- Design that was eventually universally implemented

Jet Age, Military Chronology

Inventors: Frank Whittle and Hans Von Ohain

- Air Commodore Sir Frank Whittle, a British RAF engineer officer is credited with independently inventing the turbojet engine (some years earlier than Germany's Dr. Hans von Ohain) and is generally hailed as the father of jet propulsion.
- At RAF Cranwell while writing his thesis he formulated the fundamental concepts that led to the creation of the turbojet engine, taking out a patent on his design in 1930.
- Without Air Ministry support, he and two retired RAF servicemen formed Power Jets Ltd to build his engine with assistance from the firm of British Thomson-Houston. Despite limited funding, a prototype was created, and ran in 1937.
- Official interest was forthcoming following this success, with contracts being placed to develop further engines. In 1944 Power Jets was nationalized.

- A parallel German Jet engine was perfected by Ohan working first for Henkel and then for Junkers

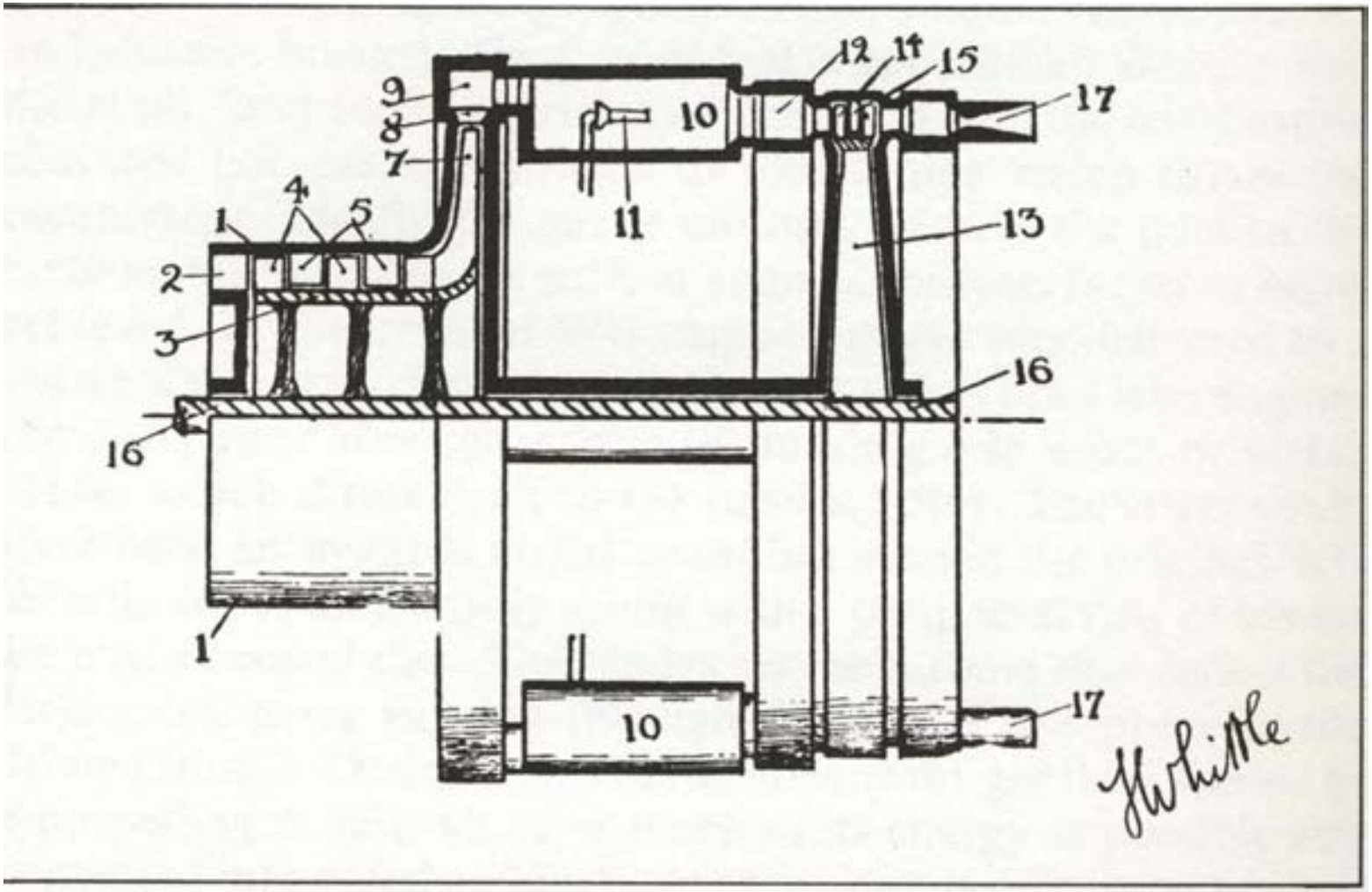
Jet Age, Military Chronology
Inventors: Frank Whittle and Hans Von Ohain

- Von Ohain , a German engineer, one of the inventors of jet propulsion.
- Von Ohain filed a patent in 1936 in Germany.
- Both Whittle and Von Ohain developed the concept independently during the late 1930s.
- Although credit for the first successfully run turbojet is given to Whittle, Ohain's design was the first to power an all-jet aircraft, the first prototype of the Henkel He 178 in late August 1939.
- Although none of his designs entered production, his underlying contributions to the development of the German version of the jet engine were invaluable.

Two Early Competing Designs

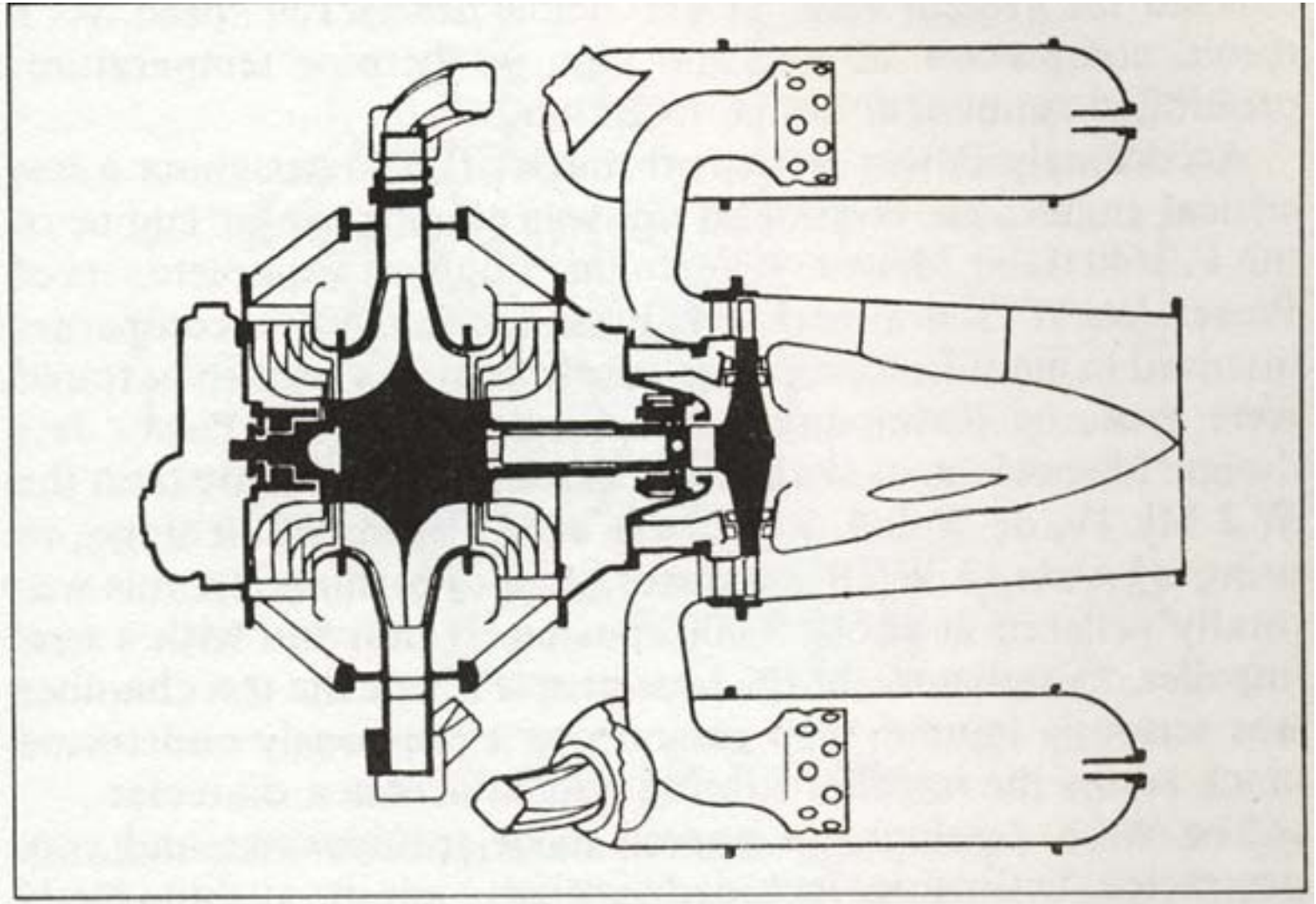
- **The first Whittle engine successfully flew in April, 1937. This engine featured a multistage compressor, feeding a single-sided centrifugal compressor and a combustion chamber, a single stage turbine and a nozzle.**
- **Ohain's jet engine powered the Heinkel He 178, it was the world's first turbojet flight. His design had multiple axial flow in-line compressors. This is the current predominant design.**
- **General Electric built the first American jet engine, the A1, based on Whittle's design. It powered the Bell XP-59A experimental aircraft.**

Whittle Engine



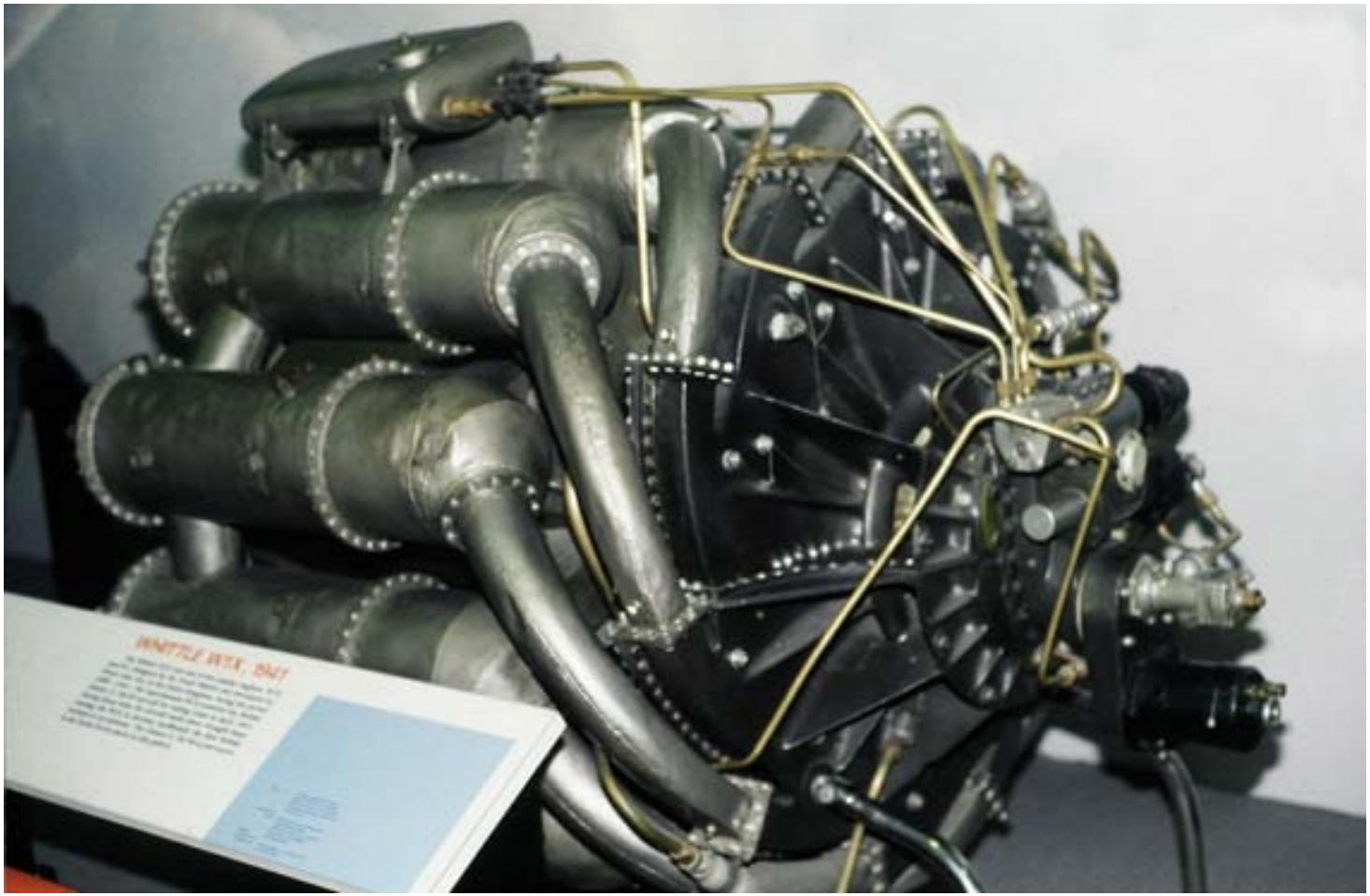
Reproduction of drawing, illustrating British Patent No. 347,206, filed 16th January 1930

Whittle's 1st Flight Engine

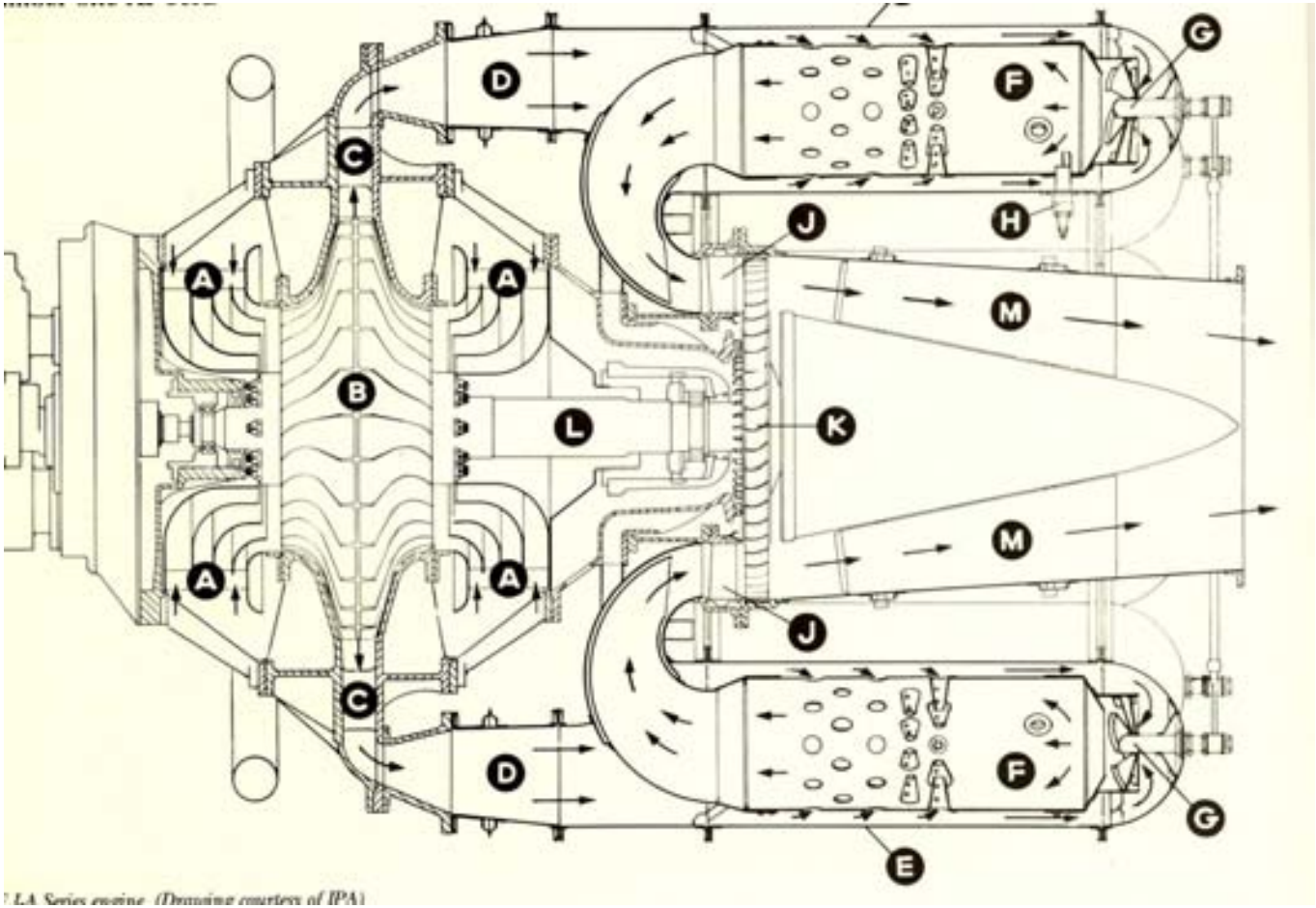


Assembly of the W.1A engine

Whittle Engine



GE I-A

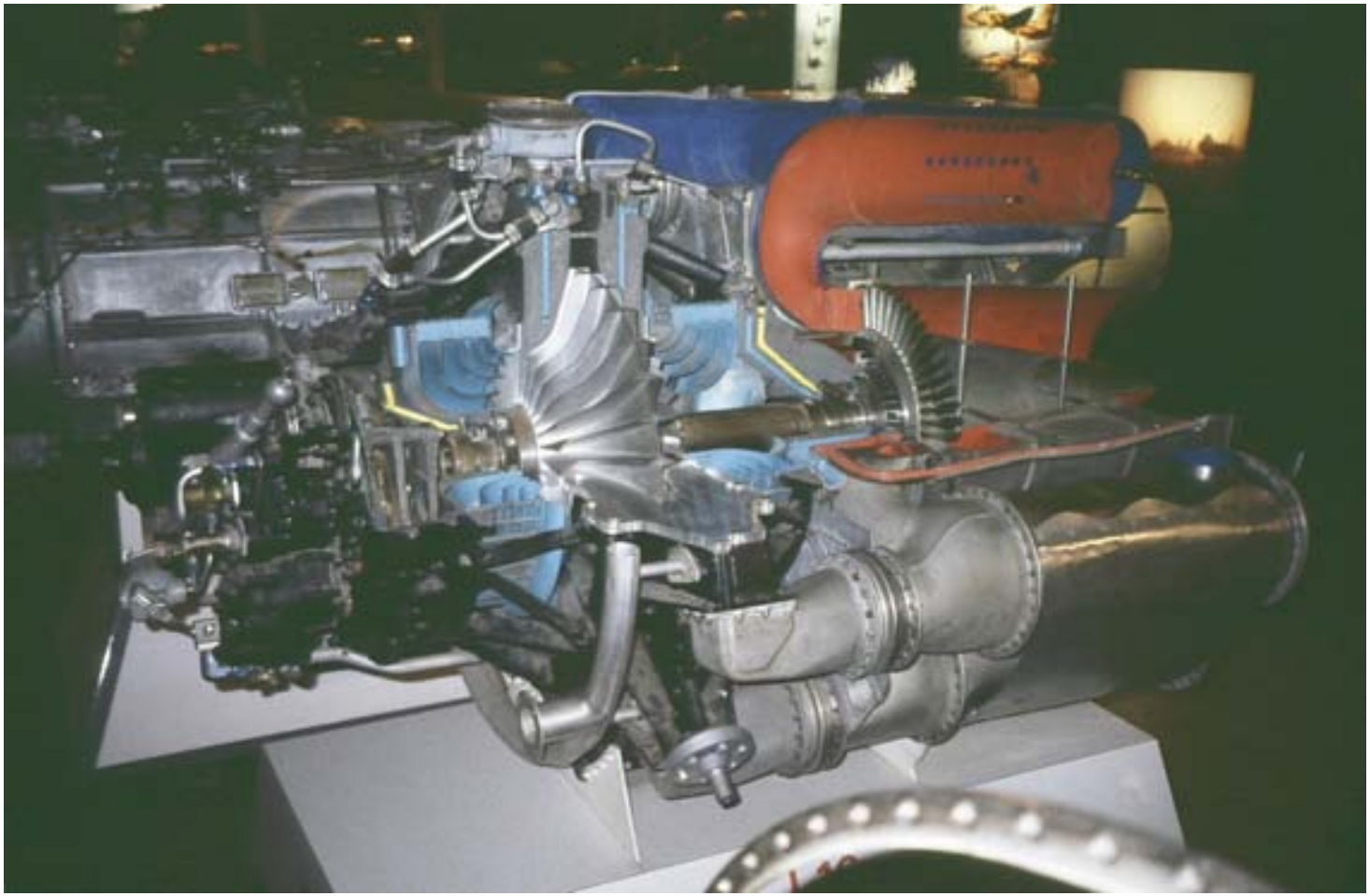


I-A Series engine. (Drawing courtesy of IPA)

Cutaway of GE Version of Whittle Engine

Powered the Bell P-59, 1943

A later GE/Allison upgrade powered the P-80, 1944



Cutaway of von Ohain Engine

Cutaway of The Junkers Jumo 004

- **Early models, the first successful axial compressor jet engine .**
- **Later models, the first turbojet engine in production and operational use.**
- **Some 8,000 units were manufactured by Junkers during late World War II, it powered the operational Messerschmitt Me 262 jet fighter, Arado Ar 234 jet reconnaissance /bomber, and prototypes of the Horten Ho 229 aircraft.**

Jet Aircraft flew in World War II

- German
  - Heinkel He 178 — 1939
  - Messerschmitt 262*+ — 1941, production 1944
  - Adaro 234 Bomber*+ — production 1944
- Italian
  - Capponi N1 — 1940
- Russian
  - Rereznyak-Isayev BI-1 — 1941-1945, prototypes

\+ Common Junker's Jumo 004 engine

- Red – On display at the Smithsonian

Henkel, with first Jumo engine

Capponi

Meteor, with first Whittle engine

Messerschmitt

Arado

Rereznyak-Isayev BI-1

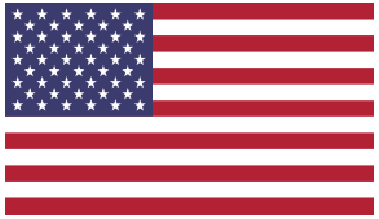
Jet Aircraft flew in World War II

- British
  - Gloster E28/39 Meteor 1941
  - De Havilland Vampire 1945
- American
  - Bell P-59 1943
  - Lockheed F-80 Shooting Star 1945
- Japanese
  - Nakajima J9Y Kikka 1945

Pre-World War II build up

- **Depression era Federal policies to keep aircraft manufactures in business.**
  - **Small buys**
  - **After World War II began in Europe, but before Pearl Harbor**

  the CAA launched a Civilian Pilot Training Program to provide the nation with thousands more aviators.
  - **In 1941 responsibility for Iceland passed to the US under a US - Icelandic defense agreement, instigated by the British.**
  - **President Roosevelt ordered occupation of Iceland on 16 June 1941. The 1st Provisional Marine unit sailed from Charleston, SC on 22 June. Army and Naval units remained through out the war and later as part of NATO.**



Late 1930s Political Actions Supporting Aviation

- Large scale pilot training
- Lead Lease - material
- Flying Tigers [American Volunteer Group] flying Curtiss P-40s
- Moth-balled Destroyers exchanged with the British for Atlantic Naval/Naval Air Bases

European Purchases sets the basis for Framework for WWII Production

- US manufacturers benefited from military aircraft purchases by European powers, especially Britain and France, when they rearmed in the late 1930s.
- Purchases by European powers doubled US output in the late 30s, bringing many aircraft companies their largest orders.
- The British and French invested directly in aircraft and engine plants, and even before the Lend-Lease program of 1941 Britain and France had ordered 14,000 aircraft from US factories.
  - Montana/Alberta tractor pull
- European purchasing missions were responsible for ordering into production aircraft such as the P-51 Mustang that would later become the staples of the US air arms.