

Introduction to aeronautics

Part 2. The era of Strut-and-Wire Biplanes

2.1 The feature of the Biplanes

- **Biplanes dominated the first 30 years of aviation**
- **The majority of airplanes during WWI are warplanes**
- **The majority of warplanes during WWI are biplanes**



2.1 The feature of the Biplanes

- **Now the Biplanes are primarily used for entertainment purpose**



2.1 The feature of the Biplanes

- **To win the battle, the following problems should be solved**
 - **To generate more lift with limited wing span**
 - **To reduce the drag**
 - **To reduce the weight of the structure**
 - **To develop engines with higher T/W and reduce the drag caused by engine**
 - **Avoid the bullets hitting the propeller**

2.1 The feature of the Biplanes

- **Solutions:**
 - **Biplane configuration**
 - **The fairings on landing gears or retractable landing gears**
 - **Radial engine and NACA cowling**
 - **Gun synchronizer**

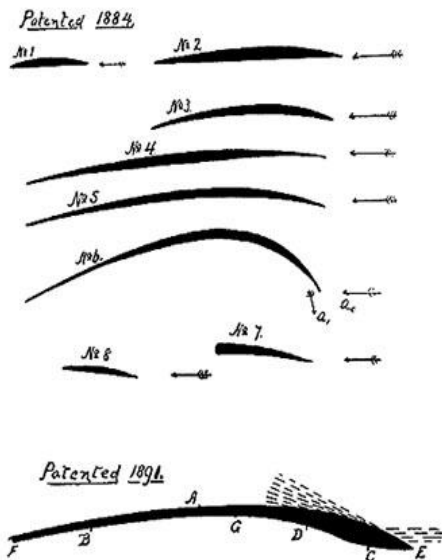
2.1 The feature of the Biplanes

- **A. The Biplane configuration**
 - Two wings are placed one above another



2.1 The feature of the Biplanes

- **A. The biplane configuration**
 - Very thin and highly cambered airfoil are first used, then they gradually diminished
 - Later, people recognized that thicker airfoils have much better aerodynamics performance, and larger structure profile and hence lower weight



2.1 The feature of the Biplanes

- **A. The biplane configuration**
 - **Very thin airfoil results in low structure profile**
 - **To reduce the weight, the bracing and wire structure for bridges is borrowed**



2.2 The feature of the Biplanes

- **A. The biplane configuration**
- **Advantage of the biplanes**
 - **For the same wing shape, the biplanes have lower induced drag**
 - **For the same wing area, biplanes possess higher aspect ratio and much shorter wing span**
 - **In case the low speed aircraft with limited wing span, biplane can be a good choice**
 - **The aerobatic plane, reduced span means higher roll rate**
 - **For aircraft with very low speed, reduced wing span means lighter structure**

2.2 The feature of the Biplanes

- **A. The biplane configuration**
- **Disadvantage of the biplanes**
 - **There is interference drag between two wings**
 - **The parasite drag is very high**
 - **For the monoplane with the same wing area and aspect ratio of each wing, biplane would generate less lift (Monoplane has larger wing span)**

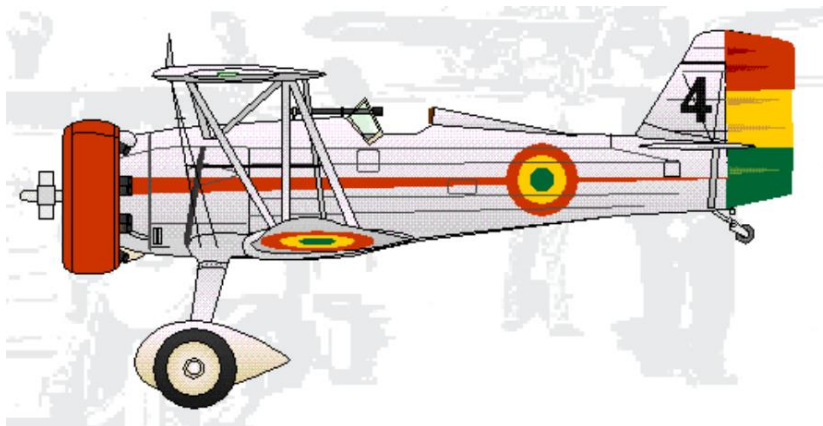
2.1 The feature of the Biplanes

- **B. The efforts to reduce the drag**
 - The fuselage is covered by fabric



2.1 The feature of the Biplanes

- **B. The efforts to reduce the drag**
 - The cockpit is opened, with very simple wind shield
 - As the speed of aircraft increases, the cockpit is enclosed



2.1 The feature of the Biplanes

- **B. The efforts to reduce the drag**
 - The fairings are mounted on the landing gear to reduce the drag



Polikarpov I-15

2.1 The feature of the Biplanes

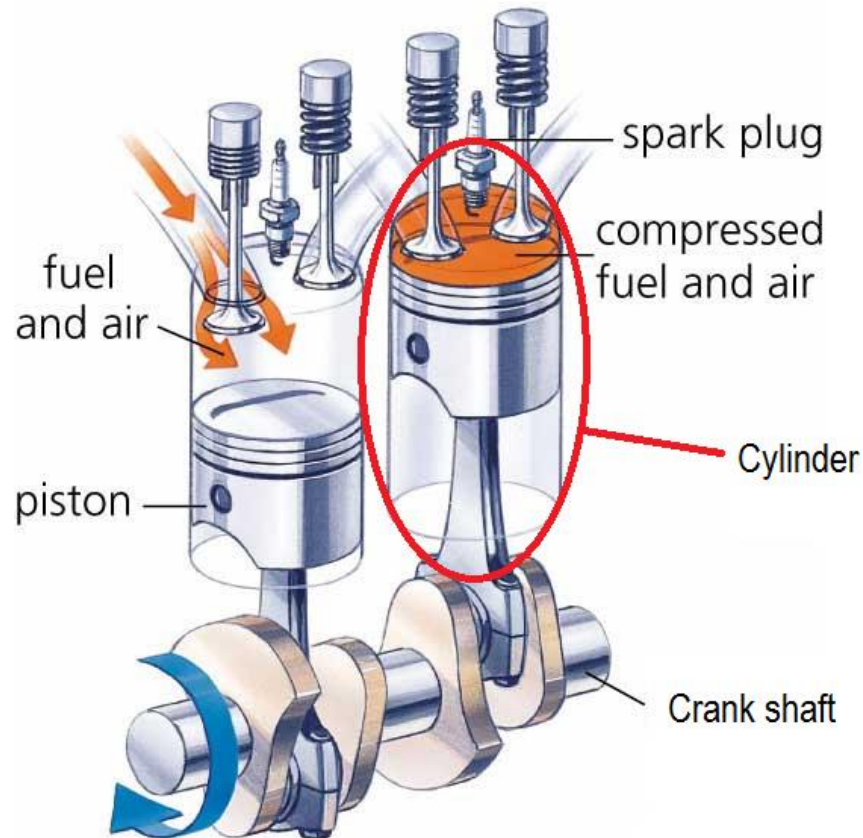
- **B. The efforts to reduce the drag**
 - **Some of them are equipped with retractable landing gear**



Curtiss Hawk III

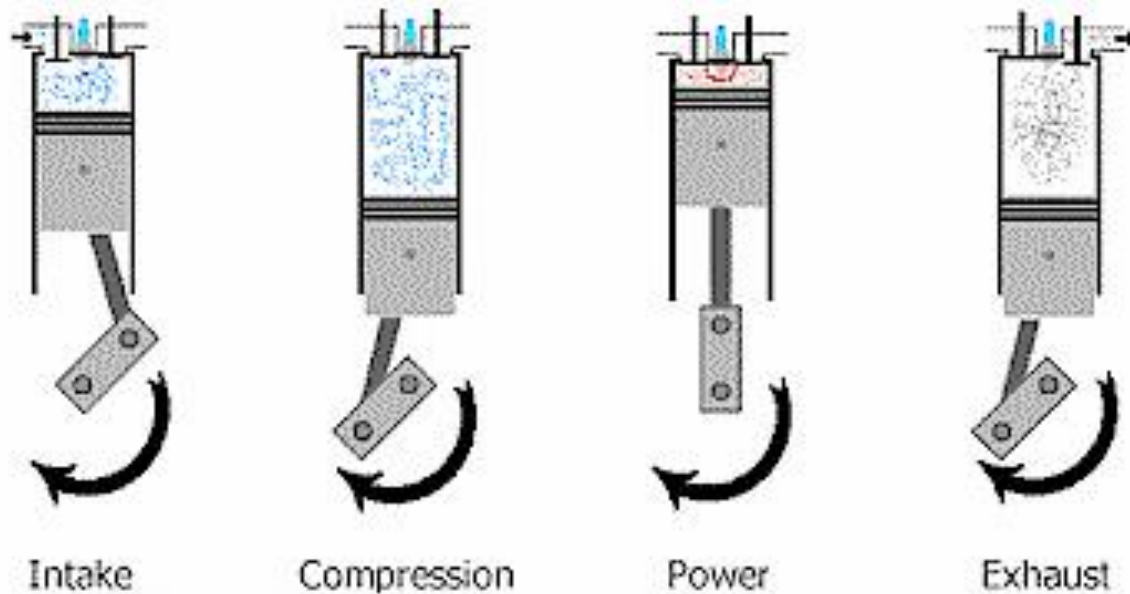
2.1 The feature of the Biplanes

- **C. The engine**
 - **The parts of piston engine**



2.1 The feature of the Biplanes

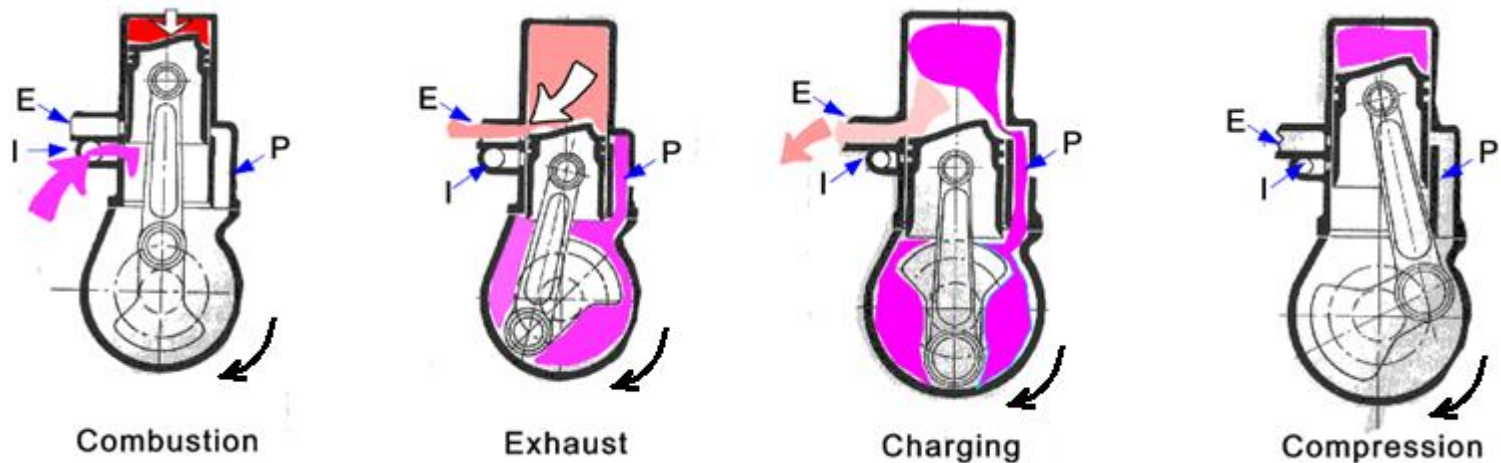
- **C. The engine**
 - How the reciprocating engine (piston engine) works



Four stroke piston engine

2.1 The feature of the Biplanes

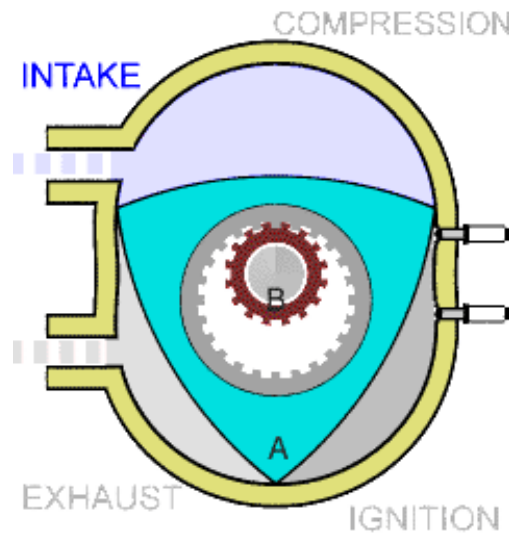
- **C. The engine**
 - How the reciprocating engine (piston engine) works



Two stroke piston engine

2.1 The feature of the Biplanes

- **C. The engine**
 - How the reciprocating engine (piston engine) works



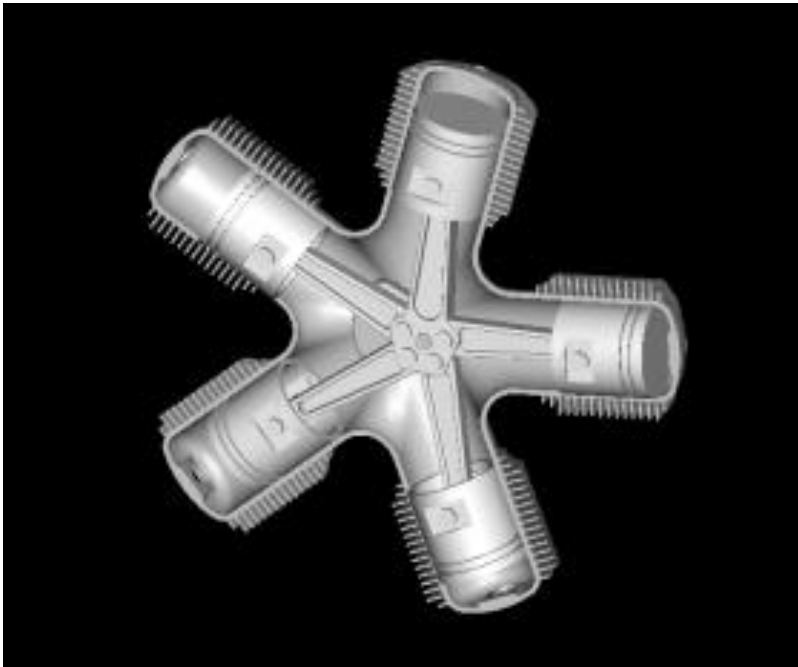
Rotary engine (Wankle engine)

2.1 The feature of the Biplanes

- **C. The engine**
 - **The arrangement of multiple cylinder piston engine**
 - **Radial engine**
 - **Inline engine**
 - **Straight engine**
 - **Flat engine**
 - **V engine**
 - **H engine**

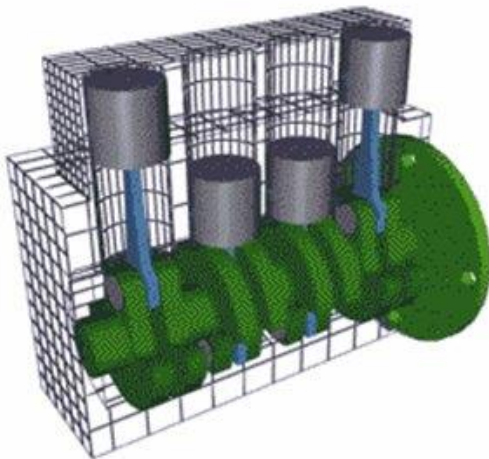
2.1 The feature of the Biplanes

- **C. The engine**
 - The arrangement of multiple cylinder piston engine
 - Radial engine



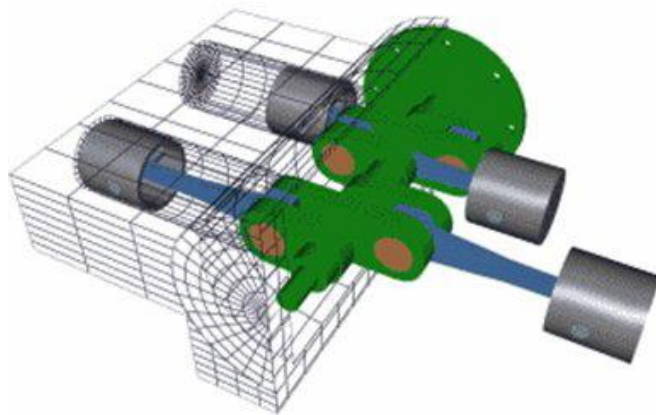
2.1 The feature of the Biplanes

- **C. The engine**
 - The arrangement of multiple cylinder piston engine
 - Inline engine
 - Straight engine

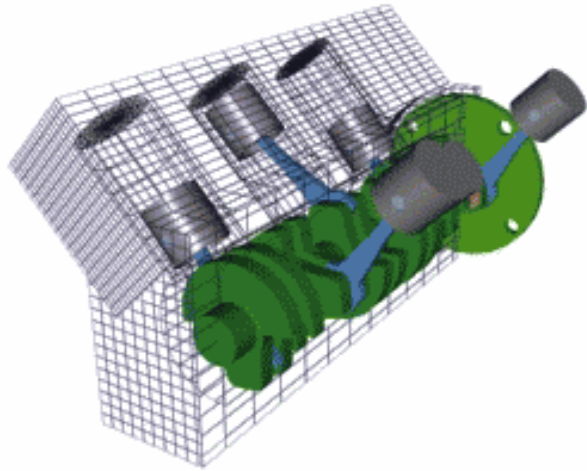


2.1 The feature of the Biplanes

- **C. The engine**
 - The arrangement of multiple cylinder piston engine
 - Inline engine
 - Flat engine



- **C. The engine**
 - The arrangement of multiple cylinder piston engine
 - Inline engine
 - V engine



2.1 The feature of the Biplanes

- **C. The engine**
 - The arrangement of multiple cylinder piston engine
 - Inline engine
 - H engine
 - Can be deemed as two flat engines



2.1 The feature of the Biplanes

- **C. The radial engine**
 - Most of the biplanes in 1920's had air cooled radial engines.



2.1 The feature of the Biplanes

- **C. The radial engine**
 - **Some of the biplanes had V-engines.**



2.1 The feature of the Biplanes

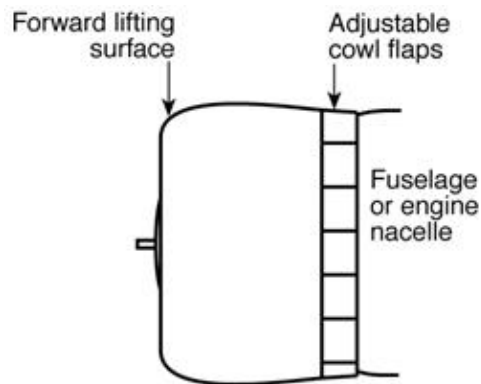
- **C. The engine**
 - **Air cooled Radial engine**
 - **Advantages:**
 - **Light weight**
 - **Less vulnerable**
 - **Easier to maintain**

2.1 The feature of the Biplanes

- **C. The engine**
 - **Air cooled Radial engine**
 - **Disadvantages:**
 - **Very large front area**
 - **Difficult to streamline the fuselage**
 - **Reduced front visibility**
 - **Cylinders exposed in the air causes drag**

2.1 The feature of the Biplanes

- **C. The engine**
 - **Air cooled radial engine**
 - **NACA cowling**
 - It is a aerodynamic fairing used to streamline radial engines
 - A long-chord ring cowl whose trailing edge fairs smoothly into the fuselage or engine nacelle.



NACA cowling



2.1 The feature of the Biplanes

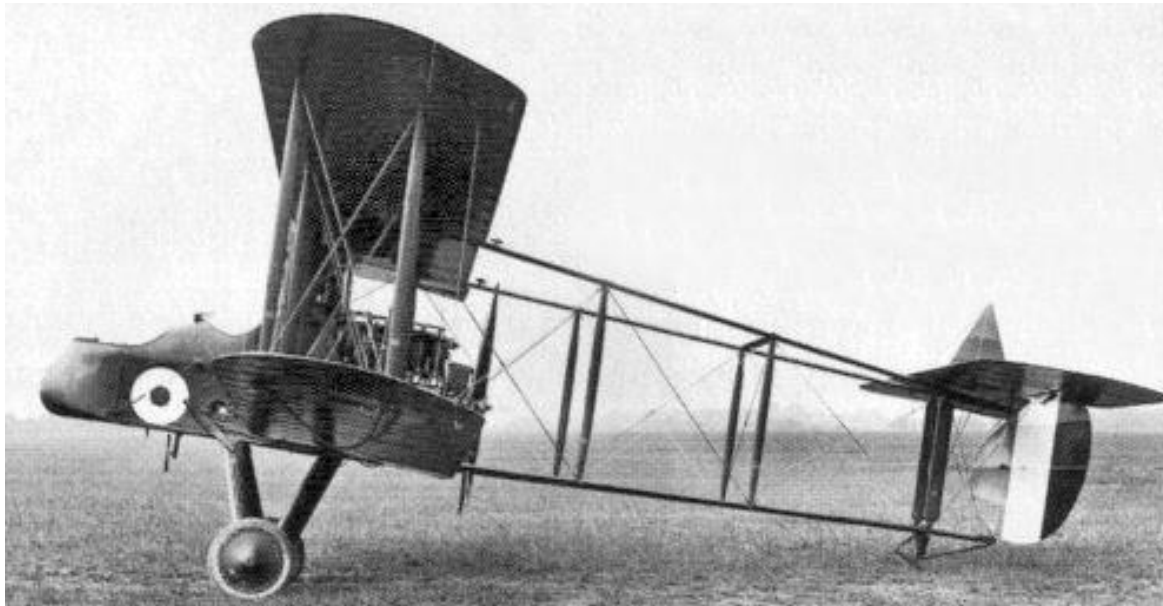
- **C. The engine**
 - **Air cooled radial engine**
 - **NACA cowling**
 - **Streamline the fuselage**
 - **Improves the engine cooling**
 - **Reduce the turbulence behind the cylinders**



The drag is reduced by 60%!

2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - **To avoid bullets hitting the propeller, people tried a lot of approaches:**
 - **Pusher propeller configuration**



2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - **To avoid bullets hitting the propeller, people tried a lot of approaches:**
 - **Pusher configuration and tractor configuration**



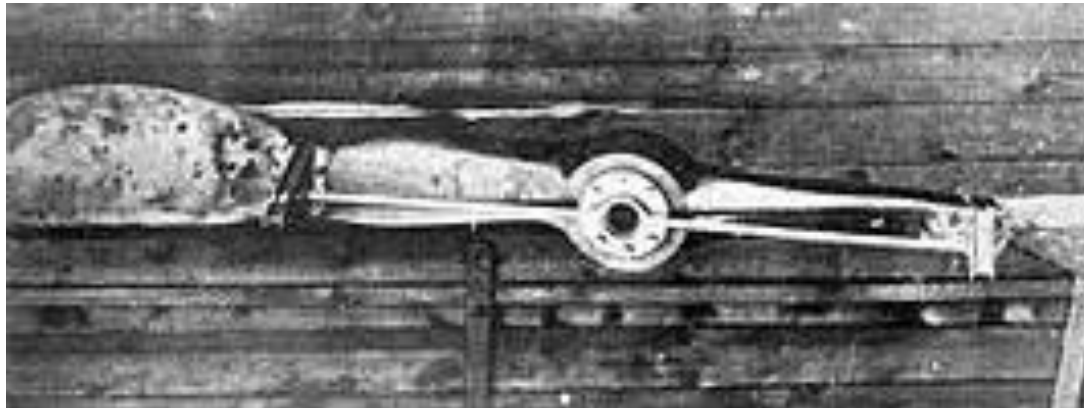
2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - **To avoid bullets hitting the propeller, people tried a lot of approaches:**
 - **Rotary engine**



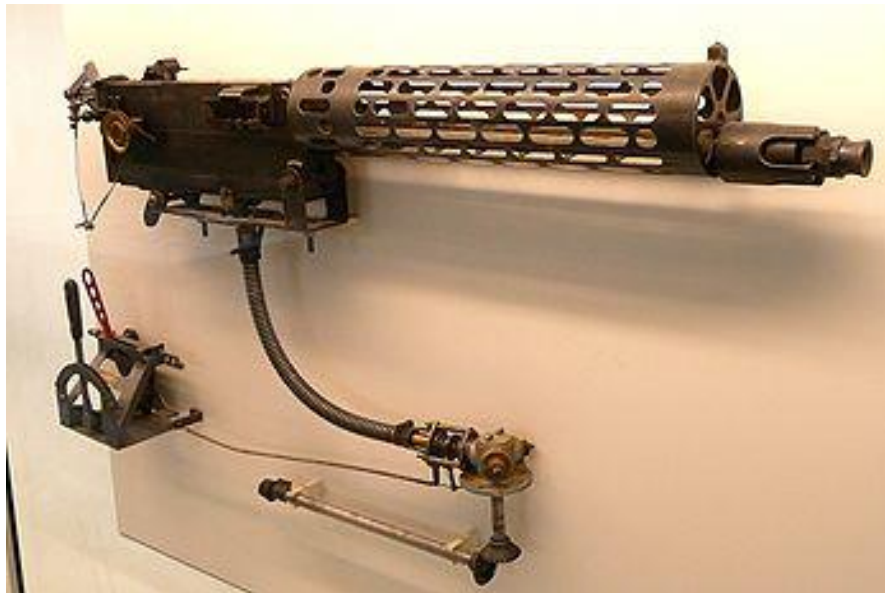
2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - **To avoid bullets hit the propeller, people tried a lot of approaches:**
 - **Armored propeller blades**
 - **Deflector wedges on the propeller**
 - **Reduced the efficiency of the propeller**



2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - To avoid bullets hit the propeller, people tried a lot of approaches:
 - The gun synchronizer



2.1 The feature of the Biplanes

- **D. The gun synchronizer**
 - To avoid bullets hit the propeller, people tried a lot of approaches:
 - The gun synchronizer

