The Wright Aeronautical Model H3 Construction Details

AEHS 2018 Convention

Sacramento, California

Terry Welshans

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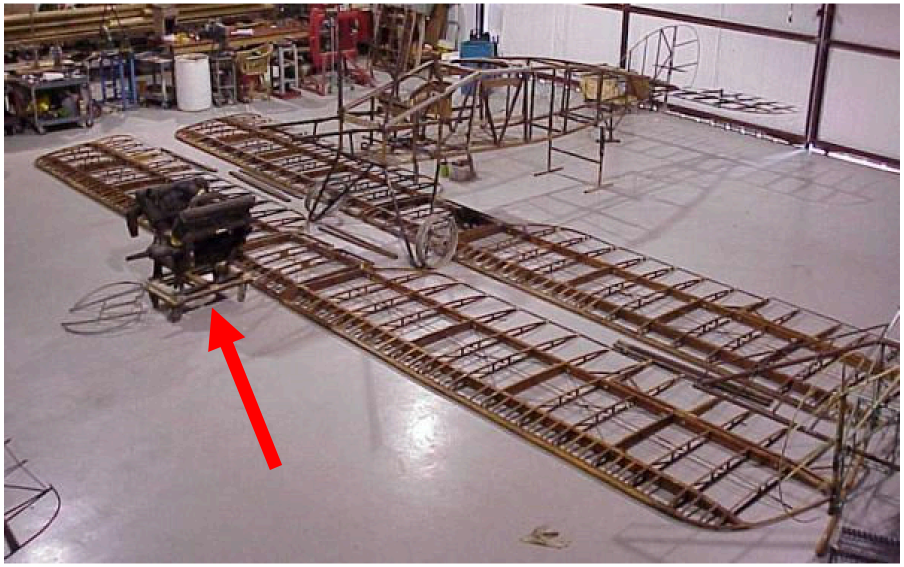
Project: An Original Bristol F.2b



There are only seven known **original** Bristol F.2b fighters in existence.

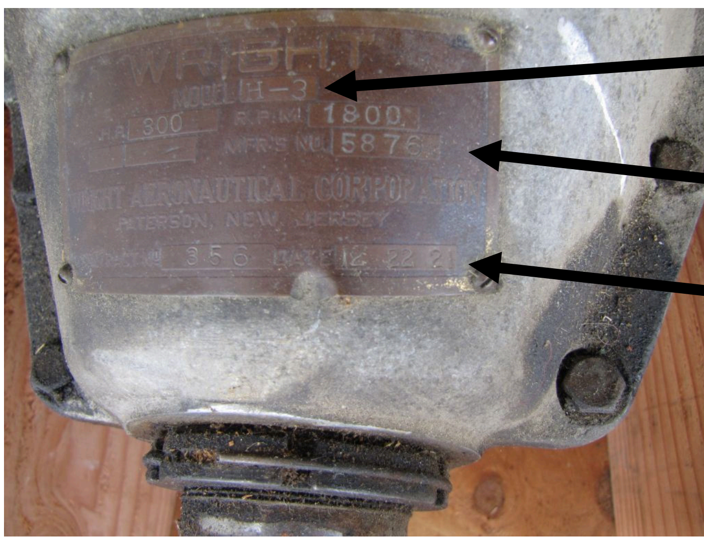
This is one of them, and is the **only** Bristol F.2b in the United States.

It is known that this fuselage, which is 1 of the 150 made by **Marshall, Sons & Co.,** of Gainsborough, along with five others, was **purchased by Mr. Bottington** in 1919 at the RAF depot at Weston-on-the-Green, Oxfordshire, England. These units served for the next 50 years as trusses supporting the roof of Mr. Bottington's barn. In the late 1960s this one was sold to **Ed Brennan** of Ontario, Canada, then sold to **Vintage Aviation Historical Foundation** of Texas, and is now owned by **Ross Walton** of Bardstown, Kentucky.

Goal: Bristol F.2B Type 17 with a 300 HP Wright H3

This Bristol F.2B (one of 15 bought by Belgium in 1921/22) is on display at the Royal Army Museum in Belgium.

Engine Starting Point

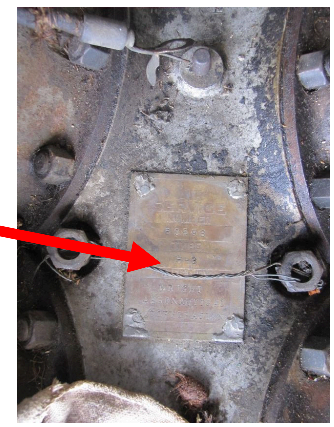


Model H-3

Serial # 5876

Air Service tag

Date:12/22/1921



All parts have the same serial number

Wright Martin

- Wright-Martin aviation firm of New Brunswick, New Jersey, licensed the original 150 hp HS-31 Model 8Aa engine for use in World War I combat aircraft that were to be built in the United States as the Wright Model A engine.
- Later, a license was granted for the 300 hp HS-42 Model 8Fb engine to be built in the United States as the Wright Model H engine.

- Wright produced a number of variants of the 150 hp Model 8Aa direct drive engine.
  - Model A of with 150 hp at 1,450 rpm.
  - Model B Experimental 4 cylinder engine, half of a model A with 75 hp at 1,450 rpm.
  - Model C Experimental V-8 200 hp, geared from the rear with prop shaft in the Vee.
  - Model D Experimental engine similar to model C but with gears at the front and a short drive shaft. 37mm cannon in the Vee.
  - Model E, E-2, E-3 of 150 to 180 hp at 1,800 rpm. (Also known as the Military V-720)
  - Wright E-4 of 215 hp at 2,000 rpm.
  - Model F Experimental geared V-8 similar to model D, but without the cannon.
  - Wright I of 150 hp at 1,800 rpm. (detuned model E.)

- Wright produced a number of variants of the 300 hp Model 8Fb direct drive engine.
  - Model H direct drive with 300 hp at 1,800 rpm.
  - Model H2 and Model H3 with improved oil and cooling systems.
  - Some were tested to 385 hp at 2,000 rpm.
  - Engines for US Navy have the Stromberg model NA-V6 carburetor
  - Model K Experimental geared at the front with a Baldwin 37mm cannon, similar to model H, but split vertically.
  - Model K-2 Modified K, split horizontally, like a model H.

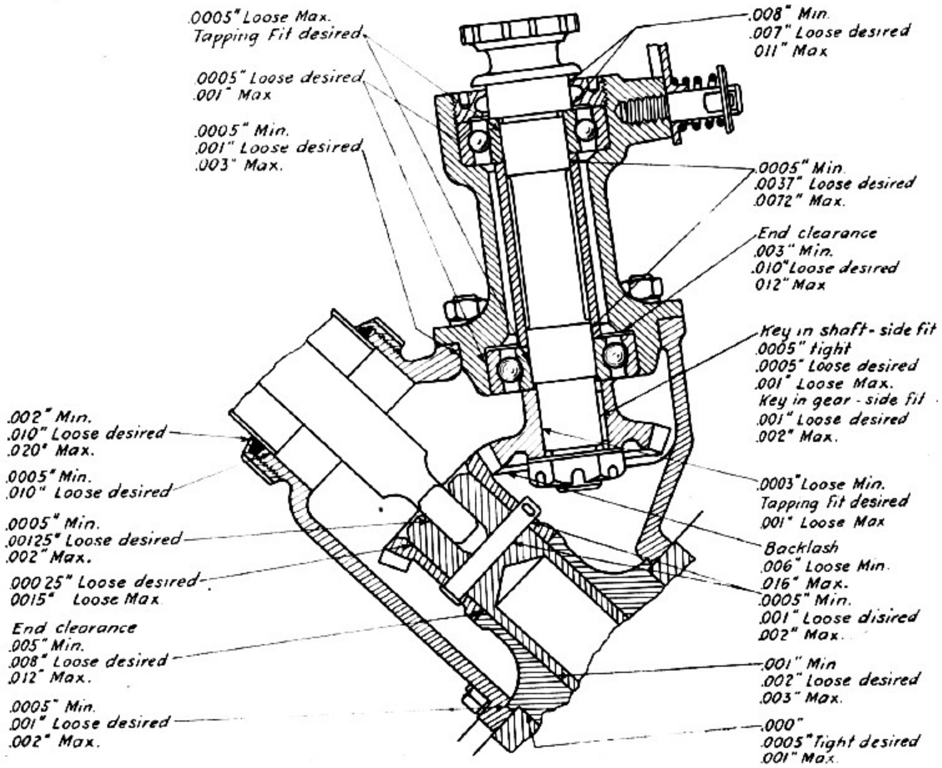
Wright Engine Applications

- **Aeromarine AS** (3 with 300 hp Wright E)
- **Boeing NB-2** (30 with 180 hp Wright E)
- **Boeing AT-3** (1 with Wright E)
- **Consolidated PT-1** (221 with 180 hp Wright E)
- **Cox-Klemin TW-2** (3 with 300 hp with Wright H)
- **Curtis HG-3** (106 with 150-hp Wright E)
- **Curtiss JN-4HM** conversion of JN-4HT (6 with 150-hp Wright E)
- **Curtiss N-9H** (44 with 150 hp Wright A)
- **Curtiss XAT-4** (1 with 180 hp Wright E)
- **Dayton-Wright OW.1** Aerial Coupe (1 with 180 hp Wright E)
- **Dayton-Wright TW-3** (2 with 150 hp Wright I and 20 with 180 hp Wright E)
- **Dayton-Wright XB-1A/USB-1** (47 with 300 hp Wright H)
- **Huff-Daland TW-5** (5 with 150 hp Wright I)
- **Huff-Daland HN-1** (3 with 180hp Wright E2)
- **Huff-Daland HO-1** (3 with 180 hp Wright E2)
- **Loening M-8/ PW2** (61 with 300 hp Wright H)
- **Naval Aircraft Factory TF** (4 with two 300 hp Wright H)
- **Naval Aircraft Factory TS-3** (2 with two 180 hp Wright E)
- **Ryan Standard: J-1** (9 with 180 hp Wright E)
- **Thomas-Morse MB-3** (265 with 300 hp Wright H)
- **Travel Air 3000** (with 150 hp Wright A or 180 hp Wright E)
- **Vought VE-7/8/9** (207 with 335 hp Wright H)
- **Waco DSO** (150 Wright A or 180 hp Wright E)
- **Waco 240-A** (with 240 hp Wright E)
- **Waco 300T-A** (with 300 hp Wright H).
- **Wright-Martin V** (1 with 150 hp Wright A)

Conversion to American Production Standards

- Wright began work on the conversion process necessary to produce these European engines using American machine tools.
- The parts retained their metric dimensions.
- Converting metric measurements was no problem – the parts could be machined to any size.
- 1 mm= 0.03937 inch.

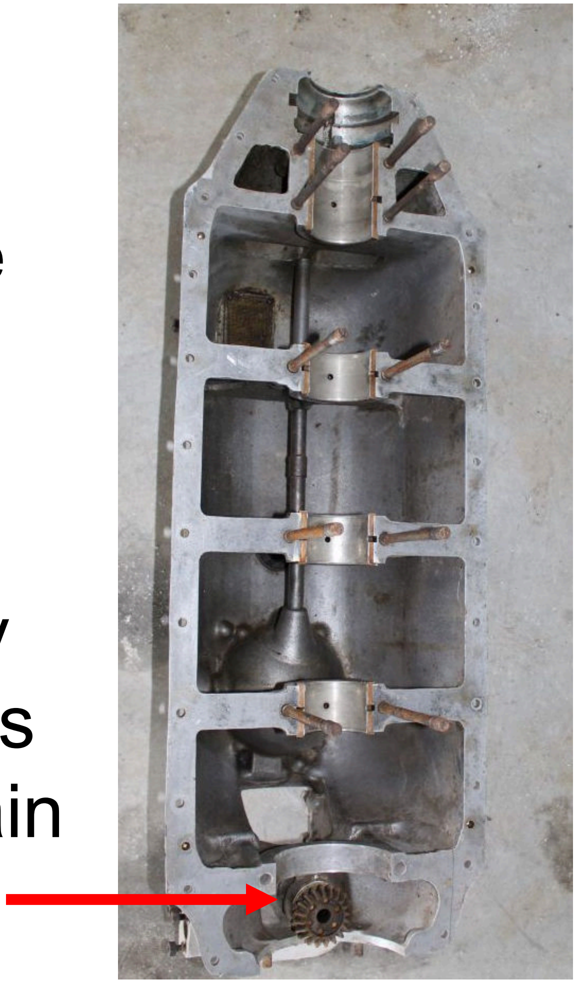
- The clearances between moving parts were converted to inch equivalent sizes to match existing gauges and measuring tools.



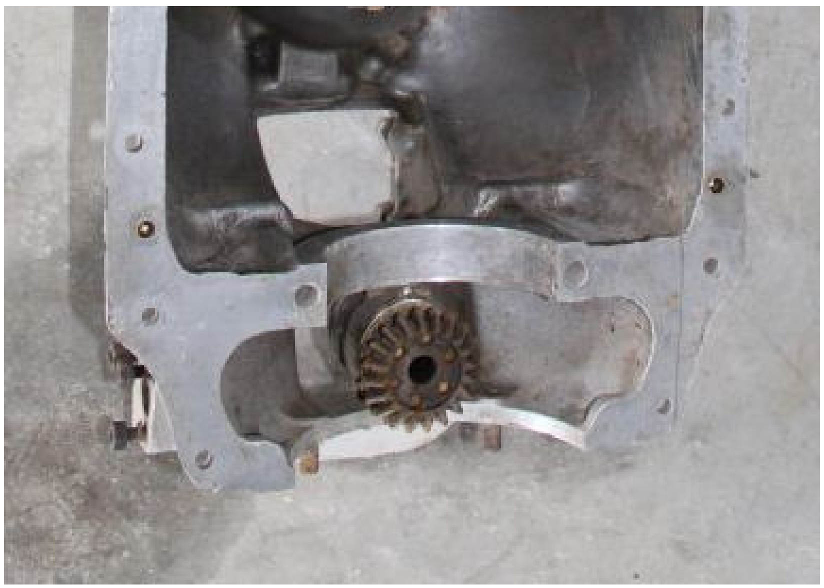
Fits and clearances for gun synchronizer drive

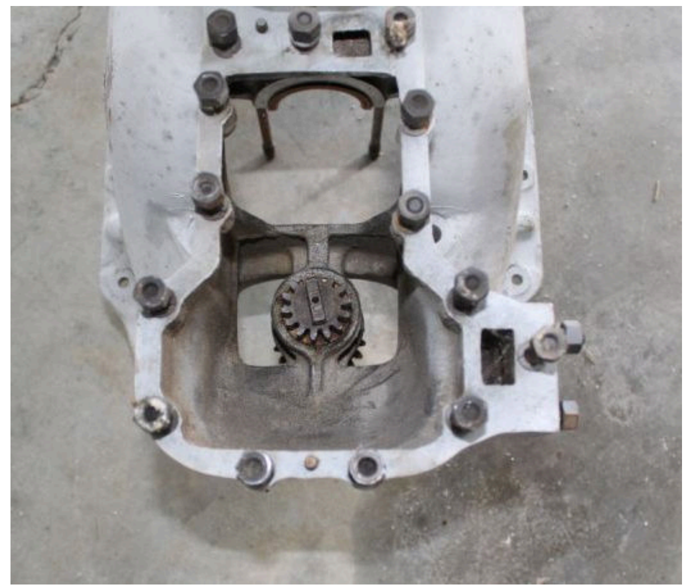
Crankcase

- The cast aluminum crankcase is split at the main bearings.
- Accessory drive gears at rear main bearing.

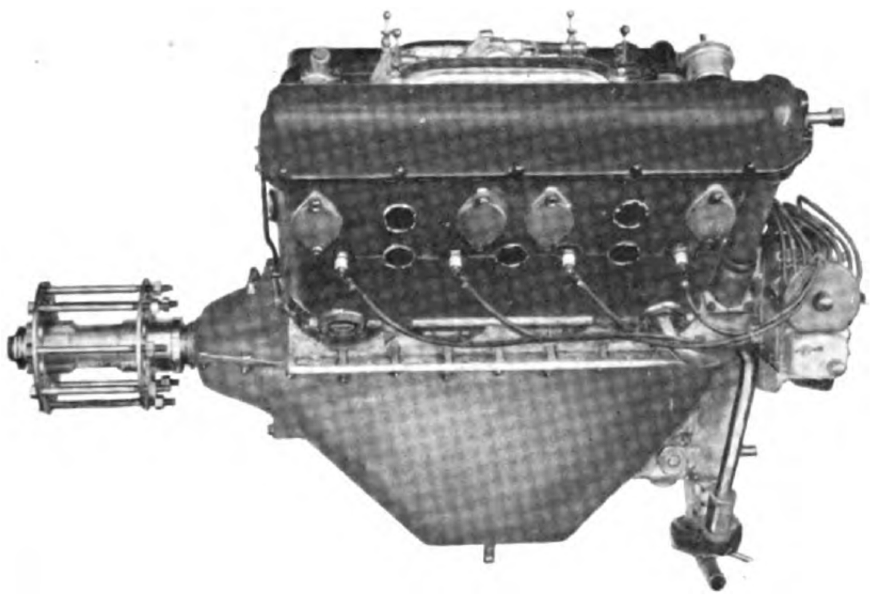


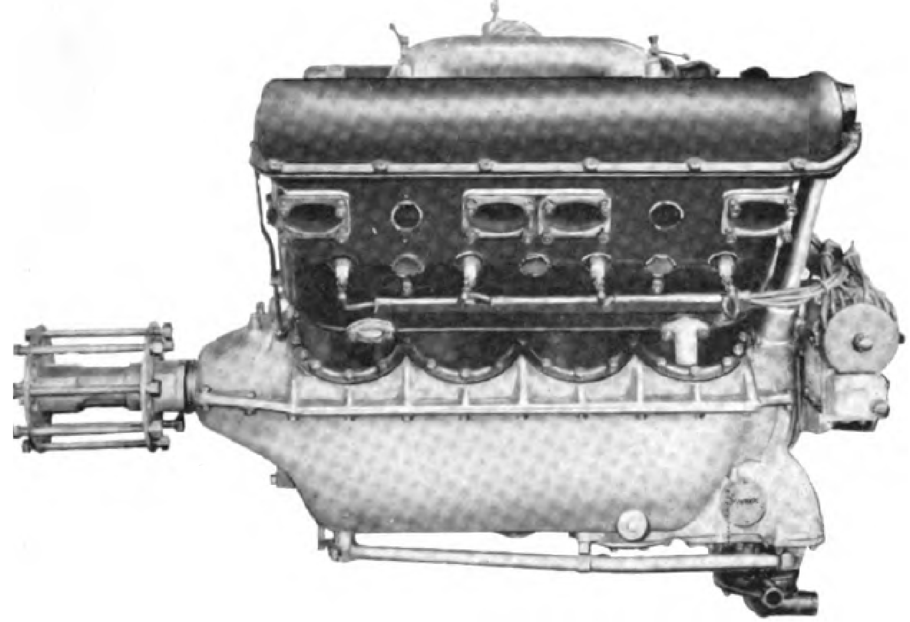
- This vertical gear drives the oil and water pumps.
- This gear drive is supported in a bronze bearing for adjustment.





- Oil sump changes.

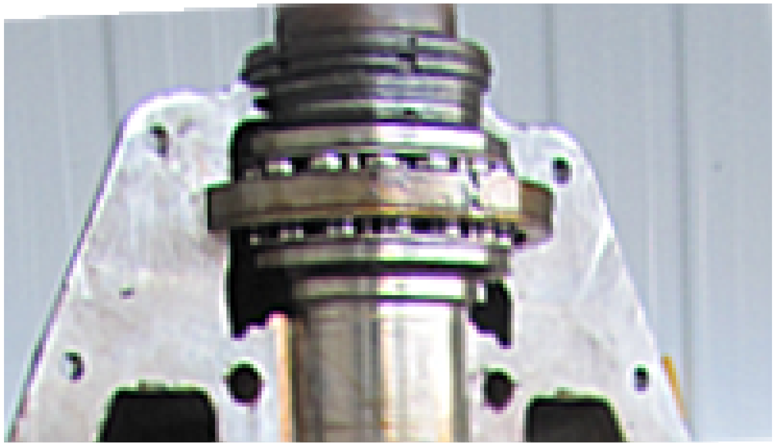




Model A, E, and I Model H

- The oil pump was changed from a vane type to a gear type and the water pump was improved.

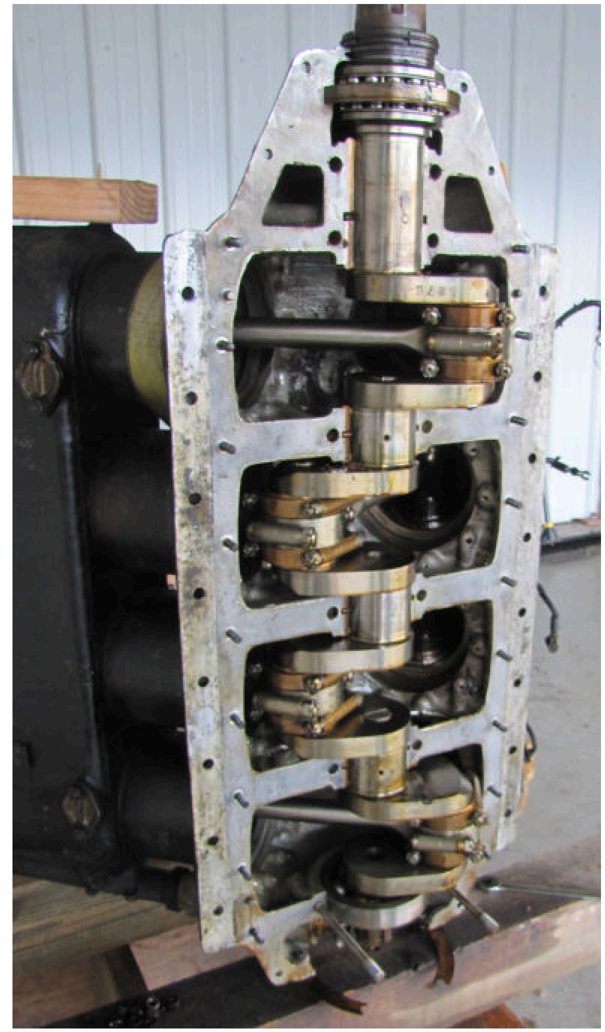
- Two-row thrust ball bearing at front.



- Ball-type rear main bearing.

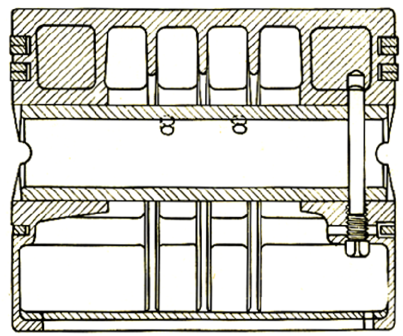
Crankshaft

- The crankshaft is a single-plane, four throw design.
- There are no counterbalances.
- Main bearings are Babbitted shell type.
- The front main bearing is more than twice the length of the intermediate bearings.

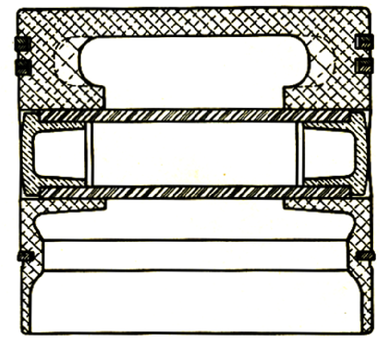


Pistons

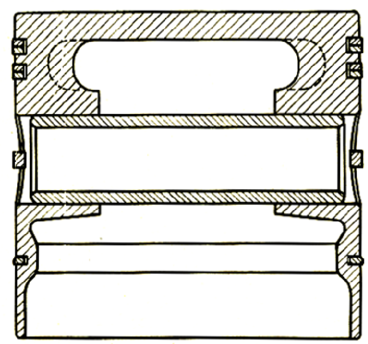
Low Compression
Used on A, E, & I



Original Model A design



E-2 Piston

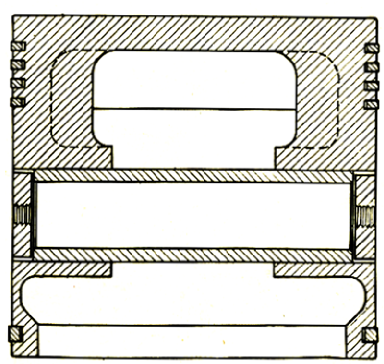


Type of ring grooves on A, I, E, E-2

Piston pin retainer ring on early E and I

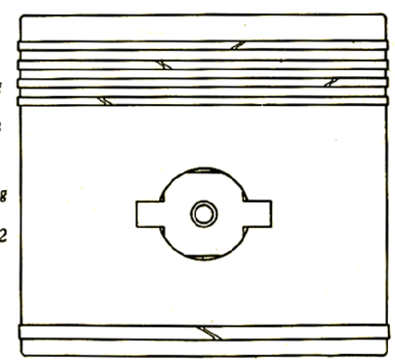
H-3 piston has plug type piston pin retainers similar to E-2; but is otherwise the same as H-2 piston.

High Compression
Used on H, H2, & H3

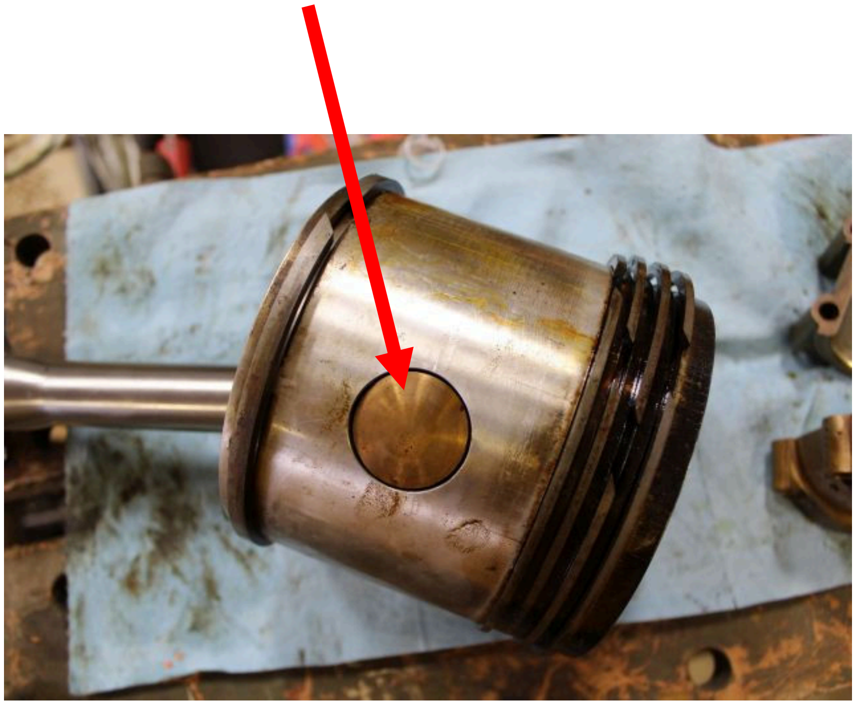


Type of ring grooves on H-2 and H-3

Piston pin plug on later E, I *and H and H2*



- The cast aluminum flat-top pistons have full floating wrist pins retained by pressed-in button plugs.

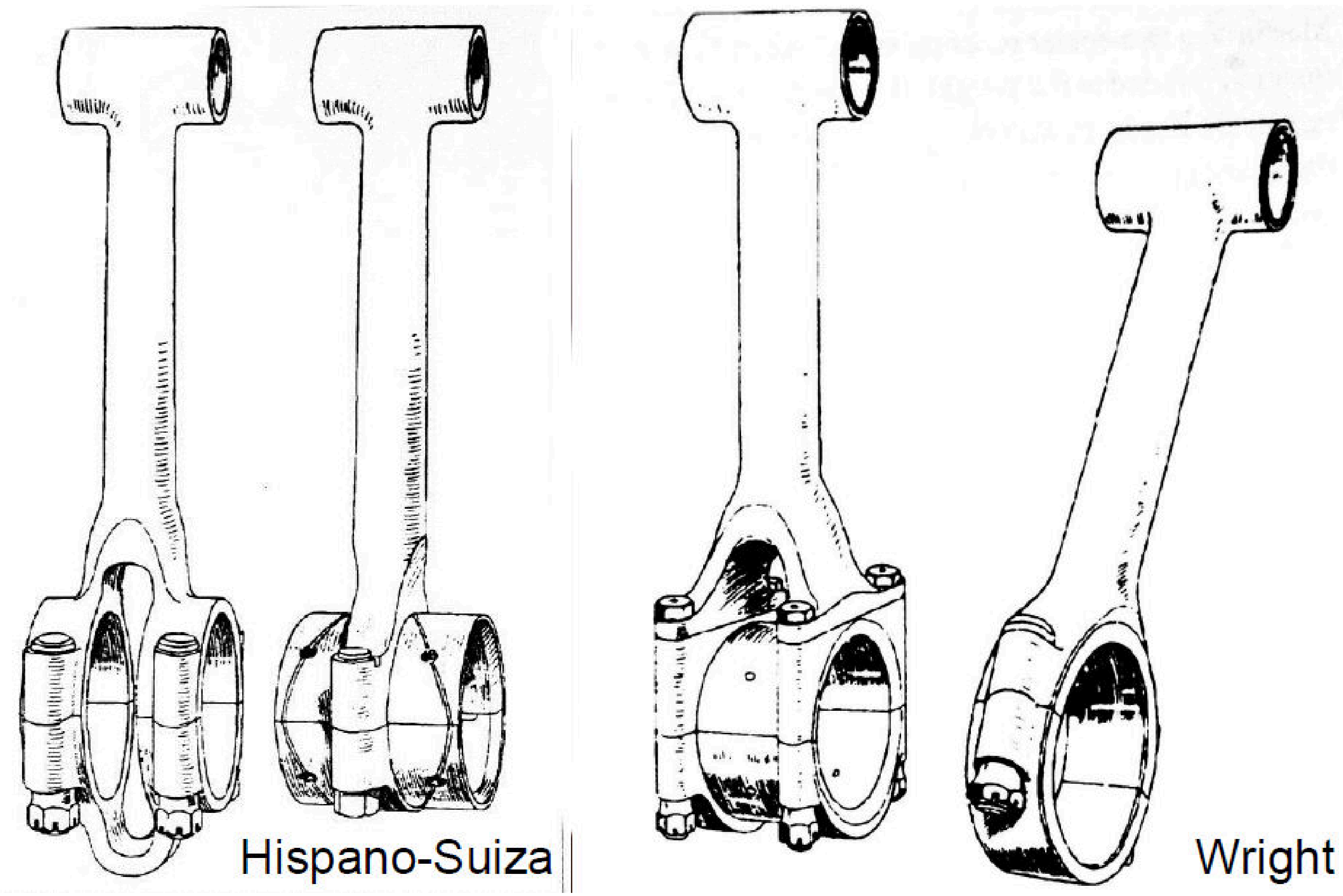


- Four thin compression rings are located in grooves above the wrist pin.
- One thick oil control ring is located in a groove below the wrist pin.
- All of the rings have angled ends that overlap with no gap.

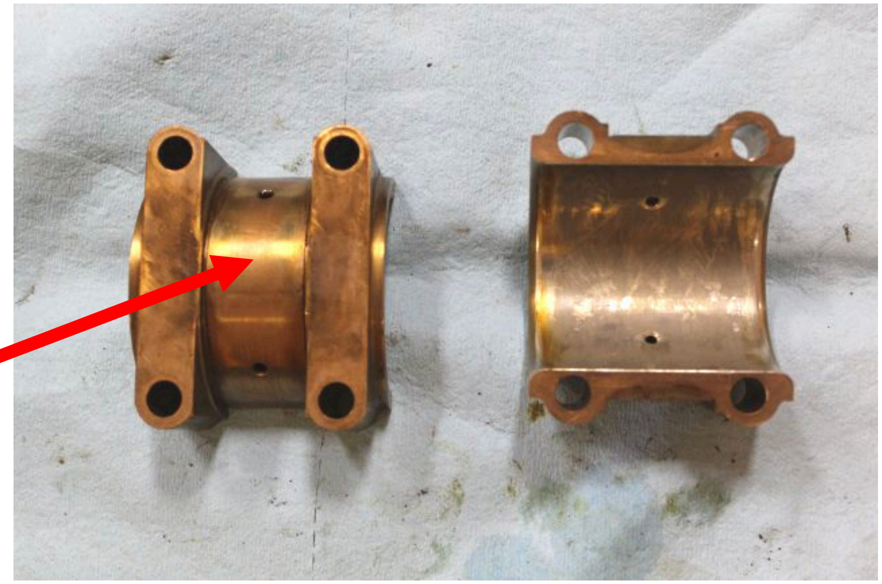
Connecting Rods

- The connecting rods are solid chrome steel forgings.
- The rods are blade and fork type, with the blade rods installed in the right bank.
- The rods are drilled hollow from the top (blade rod) or bottom (fork rod) to lighten them.

- Connecting rod changes



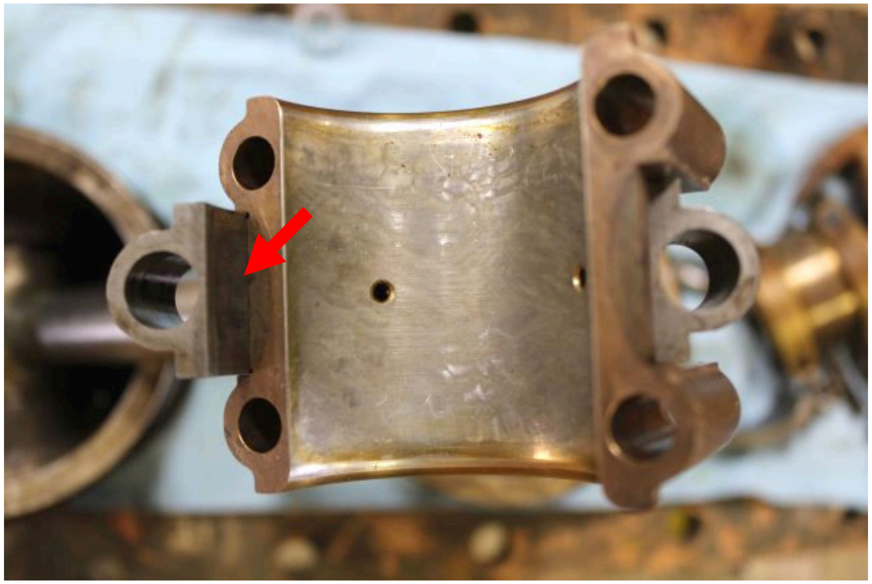
- The bearing block is lined on the inside with Babbitt.
- The bearing block's blade rod bearing surface is not Babbitted.



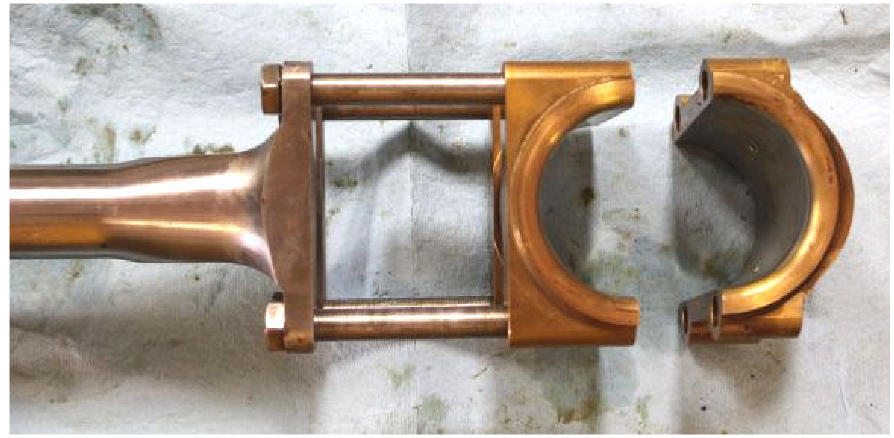
- There is only limited motion between the blade rod and the bearing block as the crankshaft rotates.

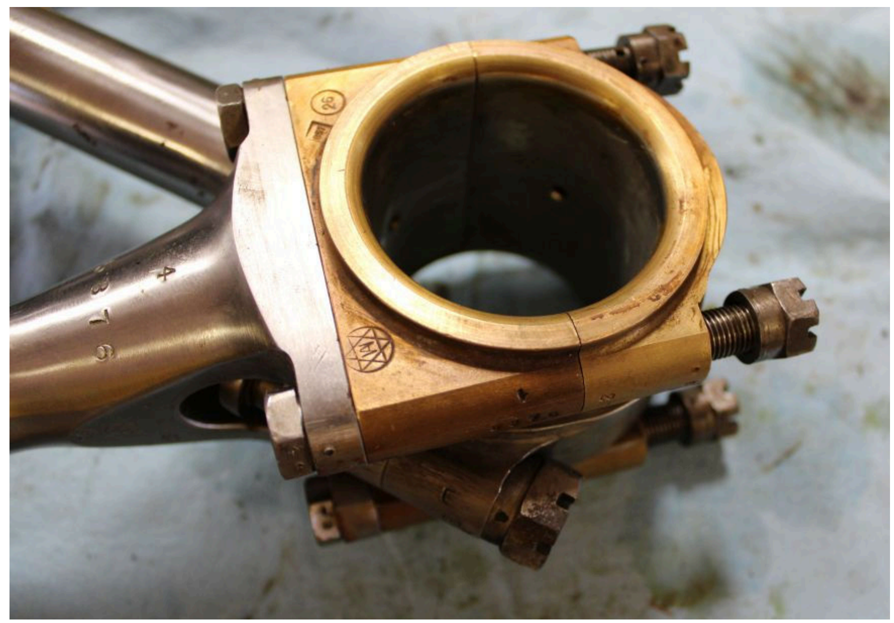
- The blade rod has a two-bolt cap and has no bearing material.

- This rod rides on a machined surface on a two-piece bearing block that clamps around the journal.



- The fork rod has a flat surface at the bottom that fastens to the bearing block with four bolts.
- The blade rod fits between the mounting bolts that hold the bearing block to the fork rod.



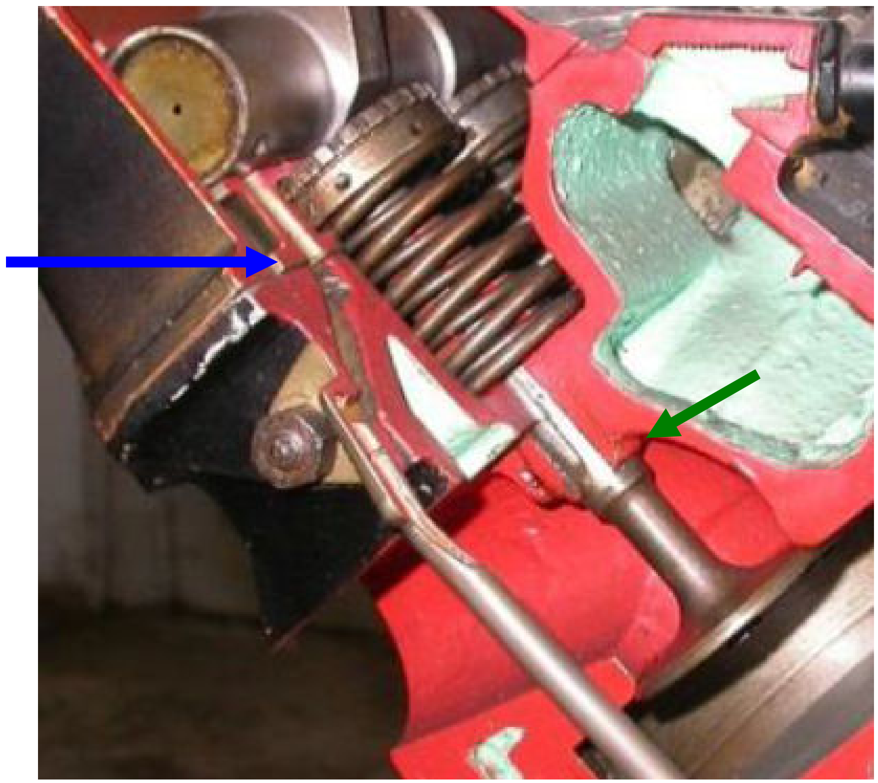


Water Jacket

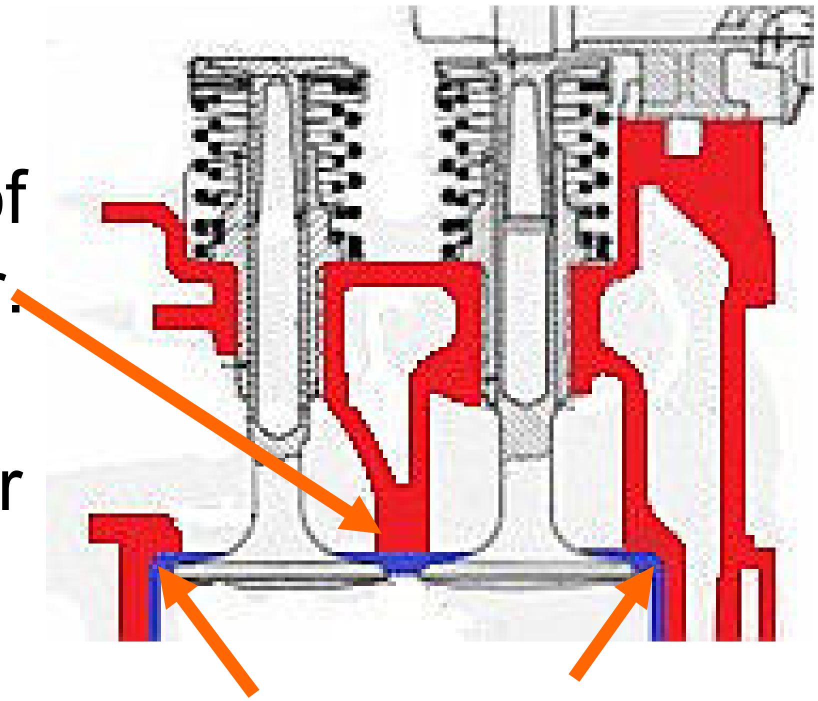
- The water jackets are thin-wall aluminum castings.

•These castings were some of the thinnest cored aluminum castings made at the time.

- The intake and exhaust valve guide bosses and ports are part of the casting, as are the mounting pads for the camshaft bearing pedestals.



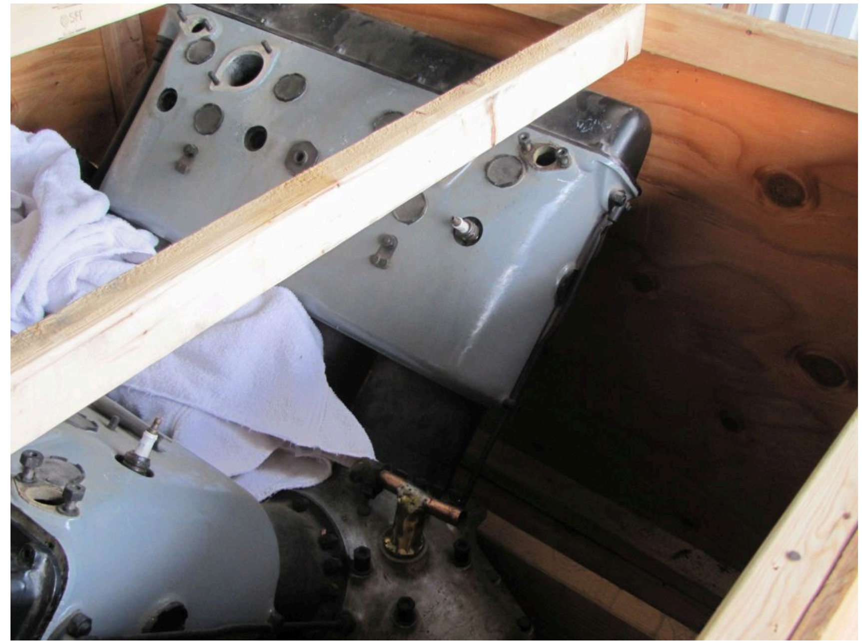
- The intake and exhaust ports have a water-cooled separator that divides the ports and seals against the top of the closed-top cylinder.
- The valve ports and divider of each cylinder are machined flat to form a sealing surface for the top of the steel cylinder.



- The cylinder mounting areas are machined to size and full length threads are made.

- The water jacket casting is machined for the valve guides and the valve guides are fitted.
- The top of the water jacket is machined flat for the cam pedestals and the cam drive bearing.
- Holes are drilled and tapped for the camshaft mounting hardware.
- The water jacket is drilled for two spark plug bushings per cylinder.

- The aluminum casting is somewhat porous, so the inside and outside are painted with an enamel paint and then cured in an oven.

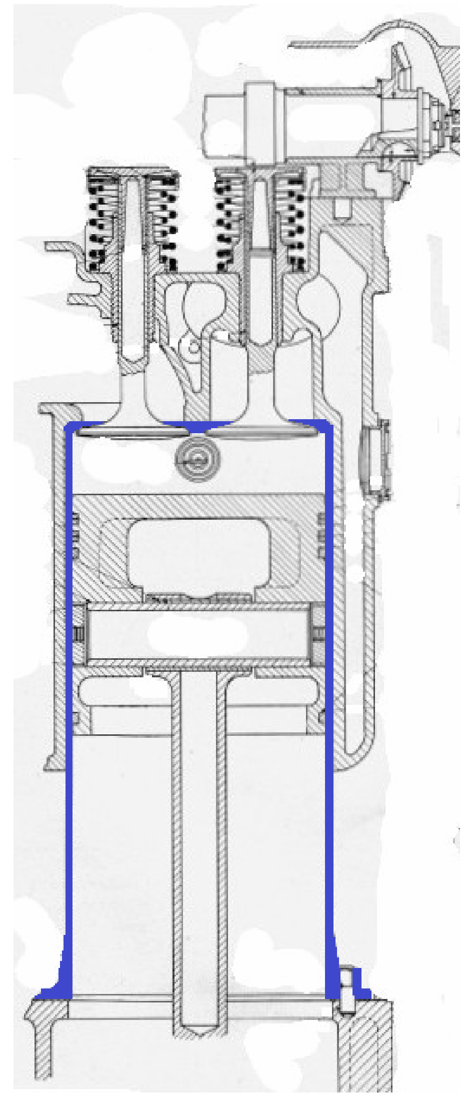


H-3 backup ‘the pretty engine’

- The intake and exhaust ports are machined flat and holes are drilled and threaded for mounting studs.

Cylinders

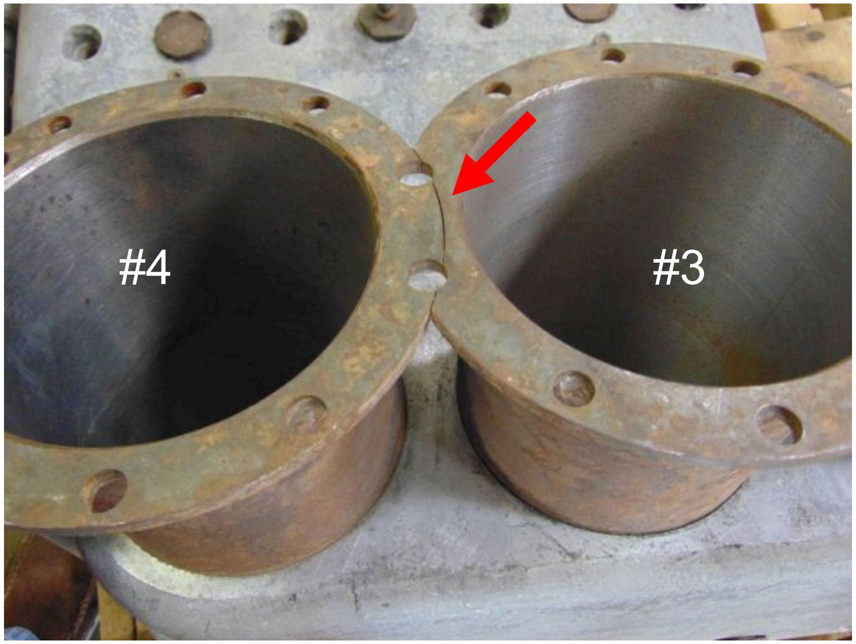
- The cylinders start out as .40% carbon steel blanks that weigh about 40 pounds.
- The blanks are forged into shape.
- The cylinders finish at about 11 pounds and are .078” thick on the side and .187” at the closed end.



- The finished forging resembles a ‘Top Hat.’ The design is sometimes called a ‘poultice head.’
- The cylinders are threaded on the outside for most of their length, except for the part that extends below the water jacket casting.
- The cylinders have a .236” thick circular bolting flange at the bottom that is drilled for crankcase mounting studs.

- The cylinder top and the water jacket mating area is a gas-tight fit.
- Once in place, if the cylinder is removed, it may never regain alignment due to the machine work that follows.
- The cylinder mounting flanges overlap due to the compact cylinder spacing.
- The water jacket is first heated with steam, causing it to expand. This makes a tight fit for the cylinders when it cools.
- Each cylinder is hand fitted for a gas tight fit.

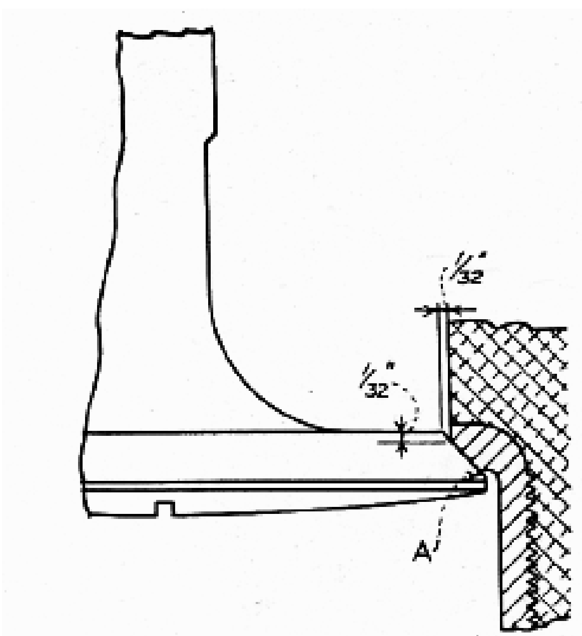
- The #1 and #3 cylinders are installed first and tightened against the machined divider and port area of the water jacket.
- The #1 and #3 cylinders are machined with a crescent shaped cutout to allow the adjacent cylinder to fit.

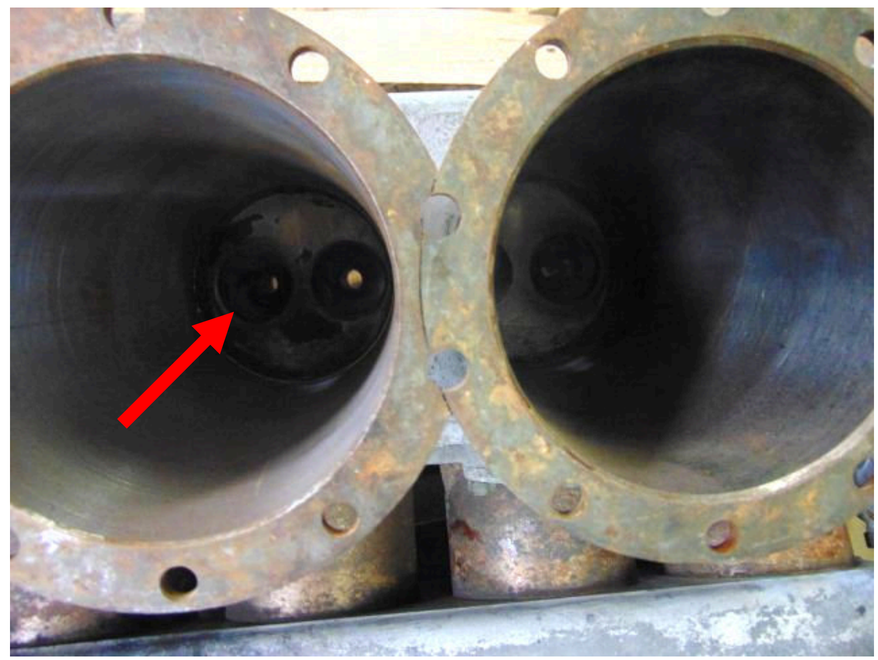


- Once these cylinders are installed the crescent cut outs are machined, then the #2 and #4 cylinders are installed in a similar way.

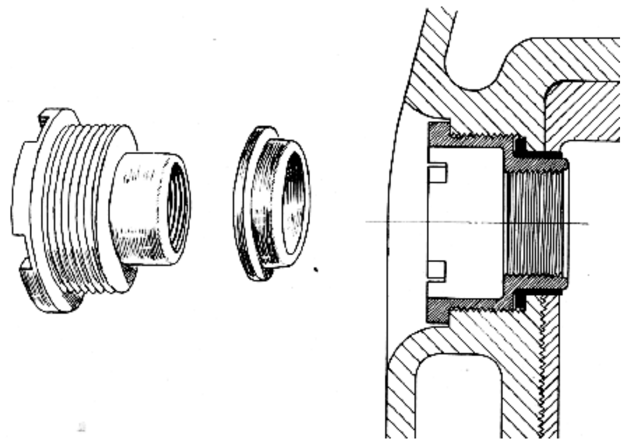
- The bottom of the cylinder flanges are then machined to a uniformly flat surface.
- Holes are drilled in the flanges for the mounting studs.
- The valve guide holes are drilled all the way through the bosses and into the top of the cylinder.
- Valve guide bosses are threaded and valve guides are installed.

- The assembly is inverted and the valve seats are machined using a piloted drill that center on the valve guides.
- The valve seats are cut directly into the cylinder top. No replaceable valve seat is used.





- The cylinders are drilled for the spark plug bushings at the appropriate places, using holes in the water jacket as a guide.
- The spark plug bushings are sealed to the water jacket and cylinder with a copper gasket.

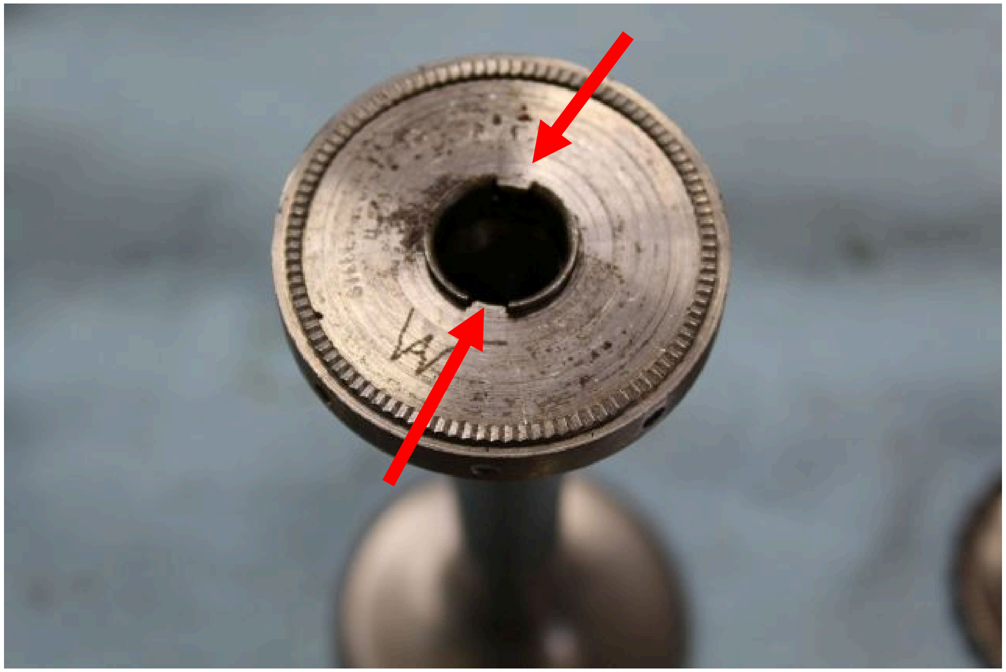


Valves

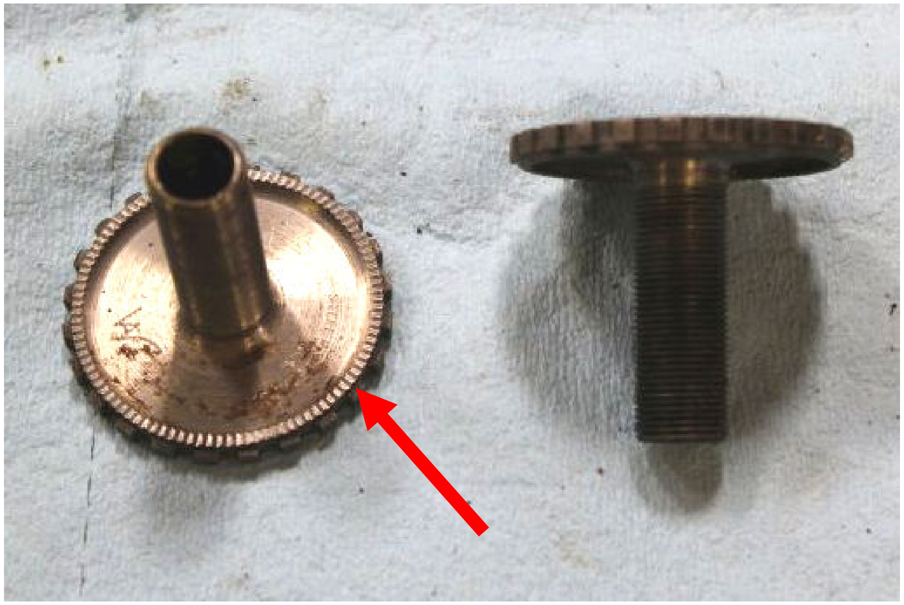
- Wright also changed the valve design and material.
  - Original valves were made of tungsten steel which often broke.
  - Wright Exhaust valves were made of silchrome steel, a material that resists wear at high temperatures, but is damaged by leaded fuel.

- The valves have very large diameter stems and are a two-piece design.
- The stem is drilled hollow and has internal threads.
- The top of the valve stem has a small notch.

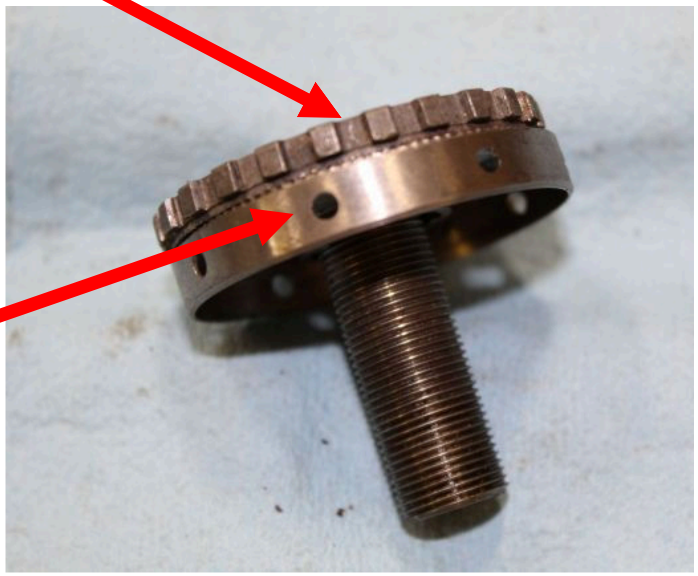
- The valve spring retainer has two tabs that fit in the slot in the valve stem, preventing valve retainer rotation, but allowing vertical movement.



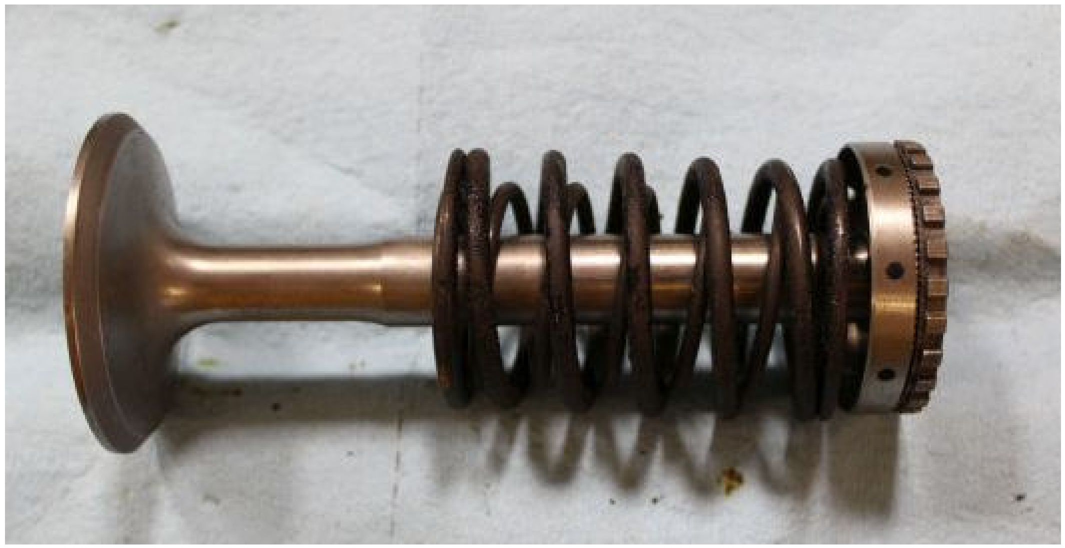
- The upper part is the valve tappet.
- The tappet has external threads that fit into the stem.
- The bottom of the tappet has a fine serration that meshes with the spring retainer's annular serration.



- The top of the upper part is a ~2.2 inch diameter flat surface that is in contact with the cam lobes.
- The circumference of this flat surface has 24 small vertical slots.
- Eight holes are machined into the circumference of the valve spring retainer.

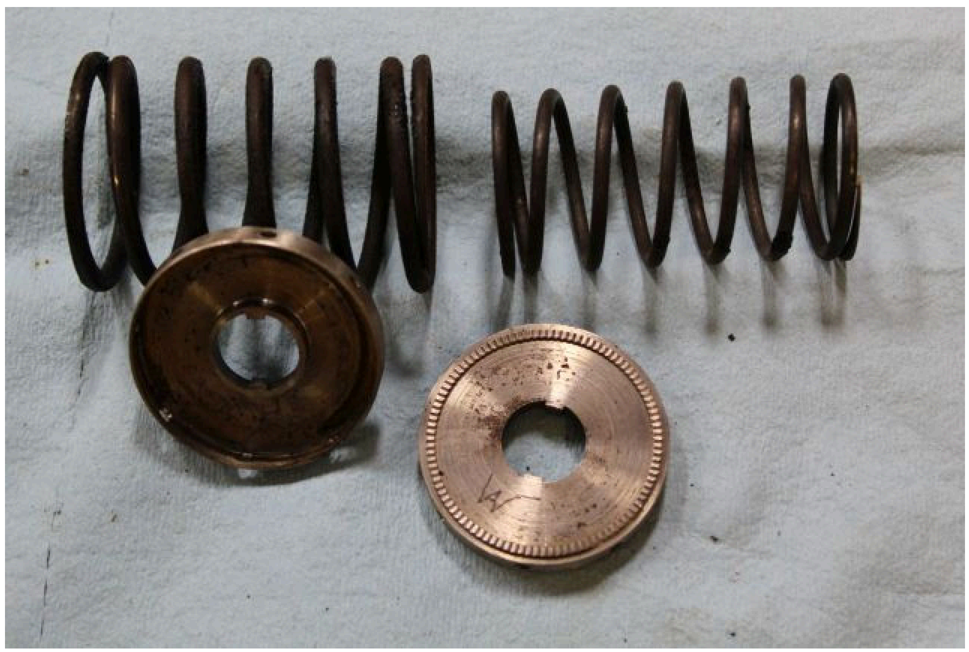


- The tappet is threaded into the valve stem as required to adjust the tappet to cam lobe clearance.



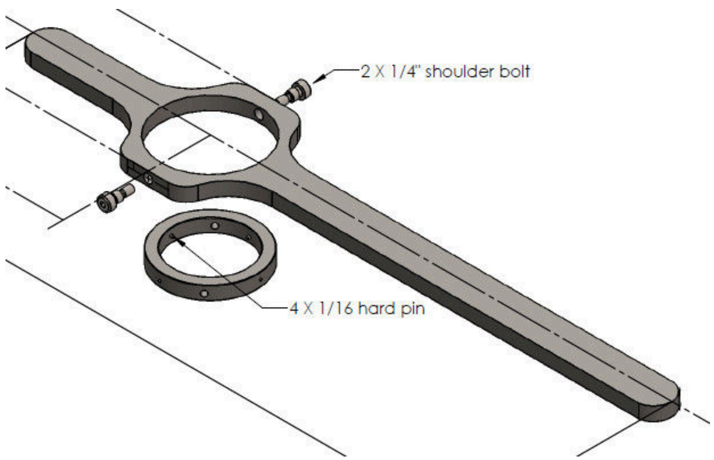
- Valve spring compression pushes the valve retainer’s serrations tightly into the tappet’s serrations, locking the valve adjustment.

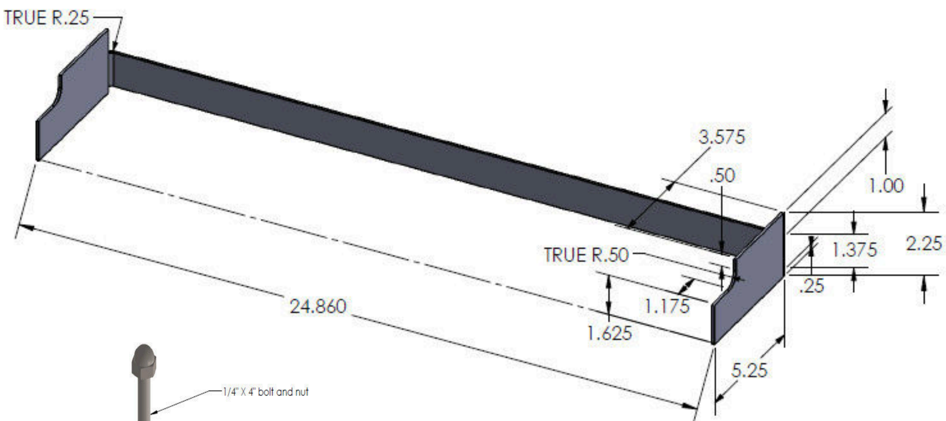
- It is necessary to compress the valve springs once the serrations start meshing as it becomes progressively more difficult to turn the tappet as the spring compression increases.

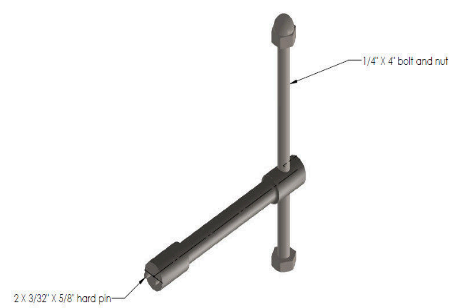


Valve installation & Adjustment

- Two special tools are needed to install and adjust the valves.
- These tools are not easily available.
- We made our own.





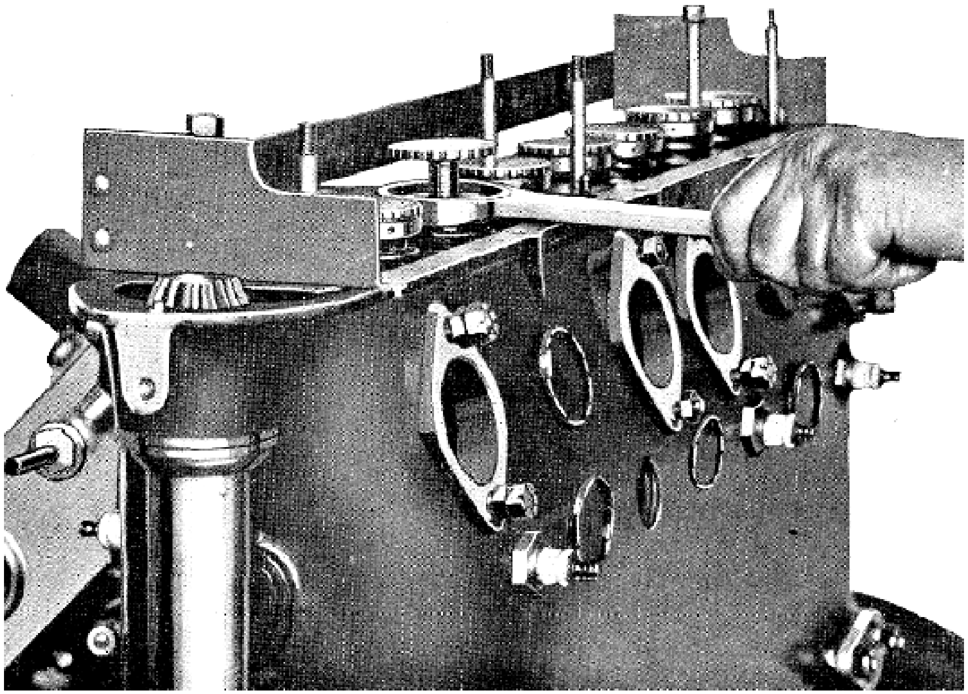


- Fulcrum bracket fastens to the cam bearing studs.
- The valve spring compressor handle presses the valve spring retainer down to clear the serrations.
- The “Tee handle” tool adjusts valve clearance once the cam is in place.

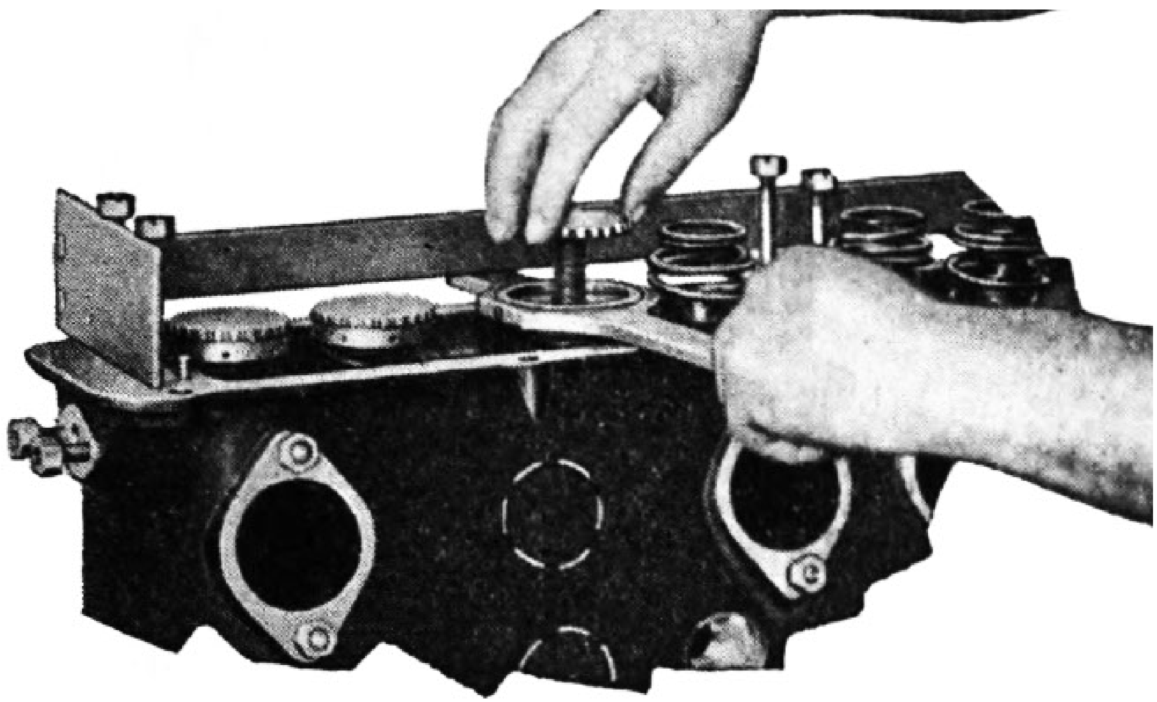
- The first tool is a lever with a gimbaled ring with pins that pass through the slots in the tappet’s circumference.

- It uses a special bracket as its fulcrum.
- Once the pins are below the tappet, they contact the top of the valve retainer.

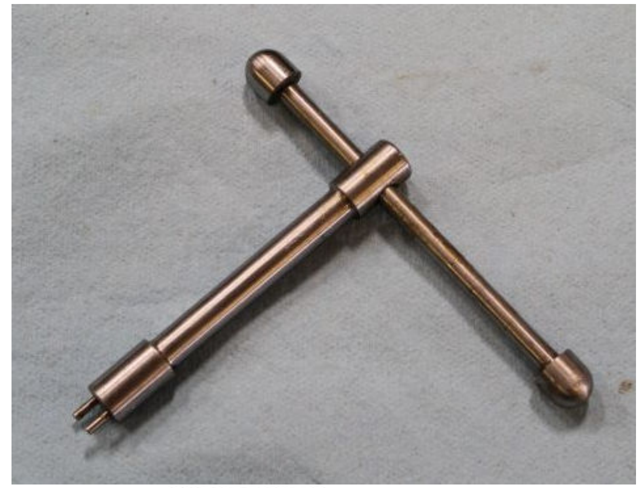
- Pressing down on the tool then compresses the valve spring.
- Once the valve spring is compressed, the serrations disengage.

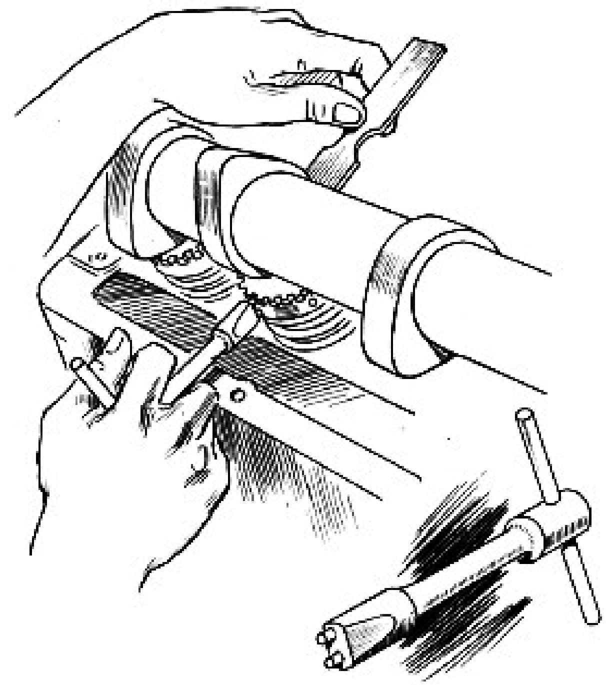


- The tappet then easily threads into the valve stem by hand.



- The second tool is used to make the final clearance adjustment once the camshaft is in place.
- This tool resembles a ‘T-type’ tapping handle.
- This tool has two pins that engage holes in the spring retainer and the slots in the tappet.

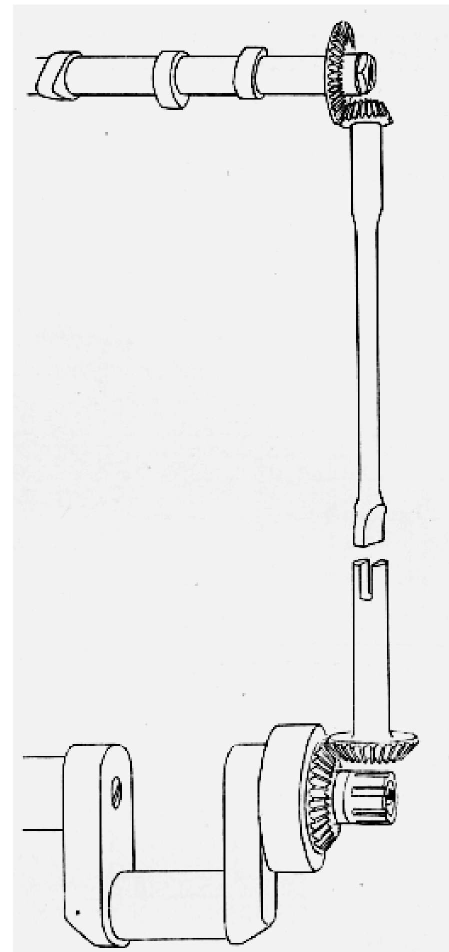




- Once the pins are engaged, turning the tool advances the threads in or out after overcoming the valve spring compression that holds the serrations in place.
- Only a few serrations will pass one another with each twist of the handle.
- The fine pitch of the serrations combined with the fine pitch of the tappet threads allow for very small adjustments.

Camshaft

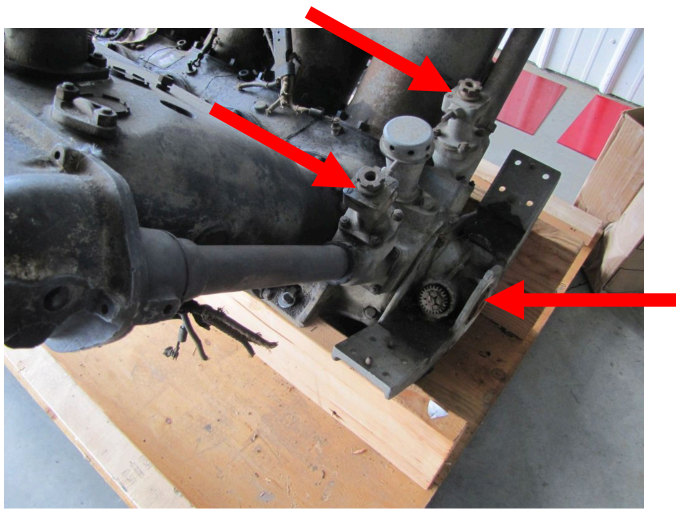
- The single overhead cams are driven by ‘quill shafts’.
- The cam drive is from a bevel gear on the crankshaft, at the rear of the engine.
- The shafts are supported in adjustable upper and lower bronze bearings to set gear adjustment.



- Cam timing is set by adjusting the gear teeth to the correct location.
- The cam drive shaft was originally designed with a separable coupling at the top.
- That coupling had a serrated joint that allowed very small cam timing adjustments.
- Wright’s drive eliminated the coupling.

- The cam drive gear and drive shaft.
- The cam is driven at half crankshaft speed.

- Cam drive shaft housings with gun synchronizers.
- The magneto bracket is to the right.

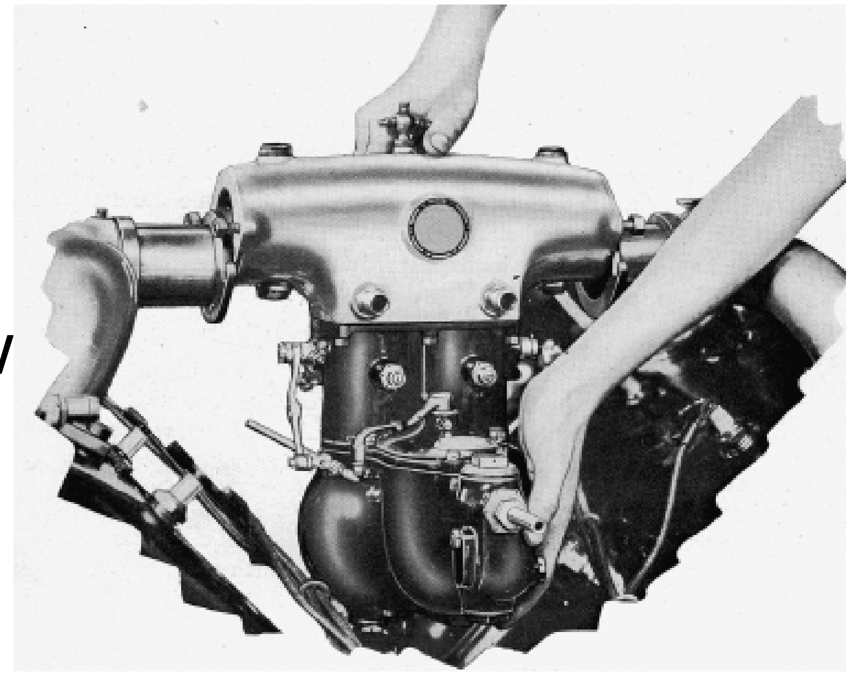


Carburetor

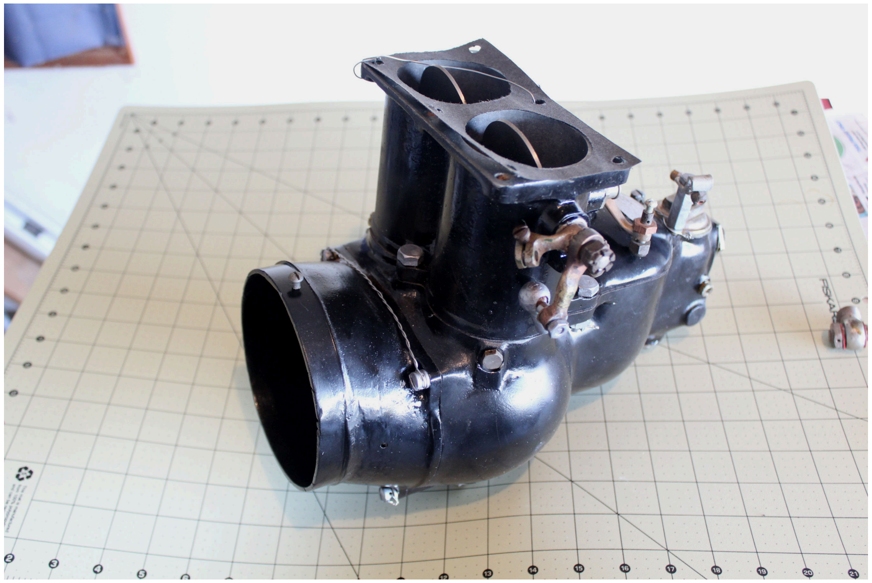
- Hispano engines used Claudel and Zenith Carburetors.
- The Wright models A and I used a Stromberg model **NA-D4**.
- The Wright model E used a Stromberg model **NA-E6** as it ran at higher speed.
- The Wright Model H used a Stromberg model **NA-D6** as the displacement increased from 718 ci to 1129 ci.
- The Wright ‘Superfighter’ 335 hp engine used a Stromberg model **NA-U6** carburetor.

Stromberg NA-D4 and 6

- This is a two barrel updraft carburetor.
- The air inlet is horizontal cross flow
- The carburetors are very similar except for venturi and jet sizes.



- NA-D6 carburetor before and after repair and overhaul

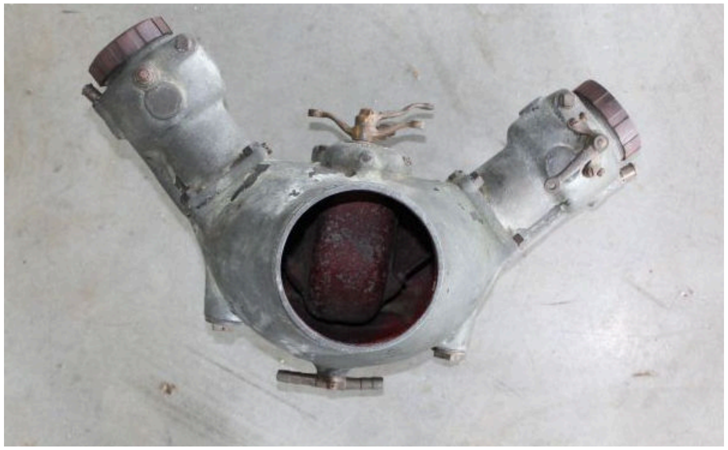


Stromberg NA-U6

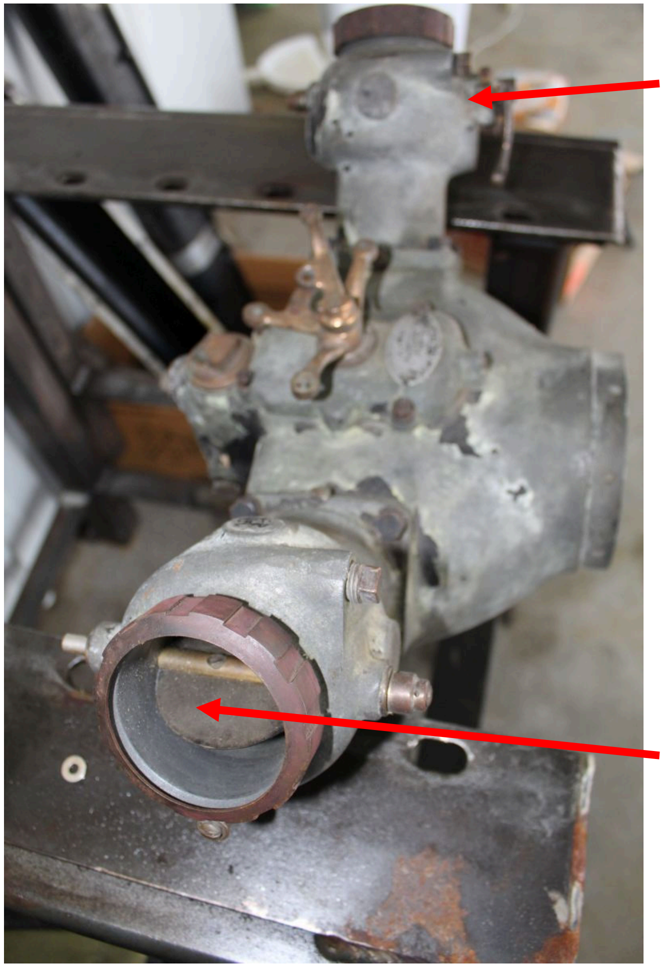
Bob Mishko's 'Superfighter' engine.

Stromberg NA-V6

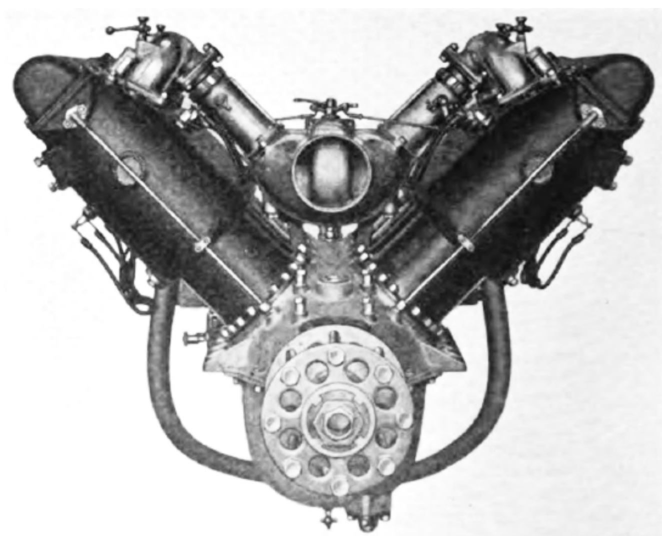
- This is a two barrel updraft carburetor.
- The air inlet is horizontal.
- Venturi and fuel nozzle are in the central body.
- The "V" designation is used only with this carburetor.



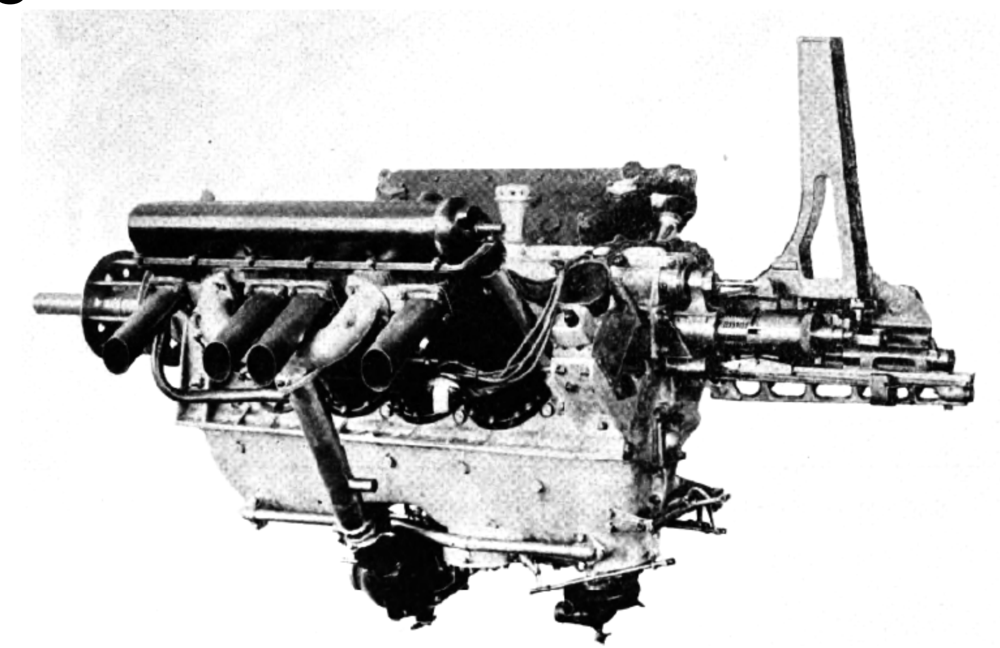
- The barrels are at 45 degree angles from vertical
- The throttle plates are located in the angled tubes.



- The Stromberg model NA-V6 carburetor was used on the Wright H3 engines used by the US Navy.
- It was also used on an experimental Wright model K engine with a 37mm cannon in the Vee.



Wright model H



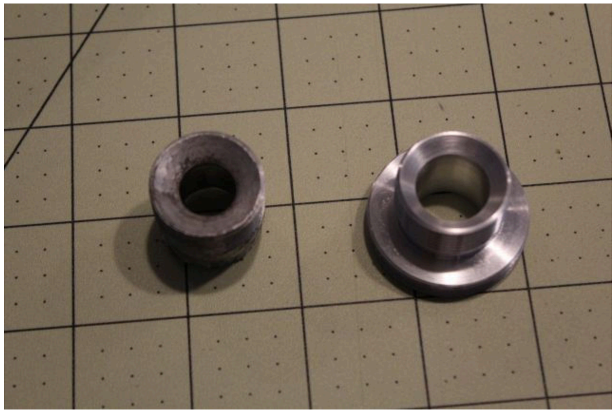
Wright model K

Water Pump

- The water pump mounts under the oil pump.
- The shaft is driven by the accessory gear.

Water Pump

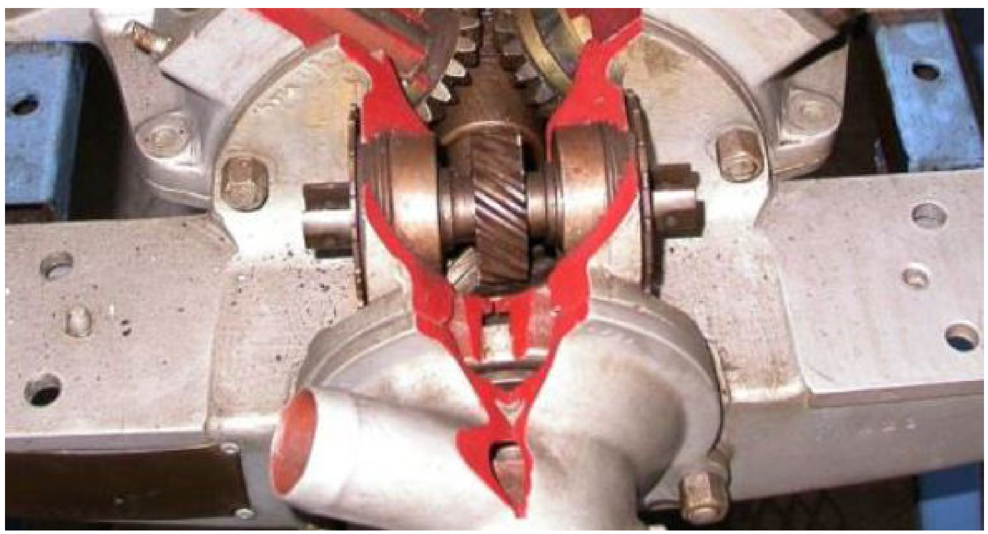
- The shaft hub was broken at the body



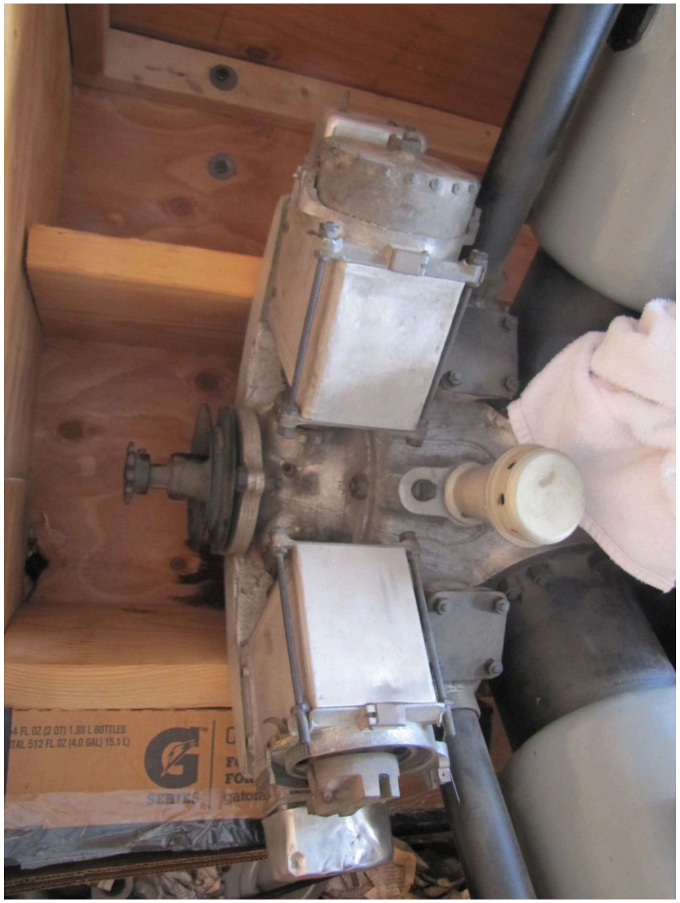
- We made a new hub.

Magneto Drive

- The Hispano and early Wright engines used a 90 degree gear to drive the magnetos.
- The magnetos are on a flat mount.
- The magnetos turn in opposite directions.



- The Wright magneto drive has an adaptor with bevel gears and mount at an angle.
- The magnetos turn in the same direction.
- This engine has 'Dixie 800' magnetos.
- Other mags are Scintilla and Mallory



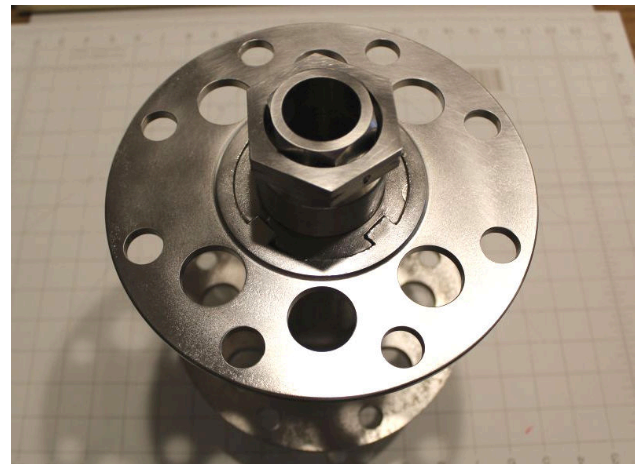
Prop Hub

- The prop hub is retained on the crankshaft with a taper and key. A double nut holds the hub to the shaft.
- The inner nut is threaded to the crankshaft and has a coarse thread.
- The outer nut is threaded to the hub and has a fine thread.
- The outer nut locks the inner nut.
- The nuts lock together with a cotter pin.

- We used Hispano-Suiza prop nuts as samples to make a pair of Wright prop nuts.
- Threads were metric, and we needed American threads.

Wright nuts on left. HS nuts on right.

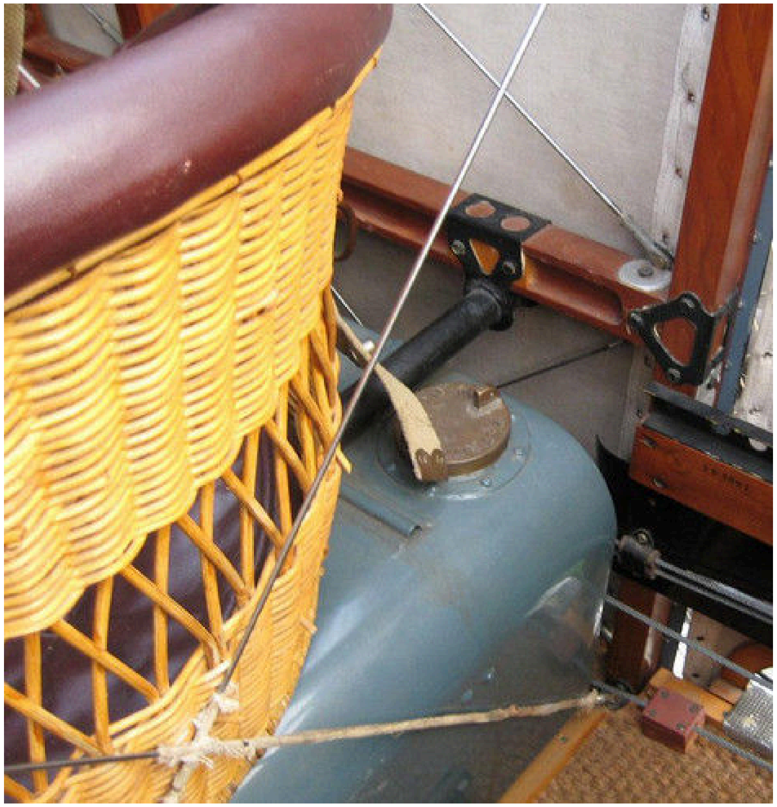
Wright	HS
3-¼” X 20	76mm X 1.5
1- ½” X 10	40mm X 2.5



Prop hub assembly with new locking nut

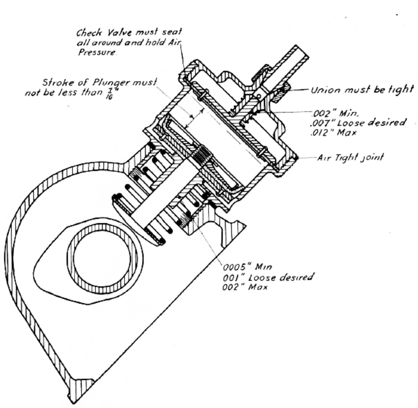
Fuel Pump

- The Bristol F.2B has a pressurized fuel system
- An air compressor pumps about 2 psi into the fuel tank.
- The fuel tank is under the pilot’s seat. (YIKES!)



- The F.2B with a Rolls engine used a propeller driven air pump mounted on a landing gear strut.
- The Wright engine used a cam driven air pump mounted on a cam cover.

Prop type pump



Cam operated pump

We made our own

‘Marshall and Son’ decal on original wood.

Data plate

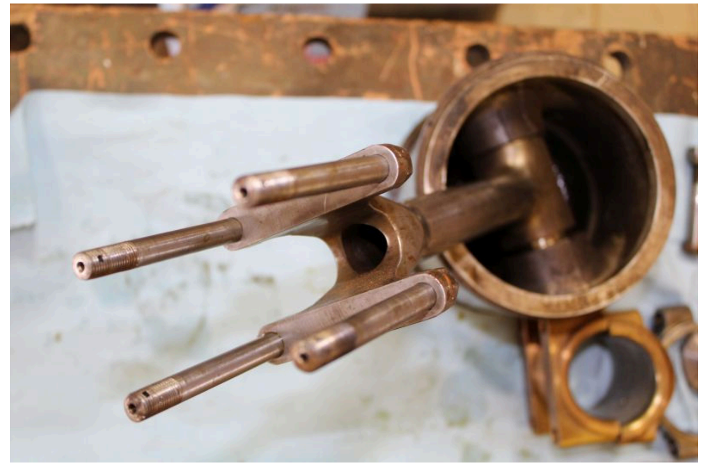
Cockpit (R) above and (L) below

Tail above
Trim controls below

Spoke wheel above
Wing below

Fuselage painted above
Ailerons finished below

Engine stand above.
“Not to be flown” ‘pretty engine’ below.



Drilled fork rod above
H2 engine below.

Notes:

- This engine had two stuck pistons, one per bank.
- Used a grease gun to hydraulic them out.
- The stuck cylinders were very rusty.
- Bored out .025” from 140mm leaving only .040”.
- Installed 3/16” thick sleeves and bored to 5-3/8”.
- New pistons to fit sleeve diameter match the other pistons to retain balance.
- Valves and sleeve interference – must remove valve guide to install valves.
- The ‘pretty engine’ has 7 stuck pistons!

Technical Sources

- Paul Dempsey (AEHS August 17, 2010)
- Fred van der Horst (2015 Convention)
- Peter Jackson (Has an original F.2B)
- Vintage Aviation Historical Foundation
- 1918 Wright Maintenance Manual
- 1919 US Air Service Manual
- 1921 Wright Maintenance Manual

Questions?