Waco RNF N11259
Serial Number 3462

Owners Manual

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2017-12-09

Waco RNF N11259, Serial Number 3462

Introduction

Forward

This owner's manual has been prepared by Dave Leedom after assuming ownership of N11259 upon the death of its restorer, Col. Jack Schifferer, Ret. Registration to Dave Leedom was dated 25 June 2007 with ACO Code 50033312.

The information in this manual represents the understanding of the author based upon historical data, reference documentation, and interviews with numerous "experts" who qualified for that moniker to various degrees of accuracy[1]. The information in this manual is thus prone to the same errors and misunderstandings that these "experts" had although an attempt has been made to eliminate inaccurate and conflicting information and some of the information has subsequently been validated through operation and performance measurements. In addition, physical descriptions have been augmented with photographs of the actual plane, engine, and accessories wherever possible.

The author assumes no responsibility for the accuracy of this manual. It is for informational purposes and not as an authoritative guide. It certainly is not approved by the FAA.

[1] There is some reference material for components of this aircraft, but very little for the integration of those components. Statements about how components are integrated together is the collective wisdom of the author as gleaned from validated experts

For physical orientation, all references in this manual are from the perspective of someone looking tail to nose except for appliances like magnetos, starters, etc. Rotational reference (mostly cylinder position) is clockwise looking forward and typically starts from the top center. With reference to driven appliances, orientation is looking at the appliance from the driven shaft.

Terminology

During creation of this Owner's Manual, the file became very large because of the extensive photographic documentation and the need to scan numerous reference documents—many historical--that existed only in hard copy format. In order to keep descriptions more readable and the files more tractable—and they are still quite large—material was organized with appendices and addendums. Appendices include material the author felt the reader would want to access while reading the main text in digital format and return to where the reference was made. MS WORD facilitates that when the material referenced is in the same file as the reference.

For reference material that is not as essential to understanding sections in this manual, material is placed in separate files that are "addendums" to this Owner's Manual file. Hyperlinks are provided for addendum material that should work if the addendum files are stored in the same file organization as original; however, return links may or may not be conveniently available.

Manual Organization

- **Specifications:** (Dimensions, Weights, Capacities, Airfoil, Standard Values, Weight and Balance, Center of Gravity)
- **Performance:** (Engine speeds, aircraft speeds, takeoff distance, rate of climb, service ceiling, landing distance
- **System and Component Descriptions**
    - Airframe (fuselage, engine mount and cowl, wings, empennage, flying wires, inspection covers)
    - Landing Gear (configuration, main gear, tail wheel, brakes)
    - Power System (motor, air intake and carburetor heat, exhaust, propeller, magnetos, starter, carburetor, tachometer)
    - Fuel and oil System (fuel, oil)
    - Electrical (battery, starter, switches, circuits)
    - Controls (overview, control descriptions)
    - Instruments (engine instruments, air speed, altimeter, turn coordinator, ELT, transponder, radio)
- **Pre-flight Checklist**
- **Maintenance Schedule and Checklist**
- **Aircraft History:** (Certification dates, repairs, STCs, ADs, recent upgrades, reference)
- **Appendices**: (Carburetor manual, starter manuals, magneto manuals)

Airworthiness

This aircraft was restored from a project status between 2000 and 2006. A new airworthiness certificate FAA Form 8100-2 was issued for the plane with no exceptions by the San Diego Flight Service District Office (FSDO) (Dan H Johnson) on 1 July 2005. That airworthiness certificate was designated WP09. When that airworthiness certificate was issued, all equipment on the plane at the time was assumed to be qualified for use on this specific aircraft regardless of the certificated or Supplemental Type Certificate (STC) status of the specific piece of equipment. The Scott tailwheel used in lieu of the original tailwheel is an example of equipment not on the original aircraft but assumed to be qualified for use on N11259 upon issuance of the airworthiness certificate

Specifications[2] and Capacities

Dimensions

Wingspan: 29’6”
Length: 21”
Wing Area: 241.5 sq. ft.
Chord: 57”
Stagger: 27.5”
Height: 8’ 9”
Gear Tread: 72”

Weights

Empty: 1380 lbs actual (1125 - 1195 lbs typical with lower weight due 125 hp engine)
Gross: 1938 lbs actual (1872 - 1911 lbs) (1897 w/ 110 hp Warner per AAF)

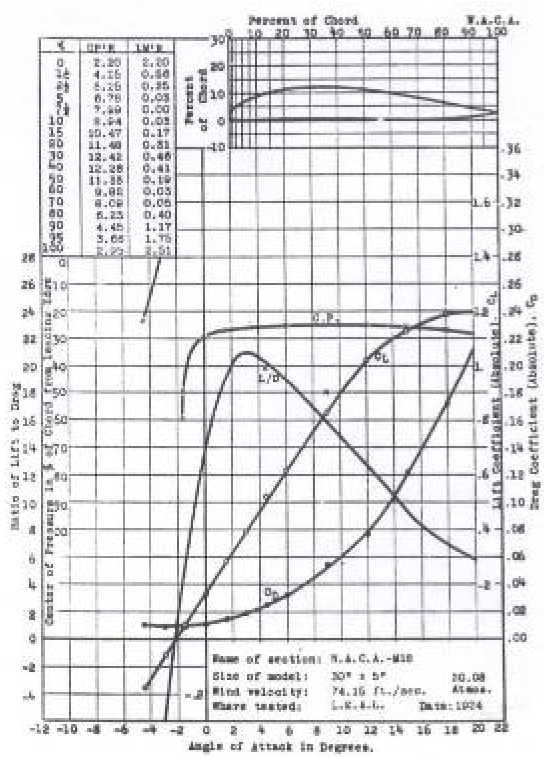
Capacities

People: 3 (2 front, one pilot rear)
Gas = 32 gallons
Oil = 5 gallon tank; filled to 4 gallons or less. (3 gallons figured in weight and balance)

Airfoil

The wing airfoil is a NACA M18. The following graph gives the theoretical performance

[2] Numbers in blue are from Sport Flying Vol. 3, No. 4, April 1969, “Identifying Waco Airplanes”, for “NF” type fuselage and wings (no engine specified.)



Standard Values and Components

Tires

There are two main and one tail wheel tire.

Main Wheels

Wheels

Aircraft Products Corporation Model 650-10.

Size and Type

AirTrack Rib 7.50 x 10, Type III, 6 ply rated nylon

Air Pressure

23 psi

Tail Wheel

Size and Type

Specialty Tire of America (STA) 2.80/2.50 x 4, 4 ply nylon

Air Pressure

50-60 psi

Oil

Type:

Oil used for the first 25 hours of engine operation (post overhaul) was straight mineral oil (non-detergent) 100 weight.

For subsequent use will switch to AeroShell W 100.

Consumption:

Oil consumption pre the Warner Engine Handbook is nominally 0.025 lb / hp / hr at max power and 0.020 lb / hp / hr at cruise. This gives a consumption of 0.39 gallon per hour at cruise.

Fuel

Type:

100 LL aviation gas with 2 oz Marvel Mystery Oil (MMO) mixed per 5 gallons of gas. (The MMO is recommended for protection of the valves guides while running—unavoidably--at lead contents / octane well above that for which this engine was designed.)
(Auto gas has been recommended in lieu of aviation fuel, but that was before ethanol was added to auto fuel on a wide-spread basis. The alcohol is more detrimental to the engine and components than the higher lead content / octane according to antique engine experts.)

Consumption (per Warner Engine Handbook):

8.1 gph @ 1700 RPM
13.4 gph @ 2050 RPM

Engine

The current engine is a Warner Super Scarab SS-50 Serial Number 693 of 145 hp. (There is a "Repair and Alteration Form for installation of a Warner SS-50 on another Waco RNF, but the one for N11259 is not available as of this writing (28 Nov 2008).

Pressure (Warner Engine Handbook)

Oil pressure should be a minimum 50 psi for operations and should not exceed 90 psi. Idle oil pressure of 40 psi is an acceptable minimum.

Temperatures

Cylinder Head Temperature

Maximum cylinder head temperature is 525^0F (according to Warner Engine Handbook p. 17) at rear plug, 300^0F at cylinder base, lee side of cylinder barrel. Using instrument reading in cockpit

CHT is to be kept below 400^0F according to Al Holloway. The Warner Engine Manual says not to take off with CHT below 120^0F but the CHT gauge cannot be programmed below 200^0F, so that value was used for minimum operating temperature on the gauge.

Oil Temperature

Minimum oil temperature is 80^0F. Maximum oil temperature is 200^0F at the engine inlet. (Warner Engine Handbook, p. 17) (The oil temperature sensor on N11259 is at the bottom of the external oil tank in the area from which the pressure pump draws.)

Performance[3]

Engine Speeds

- RPM idle = 600 (nominal)
- RPM max power = 2050
- RPM max = 2150
- PRM cruise = 1800

Power

- Maximum power output is 145 hp at 2050 rpm
- The maximum permissible cruising power rating of this engine, when using a fixed propeller is 109 h.p. at 1865 rpm

Rate of Climb

Initial Rate of Climb: 925 fpm claimed with 125 hp Warner (800 fpm quoted for 110 hp Warner)
Actual = ~500 fpm for first two thousand feet experienced during flights for PMA of new pistons with 145 hp Warner

Takeoff Distance

- Normal = <Specification not found>; Actual = <TBD>
- 50 Ft Object (Actual) - <TBD>

Landing Distance

- Normal = 235 ft (no brakes) (Grass?); Actual = <TBD>
- 50 Ft Object (Actual) - <TBD>

Service Ceiling

14,500 ft

[3] Numbers in blue are from Sport Flying Vol. 3, No. 4, April 1969, "Identifying Waco Airplanes", for "NF" type fuselage and wings (no engine specified.)

Speeds

- Vs = 50 mph indicated
- Vx = ~75 mph indicated
- Vy =
- Vne = 108 mph
- V_{cruise} = 92 mph claimed with 125 hp Warner (95 with 110 hp Warner per AAF[4]) At 90% power cruise is about 85 mph indicated with the 145 hp Warner installed)
- V_{top} = 108 mph (112 mph per AAF)
- V_{land} = 41 mph

[4] Arizona Aircraft Foundation

System and Component Descriptions

This section attempts to document N11259 systems and components. Some components have documentation, but much of the integration of systems and performance of integrated systems is not documented. There is more detail in the following where it was necessary to get the overall systems functioning correctly.

Airframe

The airframe includes the fuselage, wings, empennage, flying wires, and (included because they are accessed at least once a year) inspection covers. The landing gear is discussed separately in the next section.

Fuselage

The fuselage is welded steel tubing faired longitudinally with wood strips and with a wooden turtle deck from aft of the rear cockpit to the rudder. Sheet aluminum fairs the rudder / stabilizer area, the cockpits, and a streamlined headrest on top of the turtle deck. The following four photos show the fuselage in various stages of restoration.

During restoration, all steel was stripped and recoated with epoxy primer. All new wood and aluminum was used. Wood parts were coated with Poly Fiber EV-410 epoxy varnish.

Aluminum cowling around the cockpits is held down with #8-32 screws that go into threaded barrels glued in the wood fairings on the cockpit longerons and in the formers in front of and behind the cockpits.

The seats have lap belt restraints only, no shoulder restraints.

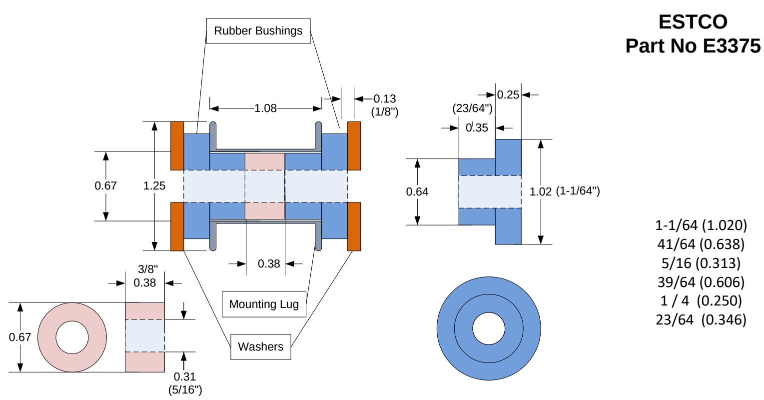
Engine Mount and Cowl

The engine mount was changed from the original at the time the engine was upgraded to the Warner Super Scarab-50 145 hp. At the time of this writing (Dec 2008) there was no Form 337 paperwork accounting for this change. A form 337 for upgrade of the engine of another RNF shows a motor mount different than on N11259. In addition, the motor mounts on two other know RNFs belonging to Susan Theodorelos are also different than that on N11259. The motor mount on N11259 was implicitly certified when the aircraft was recertified after restoration.

The motor mount on N11259 is a steel tube structure welded (not bolted) to the front of the fuselage. The motor mounts to a ring supported by six tubes, two each side from the upper longerons and one each side from the center of the bottom front fuselage cross tube. The ring has ten lugs formed of 1” long tubing with washers welded to each end. Each lug is positioned to correspond to one of the ten mounting holes on the back of the Warner SS-50 engine. The following photos show the motor mount.

In the second photo, attach tabs can be seen.

The engine is mounted to the mount ring with rubber bushings illustrated in the following diagram and photos. The rubber bushing is from ESTCO Enterprises, 1549 Simpson Way Escondido, CA 92029. A 4130 sleeve was fitted to the motor mount lugs to accommodate the rubber bushing more precisely. The sleeve was coated with room temperature vulcanization rubber before insertion. The rubber bushings insert back-to-back but require a spacer between their bottoms to make the stem expand as the mount bolt is tightened. In addition, the bushings were slightly undersize for the tubes on the engine mount, so insert tubing was used to make the fit snug.



Buna-A

A five-piece cowl covers the back of the engine compartment.

There is a nose bowl that bolts to the front of the Warner SS-50 and has “fingers” that extend back between cylinders #1, 2, 3, 5, 6, and 7. (The carburetor protrudes between cylinders #4 and #5 precluding a finger there. Each finger in the cowl front piece has a hole for a bolt that attaches to corresponding fingers in the cowl top and two cowl side pieces.

A bottom cowl piece is a reinforced aluminum plate that extends from the firewall to the bottom of the cowl ring mount.

A top cowl piece extends from the firewall forward to the cowl mount ring. The top piece has a hole for the oil tank filler cap and two “fingers” in the front that attach to the cowl front piece on each side of cylinder #1. Bolt holes in the fingers on the cowl top piece mate with corresponding bolt holes in the fingers of the cowl front piece. These holes align with nut plates on the cowl mount ring that accept #10-32 stainless steel truss head screws. The cowl top piece has Screw holes along each side for mount of the cowl side pieces. The cowl top piece has mounting holes along the back edge that mate with nut plates on the firewall flange that accept #10-32 stainless steel truss head screws.

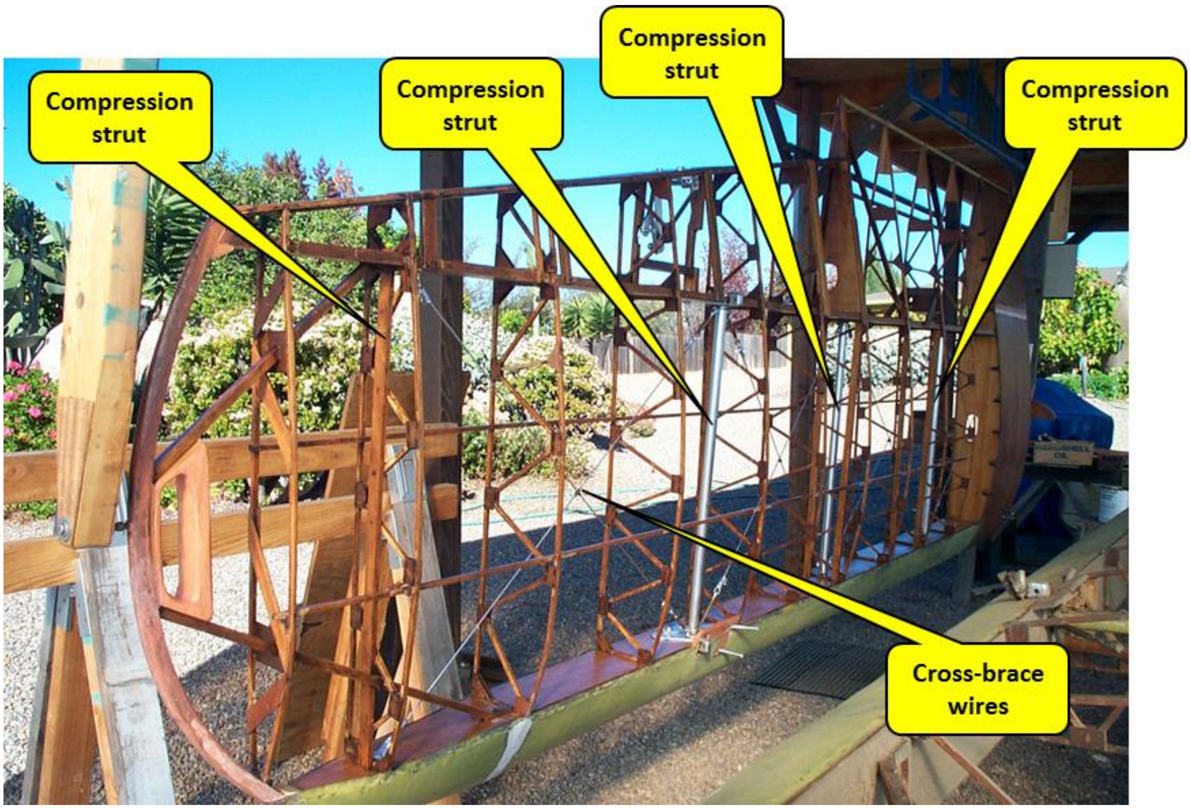
There are two cowl side pieces. Each side piece extends from the firewall forward to the cowl mount ring. Each side piece has two fingers that mate with and slip under fingers from the cowl front piece; the right side cowl has fingers either side of cylinder #3 and the left side either side of cylinder #6. Holes in the side piece fingers mate to holes in the front piece fingers and then mate with nut plates on the cowl mount ring that accept #10-32 stainless steel truss head screws The side pieces slip under the cowl top piece and have holes that mate with holes along the edge of the cowl top piece. The side pieces have nut plates imbedded behind this row of holes that accept #10-32 stainless steel truss head screws. The cowl side pieces also have holes along the back side that mate with holes in the firewall flange through stand-off stubs backed by nut plates that accept #10-32 stainless steel truss head screws of varying length. The stand-offs provide space at the rear between the side cowls and the fuselage sides for escape of cooling air for the oil tank. There are also holes along the bottom edge of the side cowls that mate with holes in the cowl bottom piece where nut plates are attached to the reinforcing channel along each side of the bottom piece. These nut plates accept #10-32 stainless steel truss head screws.

The original RNF cowl was formed from aluminum. During reconstruction, Jack recreated the nose bowl and top cowl using foam molds over the engine components and five layers of S-glass and epoxy for the cowl material. The side and bottom cowlings are made from aluminum. Nylon washers are used under all cowl mounting screws to protect the paint and cowl material. All cowl mount screws are stainless steel which tends to gall with recurrent use. All screw threads should be treated with anti-seize compound before use to prevent galling. (The same anti-seize compound used for the spark plugs is used for the stainless steel screw threads.)

The original RNF did not have screws holding the cowl together. It had studs in the top and bottom cowl pieces that protruded through holes in the side cowl pieces. The studs had holes for pins that were inserted after the side pieces were installed over the studs and a wire keeper threaded through the holes in the studs to retain the cowl side pieces. Jack didn’t understand the original cowl retention configuration and adopted the screws and nut plates instead.

Wings

The RNF wings are wood with a fore and aft spar, a spar along the aileron hinge line, and an aluminum leading edge from forward spar top to bottom. Ribs are wooden trusses with plywood gussets. The wing is braced against fore and aft forces by drag and anti-drag wires attached to the spars and tightened by turnbuckles. At the points on the spars where the drag / anti-drag wires attach there are steel tube compression bars that support the forces of the tightened wires (except for the outer-most attach point where a wood compression strut is used.) The trailing edge is aluminum bent in a "V" shape.

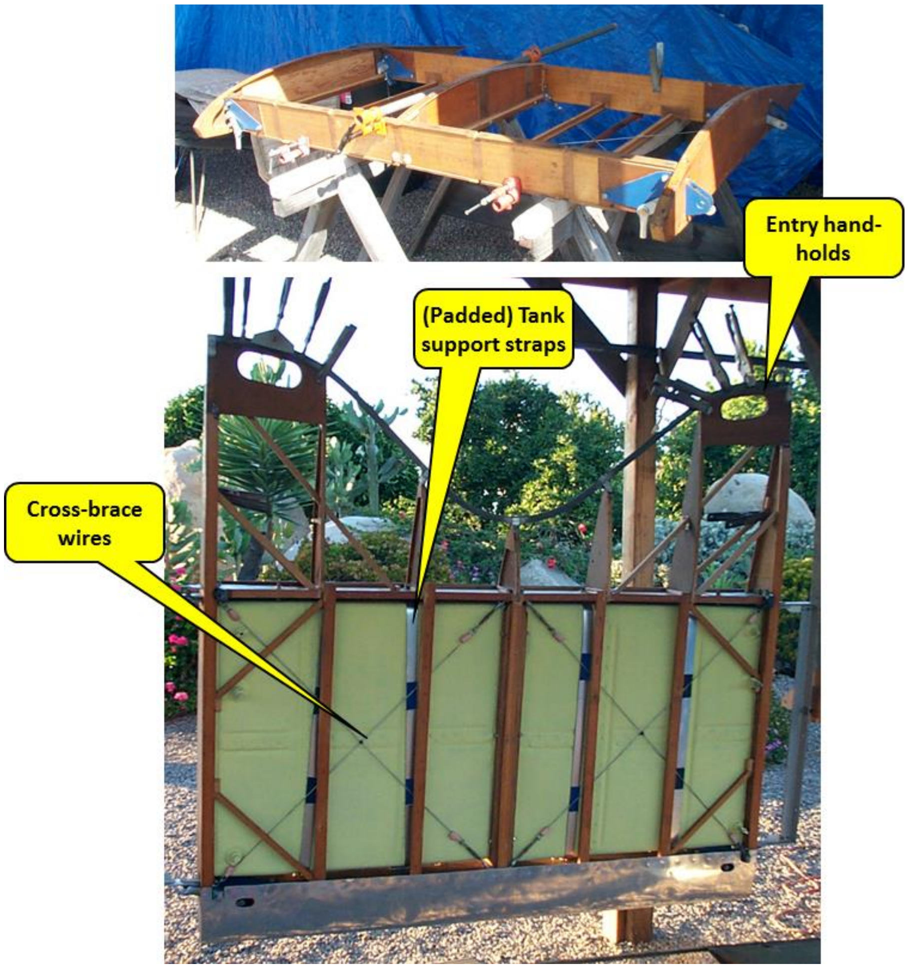


During restoration, every spar, rib, and other wood component was scraped and / or sanded smooth. Every gusset was tested for attach strength and all those that failed test were replaced. All loose or inferior glue joints were restored with T-88 epoxy. The restored wood structure was coated with PolyFiber EV-400 epoxy varnish.

All metal fittings (wing / fuselage attachments, compression struts, cross-brace attachments, flying wire attachments, strut attachments, aileron pushrods and bellcranks) were stripped, primed with epoxy primer and coated with silver Alumigrip. The leading edge aluminum was coated with PolyFiber epoxy primer.

The lower wing has plywood covering from the root rib to the second rib. That plywood had to be replaced in places and was increased in thickness slightly. Hand holds were molded into the lower wing tips per original practice for the float version of the RNF.

The wing center section had to be completely reconstructed. The basic parts created for that reconstruction are shown in the following photo. The center section has cross-brace wires at the bottom of the airfoil (to allow space for the gas tanks) and an aluminum leading edge from front spar top to bottom. The trailing edge is a curved "V" section piece of aluminum. At the aft ends of the center section, there are molded and reinforced wooden hand-holds to aid the pilot in entry to the aft cockpit.



Two gas tanks are contained in the center section. They are suspended between the fore and aft spars by attachments that capture stainless steel straps that surround the tanks (padded by thick fabric). The top center section is covered by an aluminum sheet attached to the spars and end ribs by #10-32 screws into nut plates attached under caps on the ribs and the spars.

The ailerons are wood structures. A typical photo is shown below prior to restoration (lower right aileron).

Empennage

The fin, rudder, horizontal stabilizer and elevator are all welded steel structures. All steel was stripped to metal and refinished with epoxy primer before covering.

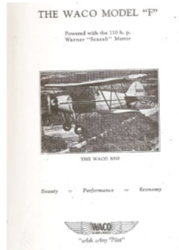
Covering

All covering followed the Poly Fiber process exclusively using Poly Fiber cloth attached with Poly Tac and coated with Poly Brush which is also used for attachment and initial coating of protective tapes. All flying surfaces were rib-stitched with areas where sheeting precluded top-to-bottom stitching stitched to attached members before the occluding side was covered. After coating with Ploy Spray silver ultraviolet protection, the flying surfaces were painted with Juneau White and the fuselage and rudder with Bahama Blue. Poly Tone paint was used on fabric surfaces; Aero-Thane paint was used on metal and composite surfaces

Flying Wires

Flying wires were purchased from Steen Aero Lab, 1451 Clearmont Street NE, Palm Bay, FL 32905, (321) 725-4160. Steen orders the wires from Bruntons Aero Products, Ltd in England (formerly McWhite.) The exact wires ordered are in the Appendices to this Owner's Manual

They were installed using information from the Waco Type "F" Instruction Manual and verbal information from other biplane restorers. The Waco Instruction Manual is accessible via the following PDF icon.

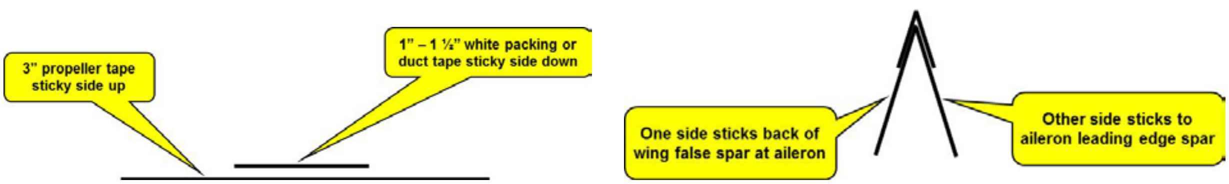


Waco Model F Instruction Manual

Aileron Gap Seals

The gap between the wing and aileron is significant because of the size of the hinges used. In flight air leaks from the (higher pressure) lower surface to the (lower pressure) upper surface of the wing through the wing / aileron gap and significantly reduces aileron effectiveness—especially in the lower speed landing configuration.

In order to prevent loss of control during low speed operations, the wing / aileron gap needs to be sealed. There are a number of ways to accomplish this but the means selected for this plane was to use 3" propeller tape with a 1" or 1 ½" smooth (white duct or packing) tape along it's middle. White is used to make the seal seem more aesthetically pleasing. The following figure illustrates the tape used to seal the gaps.



The following picture of a gap seal in place is taken looking down the wing / aileron gap from the wing tip.

Inspection Covers

There are 51 inspection covers on the RNF that need to be removed for annual inspection in addition to the side cowl pieces. They include the following. (Not included is the aluminum fairing between the rudder and stabilizer; that area can be inspected through the hole for stabilizer trim motion and the inspection plate on the bottom of the fuselage in that area. The rear stabilizer fairing can be removed if necessary.)

- Six round covers on the bottom of each lower wing these are at the compression strut and anti-drag cable fittings on the spars and wing-fuselage attach brackets on the spar
- An aileron bell crank cover and a round cover on the aileron at the control horn (each wing)
- Four round covers on the bottom of each upper wing where the compression struts and anti-drag cables attach to the spars
- Four rectangular covers on the top inboard of each upper wing that cover the
- Three rectangular plates on the bottom of the fuselage from the motor mount back behind the landing gear that show landing gear attachments, antenna attachments, and some of the Johnson Bar brake cabling.
- One round cover on the bottom of the fuselage at the tail that shows stabilizer attachment (in addition to that visible through the stabilizer / fuselage fairing
- Two covers under the fuselage at each forward lower wing spar attach point. (The rear spar attach points are visible from inside the rear cockpit.)
- One bubble cover under the fuselage port side that exposes a pulley of the Johnson Bar brake system

There are additional covers at the point where the flying and landing wires attach to the wings. Whether these need to be removed for annual is up to IA discretion. There is more discussion and documentation of inspection covers in the maintenance addendum to this owner's manual. See this imbedded file.

Waco RNF N11259 Inspection Covers

Landing Gear

The landing gear includes the main gear, tailwheel, and brakes.

General Configuration

The RNF landing gear is a tail wheel configuration. The main gear is an outrigger type with oleo struts. The brakes are mechanical actuated by a "Johnson Bar" lever described below. The original tailwheel on the RNF was a free-castoring wheel mounted under the fuselage even with the stabilizer leading edge as shown in the pre-restoration photo below.

In the interests of safety, Jack replaced this tailwheel with a modern Maule tailwheel mounted at the tail post of the fuselage during restoration. The tailwheel mounting configuration copied the practice of other planes (like a piper cub) in attaching the Maule tailwheel to the fuselage.

Main Gear

Design

The main landing gear mounts on braced outrigger struts just behind the firewall. The wheels are suspended on oleo struts from the outriggers. The oleo struts pivot at the axle and are braced by fore and aft struts welded to the axle and hinged at the fuselage center. These lower brace struts are faired with balsa wood to an airfoil shape and wrapped in Ceconite for strength.

The wheels are supported on axles of stepped-down dimensions as shown in the following photo.

(On some RNFs the oleo struts are enclosed in an aluminum airfoil-shaped fairing. Reportedly, this fairing also encloses a safety cable that connects the axle with the outrigger. The safety cable is to preclude the wheels from dropping out of the oleos should there be a failure of the oleo struts. At the time of this writing, those safety cables are not installed on N11259.)

The wheels and brakes are Aircraft Products Corporation Model 650-10.

Tires

Tires are Specialty Tire of America (STA) 2.80/2.50 x 4, 4 ply nylon inflated to 23 lbs. They need to be balanced on the wheels. The wheels are not well balanced and if left that way, the heavy side rotates to the bottom during flight and the bottom becomes the same place scuffed upon landing every time. It doesn't take too long to scuff through to the cords. Balancing avoids that and distributes the scuffing around the tire.

Maintenance

Brake adjustment is detailed in the Waco Model F Instruction Manual. The oleo struts use brake fluid. The amount and the check and fill process are also detailed in the Waco Model F Instruction Manual.

The tires and wheel are relatively heavy as aircraft tires go. They do not need to be balanced for running but they do need to be balanced to preclude bald spots. If the tire / wheel combination is not balance, the tire will rotate to a heavy side low position in the air and that spot on the tire will be scuffed on each landing. It doesn't take long for a flat spot to develop and threaten to go into the tire cord. It takes up to 4.5 oz of weight to static balance a wheel / tire combination.

Tail Wheel

Design

The tailwheel is a Maule Model SFSP8A1-2, Part Number TW-100. Installation instructions and a blow-up diagram of components is in the appendices to this Owner's Manual and accessible via the PDF icon.

Maule Tailwheel Installation Instructions

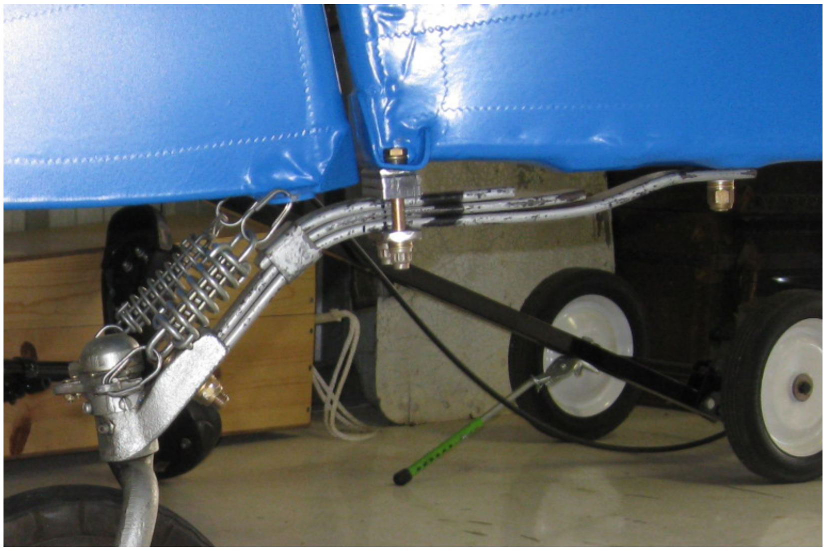
Some shimmy was experienced during touchdown. The tailwheel was shimmed so that the kingpin pivot axis of the tailwheel is back at the top and forward toward the bottom. (This is referred to as a negative kingpin angle.) Spring tension between the tailwheel control horn and the control arms on the rudder is barely taught (with no tension). There is more information on tailwheel shimmy in the appendices to this Owner's Manual and is accessible via the PDF icon.

Tail Wheel Shimmy

The primary condition to preclude shimmy is the negative kingpin angle, but the extent of that angle has to be modulated to ensure steering is stable. With a negative kingpin angle the height of the tail decreases as the tailwheel rotates from straight back. That creates a condition of increasing stability when tailwheel turns. The tailwheel wants to reverse and the only thing that prevents that is tension in the kingpin that keeps the tailwheel locked and steerable by the rudder pedals. If the kingpin angle to too negative, the tailwheel will unlock easily and the plane becomes very difficult to steer. It is likely that this condition would promote much easier ground-looping, too.

Tailwheel springs are the compression type meaning that they are initially extended and when the rudder pedal is used to pull on the rudder horn for steering, the spring is put in compression. There are those who argue compression springs are bad because, if they bottom out, they impart significant force on the rudder horn with the potential for damage. On the Maule tailwheel unit, the compression stroke is long and bottoming is unlikely. In addition, the tailwheel should unlock before any damage occurs.

The tailwheel is held on to the fuselage with a square tubing cross piece between the lower two longerons. That square tubing has a bushing in the middle where the bolt holding the front of the tailwheel leaf spring is attached so that tightening that bolt will not crush the tubing. The aft portion of the tailwheel leaf spring is bolted to the tailpost with two bolts through a plate that goes under the springs. The attaché point on the fuselage is a fitting similar to what is used on Univaire tailwheel mounts on Cubs and other planes.



Maintenance

The tailwheel needs to be inspected annually to ensure the kingpin angle remains negative in spite of possible spring wear / fatigue. The kingpin should be greased annually. Tailwheel inflation should be maintained at 65 lbs/ sq in.

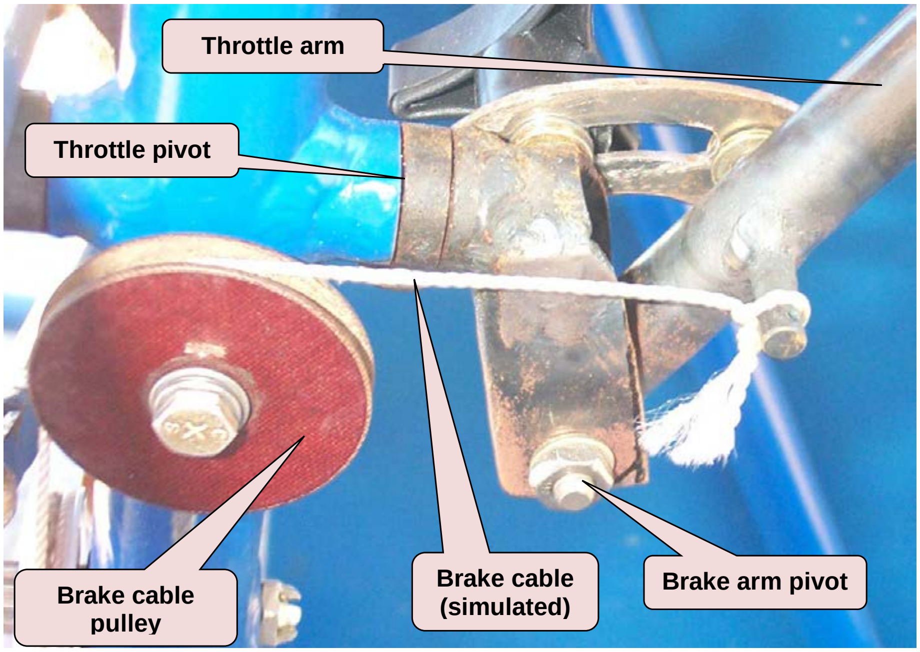
Brakes

Design

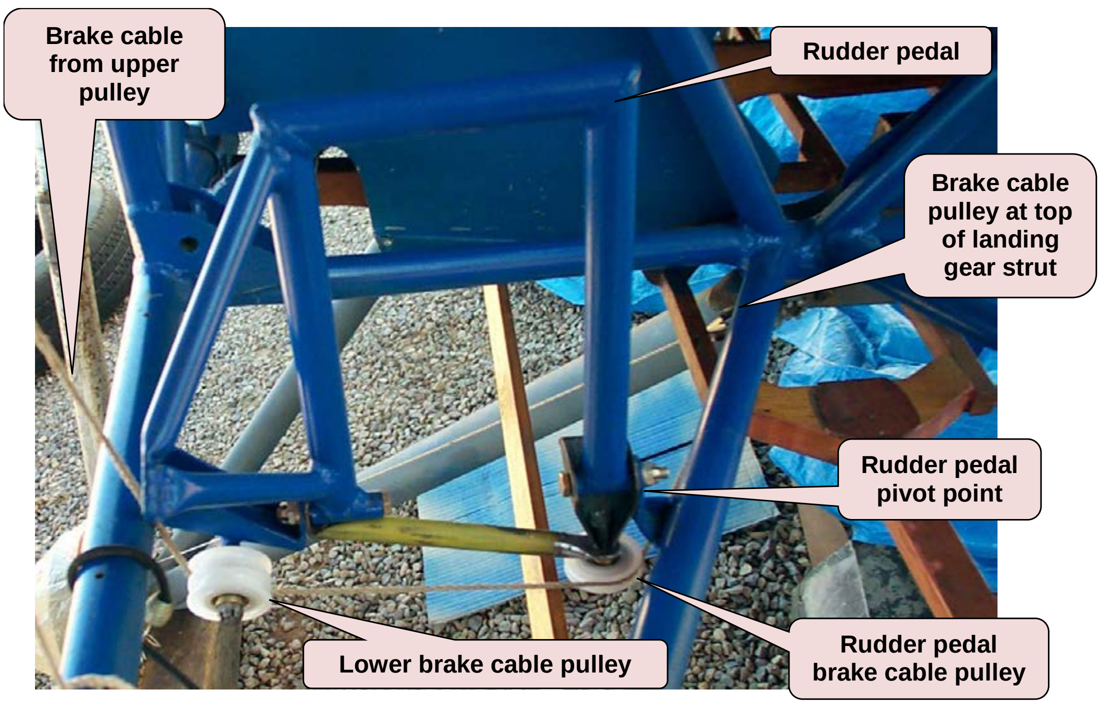
The brakes are drum type and are manually actuated by a cable that runs from the throttle lever in each cockpit to the brake lever on the wheels. On the way to the brake lever, the cable passes around a pulley on an arm off the bottom of the rudder pedals. These pulleys change the pressure applied to each brake in such a manner that braking is increased in the direction of applied rudder; brake application is not independent of rudder application as in modern aircraft.

Mechanical Linkages

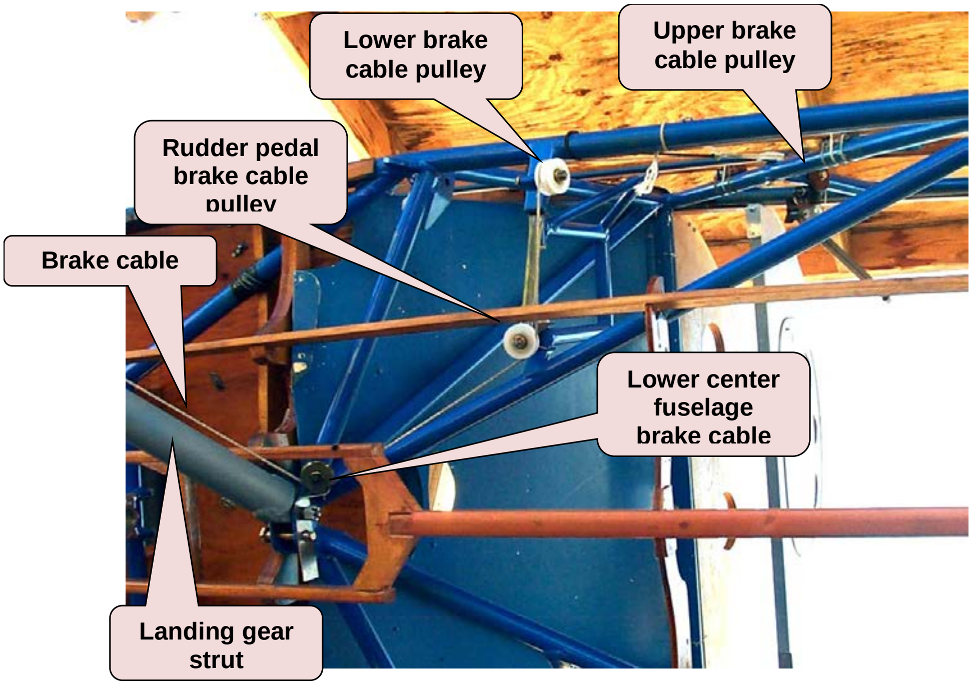
The following photo shows the way the cable comes off of the throttle arm on the left side of the cockpit when the throttle arm is rotated inboard. In the photo, white cord has been used to check the cable path during restoration. The white cord shows up better than the actual cable and thus photos with cord are used here for illustration.



The cable proceeds from the pulley shown above to a pulley at the bottom of the left side of the fuselage and from there around the pulley on the bottom of the rudder pedal.



From the bottom of the rudder pedal, the cable goes around a pulley near bottom fuselage center and then travels down the landing gear strut. Note the following picture is looking up at the bottom of the u covered fuselage.



At the base of the landing gear strut, the brake cable goes around yet another pulley to gain position to apply leverage on the brake actuation arm attached to the wheel.

The following photo shows the inside of the brake. The brake actuation arm is not shown, but goes on the far side of the brake shoes as shown in the photo. The actuation arm operates an elliptical cam inside the joint shown on the right in the picture. When the lever is actuated, the wide part of the cam forces the shoes apart and applies the brake. On the opposite end of the shoes are two short metal pieces that meet at an angle and are pivoted from a bolt that extends through the back of the brake plate through a radial slot. If the pivot bolt is moved in or out in the radial slot, it expands or retracts the shoes and that is how the brakes are adjusted in accordance with the process described in the Waco Model F Instruction Manual. There is a nut on the pivot bolt and a slot in the end of the pivot bolt that protrudes from the back of the brake plate. There is no need to remove the wheel to adjust the brakes; the bolt and nut are accessible from the back of the brake plate as shown in the second picture.

Actuator

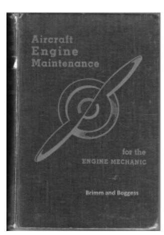
The brake actuator is the throttle lever. Brakes are applied by tilting the throttle lever inboard. **Note that the brakes are not strong enough to hold the plane when the engine is run above 1200 RPM.**

Maintenance

The brakes are to be adjusted as needed. The adjustment procedure is described in the Waco Model F Instruction Manual.

Power System

It is useful to be acquainted with radial engines in general when looking at the Warner in particular. General information on radial engines from “Aircraft Engine Maintenance for the Engine Mechanic” by Brimm and Boggess is contained via the following PDF icon.

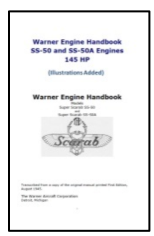


“Aircraft Engine Maintenance”, Brimm and Boggess

Engine

The engine in N11259 is a Warner Super Scarab 145 hp, Serial Number SS693E. It has an enclosed valve rocker, manually greased.

Overview of the Warner Super Scarab is contained in the Warner Engine Handbook. That handbook can be accessed by double-clicking the following PDF icon.



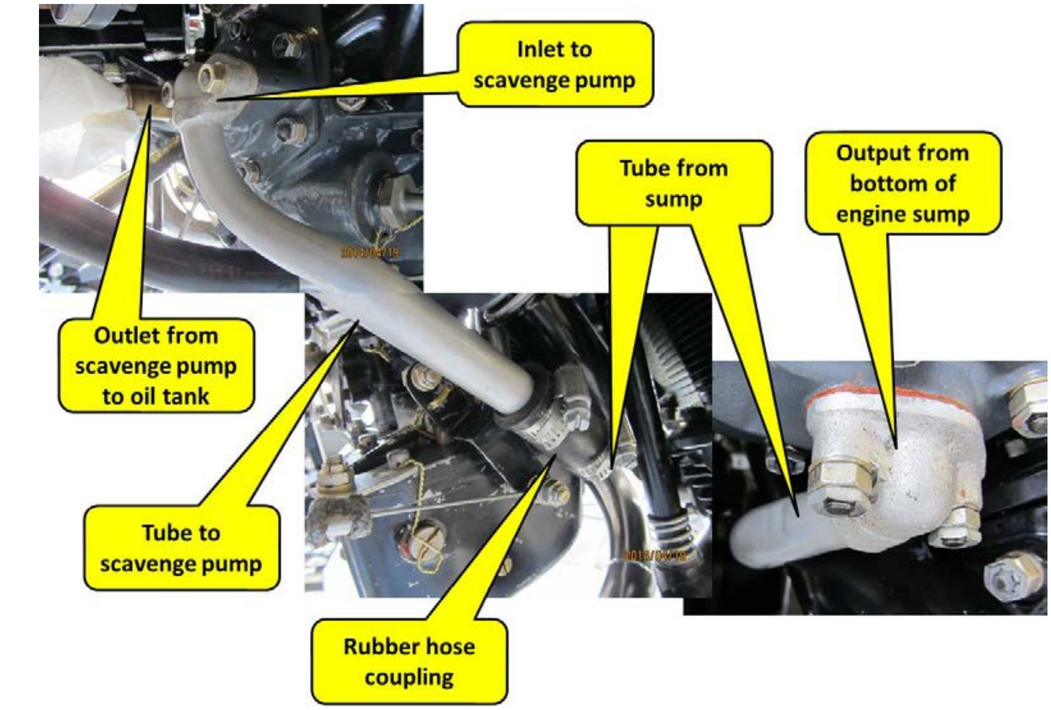
(Illustrated) Warner Engine Handbook

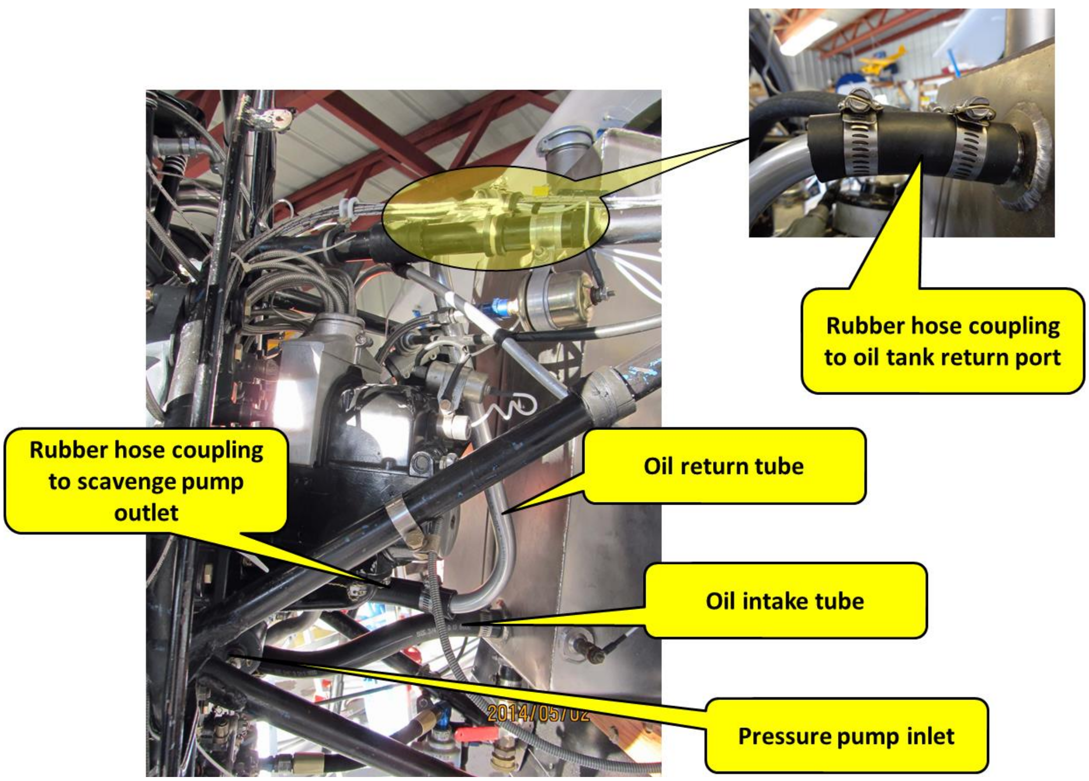
There are references care and operation of Warner engines obtained from the web. They are in an Appendix to this Owner's Manual. (Note that one reference applies to a 165 hp Warner, but that information is useful by analogy.)

The following components are integral to the Warner engine and are discussed in the Warner Engine Handbook. They are included here because they are important to engine hookup and integration in to the airframe and / or maintenance during operation.

Oil Pump

There are two oil pumps, a primary pressure pump that pumps oil from the tank into the engine for lubrication and a second scavenger pump that sucks oil out of the sump and pumps it back into the external oil tank.





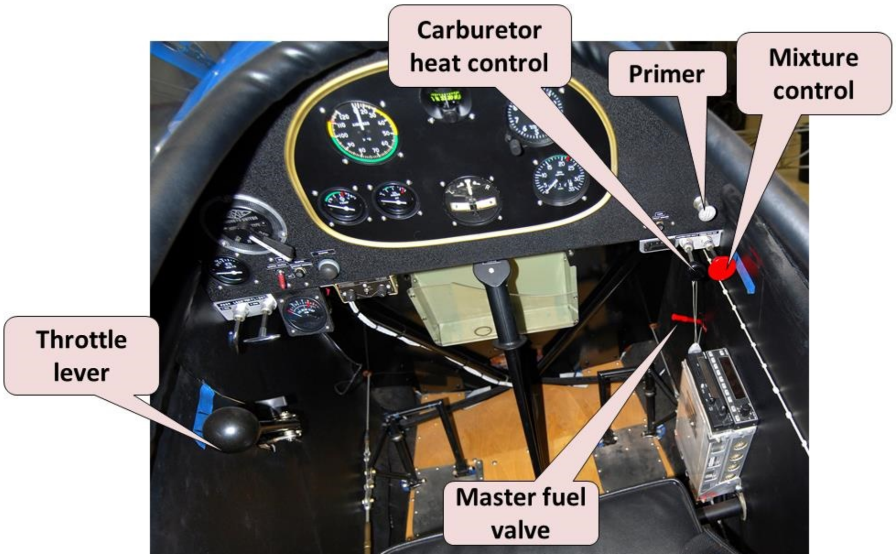
Rocker Arms

The rocker arms have to be manually greased.   Zerk fittings are provided on each rocker arm to accomplish this. According to Al Holloway, he uses about ten strokes of a manual grease gun per zerk on similar engines, but it is best to remove the rocker arm covers and observe when the grease just starts to come out of the rocker arm pivot bearings. The grease used is Chevron Ultra Duty Grease EP NLGI 2.

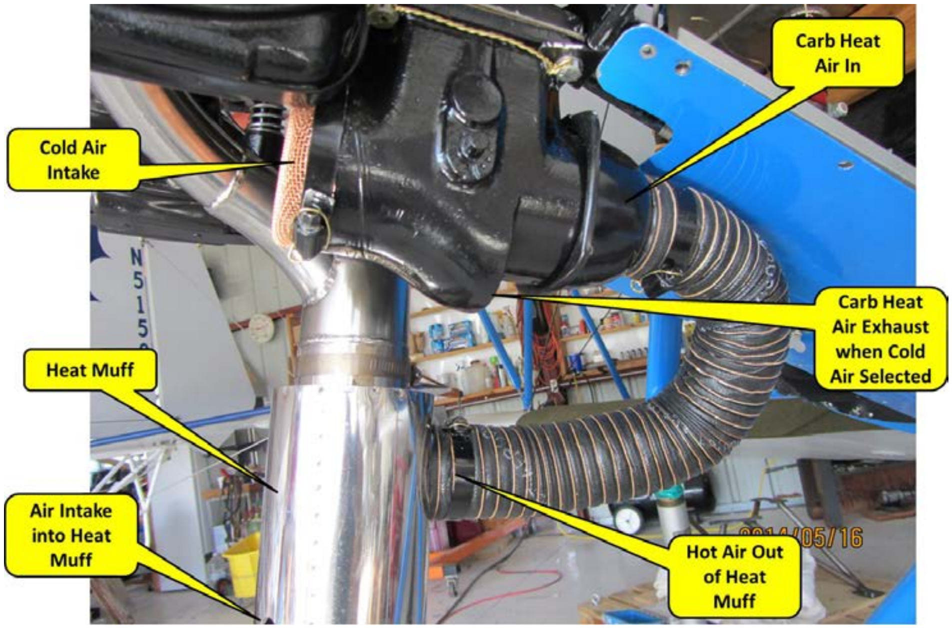
Air Intake and Carburetor Heat

The carburetor has a cover that includes a valve which can select air delivery to the carburetor from outside air or from air that has passed through a heat muff. The valve is controlled from a [black] push/pull knob in the rear cockpit (right side) via a Bowden cable.

The carburetor air intake cover has an opening rearward (in addition to the hot air intake port) to exhaust hot air from the heat muff when that air is not selected.

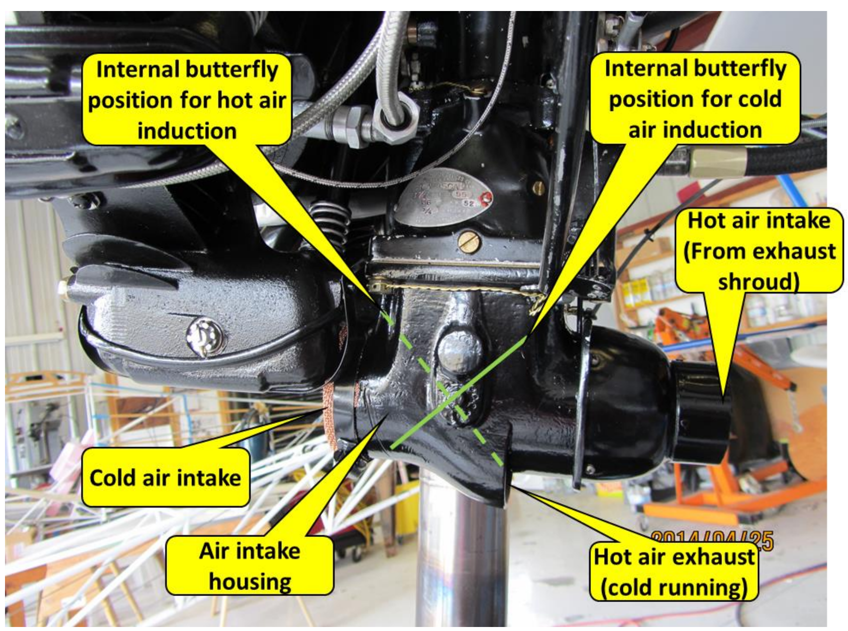


The heat muff is formed around the exhaust pipe where the ring converges for a single pipe outlet. The muff has holes in front at the bottom and a single large hole in the back at the top. In theory, air entering the front holes is heated as it passes over the section of exhaust pipe before exiting to the carburetor air intake. There is a CEET hose delivering the exiting air from the heat muff to the rear of the air intake where it can go to the carburetor when the air intake valve is switched to select heated air.

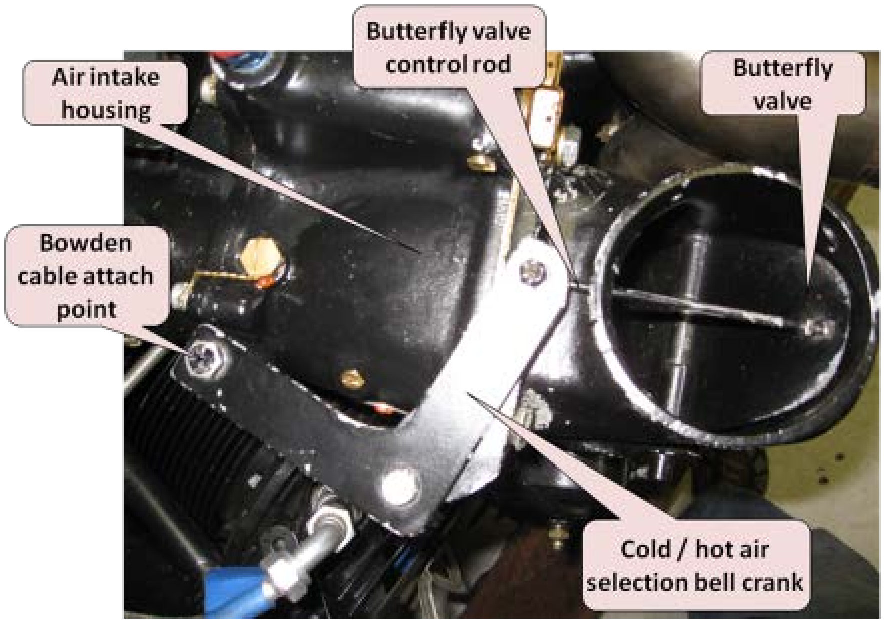


There is about 50-75 RPM drop when the carb heat is applied at full power.

The carburetor air intake is between the two bottom engine cylinders immediately in front of the carburetor. Cold air enters directly into the air intake housing through a relatively coarse mesh screen. Cold air or hot air is selected by control of a butterfly valve inside the air intake housing. When cold air is selected the hot air is vented through a port in the bottom of the air intake housing.

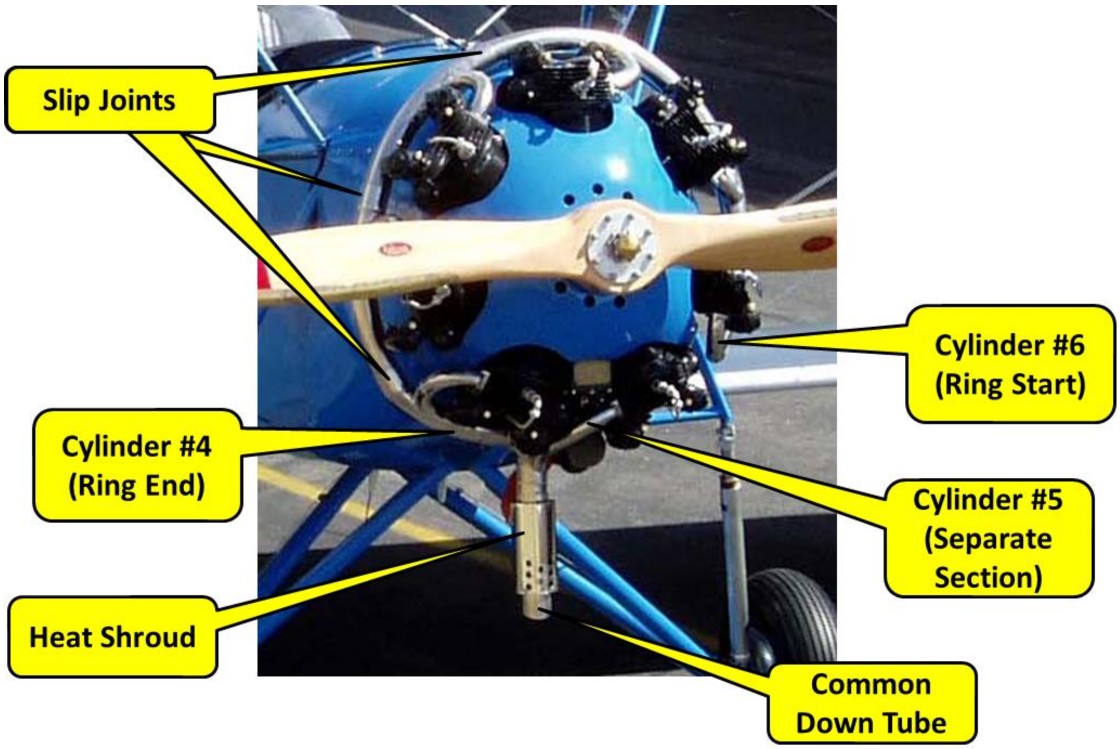


The butterfly valve for cold or hot air selection is controlled by the carburetor heat knob on the lower right side of the aft cockpit (only). It is attached to a Bowden cable that runs to a bell crank that, in turn, moves the butterfly valve. The black control knob can be seen in the cockpit photo above. The bellcrank and control cable are shown below.



Exhaust

The exhaust is a stainless steel collector ring fabricated by Aircraft Exhaust Systems, Inc. of Jumping Branch, WV. That firm has since gone out of business and assets have reportedly been transferred to Acorn Welding (Acorn Welding Ltd., 10916-119 Street, Edmonton, Alberta, Canada, T5H 3P4, Phone: 1-888-388-8803 or 1-780-447-5955, sales@acornwelding.com). The exhaust ring is a series of pieces that slip-fit one into the next from cylinder #6 clockwise (from the cockpit) to cylinder #4. Cylinder #5 has a separate short section that joins with the ring formed by sections from #6 - #4 to make a common single exhaust portion pointing straight down from to below the air intake. The heat shroud that produced air for carburetor heat surrounds this common down-pipe.



Propeller and Shaft

Propeller is a Falcon wooden propeller Model Designation Tc-800, D-627A, Serial Number 30. Propeller diameter is 84"; pitch is 67".[5]

The propeller hub consists of a front and back flange with cylindrical protrusion through the propeller hub that is an integral part of the rear flange. The front flange can be seen in the above photo for the exhaust system as the silver disk bolted to the propeller. Front and back flanges are bolted to the prop with 3/8"-24 bolts and nuts. They are torqued to 175-225 in-lbs. The front flange is also secured with a nut that screws over the front portion of the rear flange cylindrical protrusion. (This is not visible in the above photo; it is obscured by the brass colored prop nut.

[5] Other RNF owners with Warner Super Scarab engines report using 86" x 67" and 86" x 63" props.

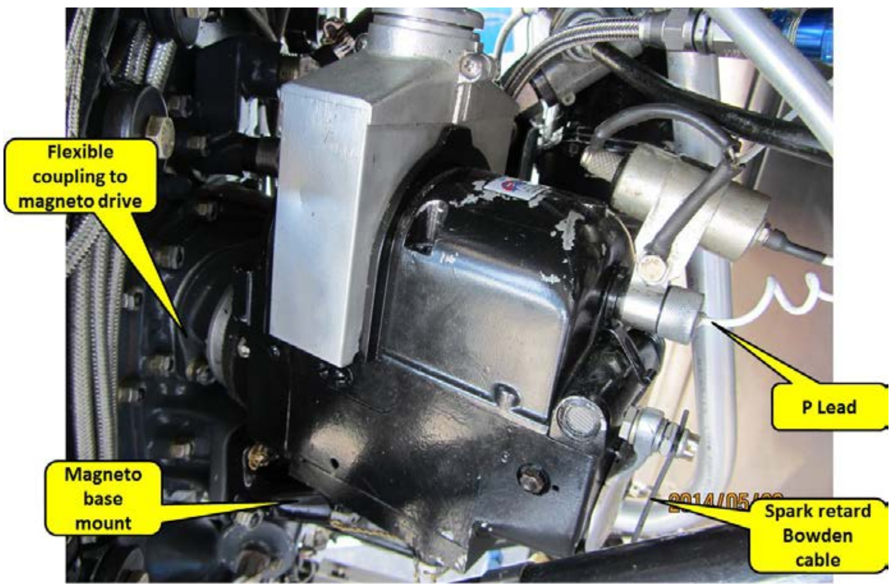
The propeller shaft is the forward part of the Warner crankshaft. It is a tapered shaft with a key in it. The inside of the rear flange cylindrical protrusion has a mating keyway that keeps the propeller from slipping on the shaft. The propeller hub fits against tight on the propeller shaft held in place by the brass propeller nut. Both the nut on the rear flange cylindrical protrusion and the prop nut are held in place with cylindrical clips

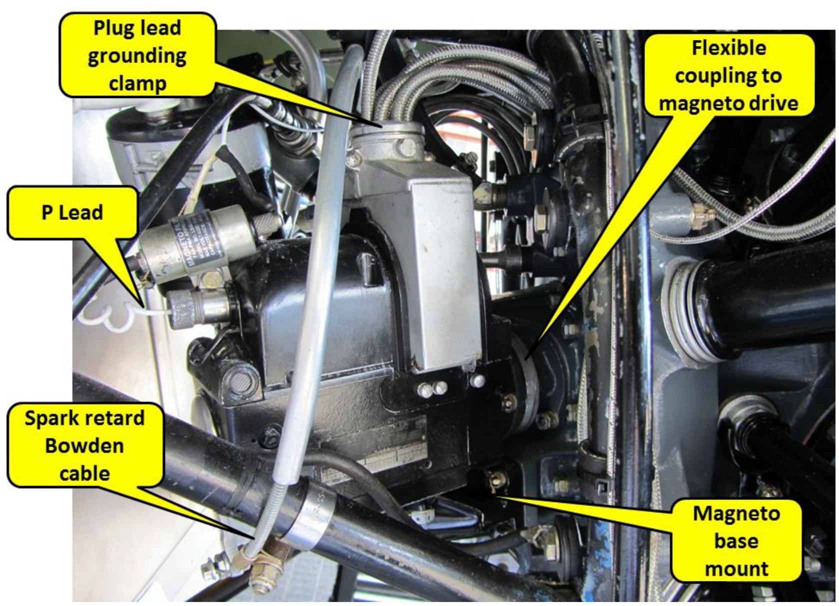
A special wrench was made by Matt Hlavac and used on the unique propeller nuts because previous use by (apparently) spanner wrenches had significantly marred the nuts. The special wrench is shown below.

Magnetos

Magnetos are Scintilla VMN-7D type with a base pad mount that, in turn, mounts to the engine pad forged on the back of the Warner SS50. The magnetos were rebuilt during the second Warner overhaul and are now configured with parts from various old magnetos.

Correct magneto installation and timing procedure is document further in this section of the owner's manual and is based on information and demonstration by Al Holloway, Holloway Engineering, Inc., 262 Spanish Creek Rd., Quincy, CA, 95971, (530) 283-2500, www.radialengine.com . The following pictures show the magnetos as install, left first, then right.



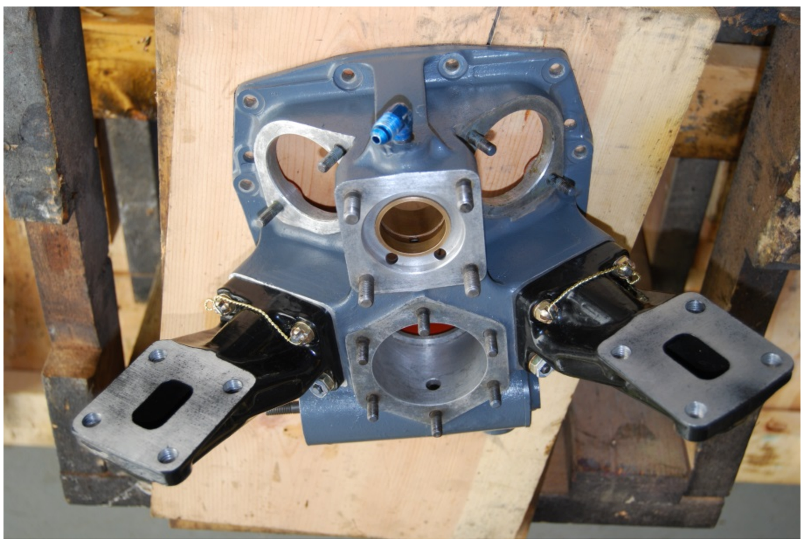


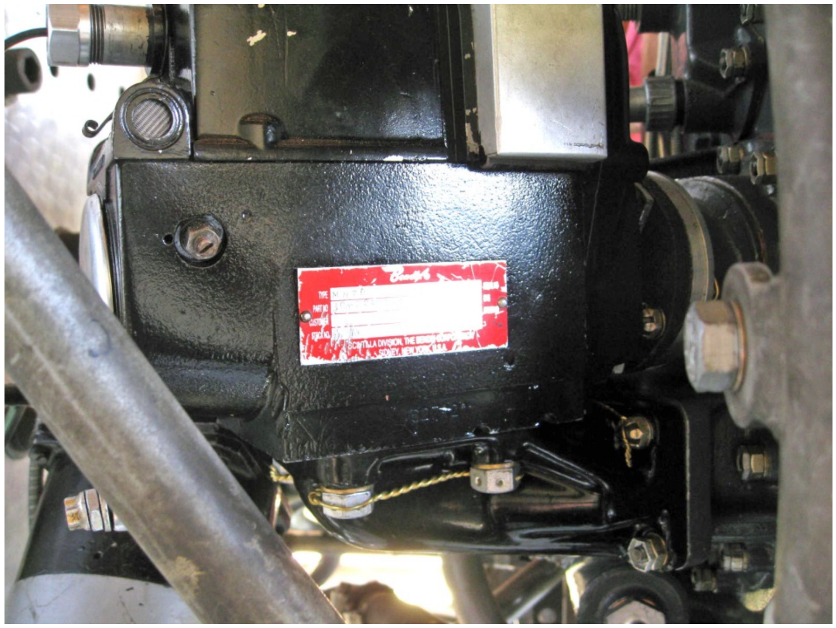
General information on engine magnetos is available from web information included in an appendix to this Owner's Manual. An Operation, Service, and Overhaul Instruction Manual for the Scintilla VMN-7 magneto family is also in the addendum to this Waco RNF N11259 Owner's Manual.

Spare parts have been obtained from Harmon Dickerson [(573) 449-6428, hdaircraft@hotmail.com , 3657 Ben Williams Rd, Columbia, MO 65201] and Gene Augustine [Augustine Magneto Parts Co. (818) 399-1904, 2416 West Victory, Burbank, Ca 91506]. An Alternate source is Savage Magneto Service [(510) 782-7081, 2415 Radley Court #7, Hayward, CA 94544].

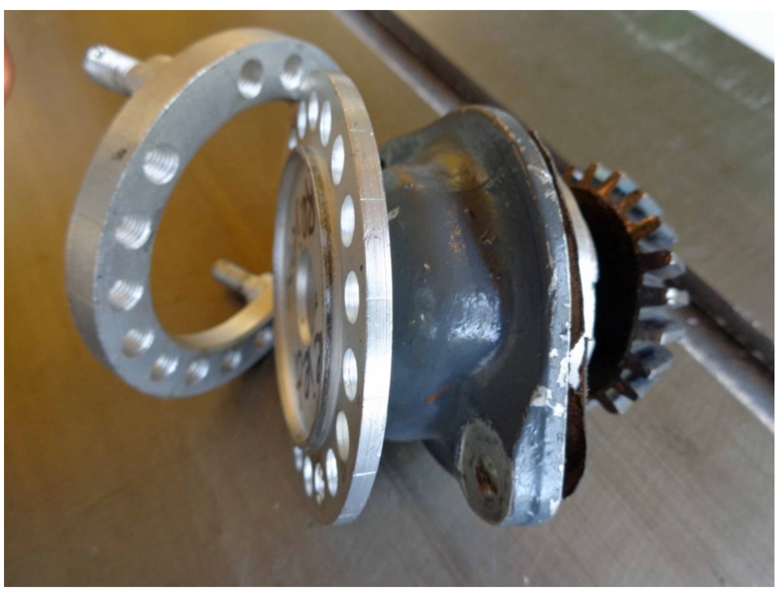
Installation

The magnetos are base mounted on brackets cantilevered from the back of the Warner engine accessory case. The brackets are shown in the first photo below; the magneto mounted on the bracket and coupled to the magneto drive extending from the back of the accessory case is shown in the second photo.



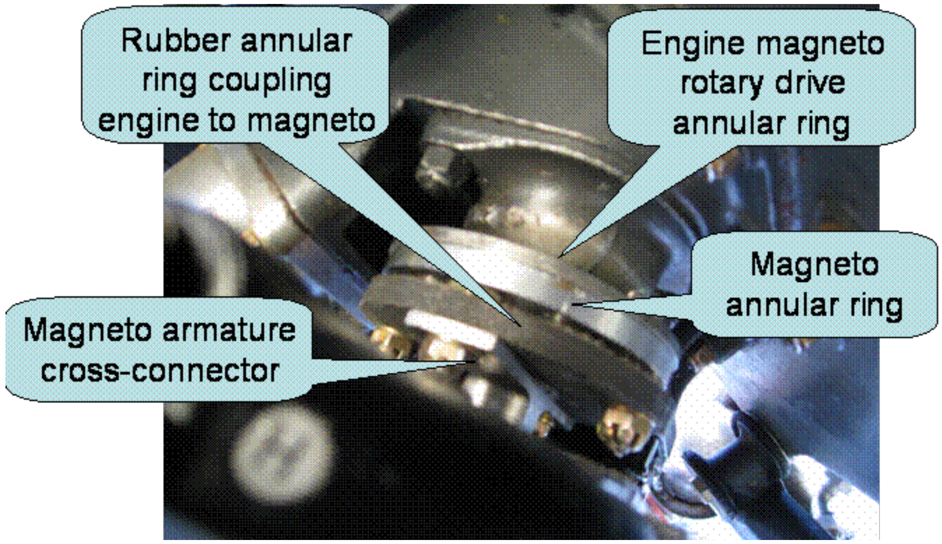


They are driven from rotary drive shafts protruding from the back of the Warner accessory case (The two round holes in the picture above) which are terminated in annular rings that have a series of attach holes around the annulus. The drive ring from the back of the engine mates with the magneto ring as shown in the following pictures. Both magnetos are driven clockwise looking at the driven end of the magneto.

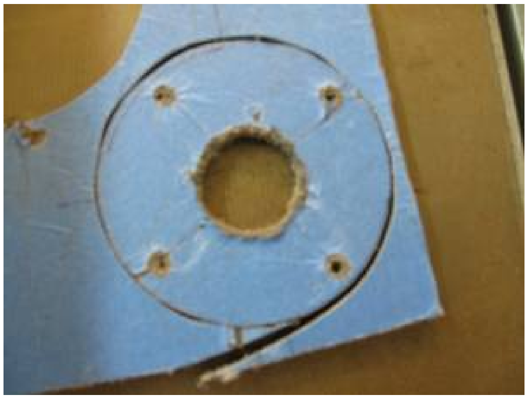


The uniqueness of these rings are that the hole pattern is such that if the two rings—the one from the engine and the one on the magneto—are put together, there will be two opposing holes that will line up within 1-2°. This becomes important when setting the magneto up for timing.

The challenge mounting the fixed-base magneto to the engine drive is that perfect alignment is virtually impossible and so a flexible drive arrangement is made. Description of this flexible drive refers to the following picture.



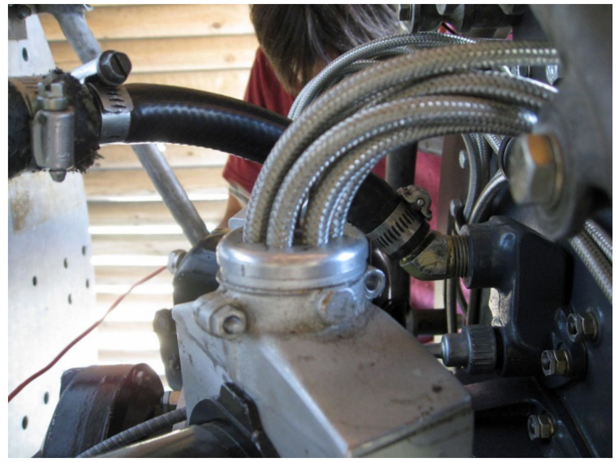
The magneto has a cross arm on its output shaft. The magneto ring that mates with the engine drive ring has two opposing studs. The magneto mating ring is attached to the magneto cross arm via a flexible rubber annulus made of ¼" conveyer belt-like material reinforced with fiber chords. The material was obtained from Restoration Supply Company (RSC) of Escondido (15182-B Highland Valley Rd., Escondido, CA 92025, (800) 306-7008).



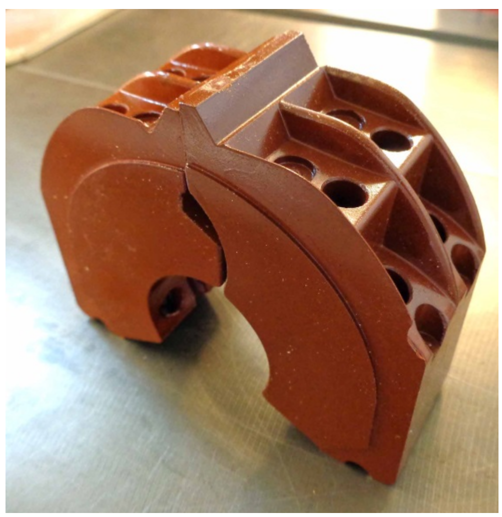
The coupling was cut from the material with masking tape temporarily on its surface to provide drawing surface for the part. The magneto cross arm and mating ring attach to the flexible coupling 90° from each other and the intervening space allows flex to correct for any slight misalignment. This allows the magneto to be set correctly for timing and then mated to the engine drive ring after the engine is also set correctly for timing.

Spark Plug Leads

At the time of this writing (Aug 2008), the spark plug leads are shielded with stainless braid from just above magneto phenolic resin block to the spark plug. An aluminum cover made by Al Holloway clamps the lead braid to make a closed, grounded attachment for the leads to the top of the magneto.

Looking from the back of the magneto, spark plug wires attach to the phenolic blocks according to firing order (not cylinder) number. Firing order to cylinder number correlation is in a table in the Warner Engine Handbook, Section 5, "Ignition Harness Assembly". The number for each spark plug wire is embossed on the phenolic blocks.



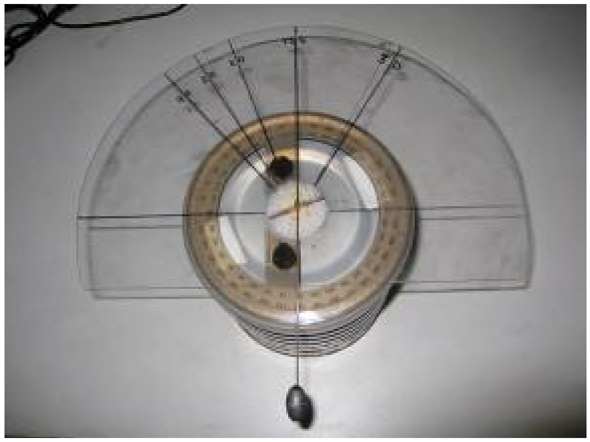
Firing numbers 1,5,6,7 are on the left half phenolic block and firing numbers 2,3,4 are on the right half. Firing order is 1, 3, 5, 7, 2, 4, 6.

Engine Ignition Timing

The Warner Super Scarab Engine Handbook (WSSEH) says to set Magneto timing to 28^0 before top dead center when using a timing light. Timing is determined by the points opening (degrees before piston reaches top dead center) on number one cylinder.

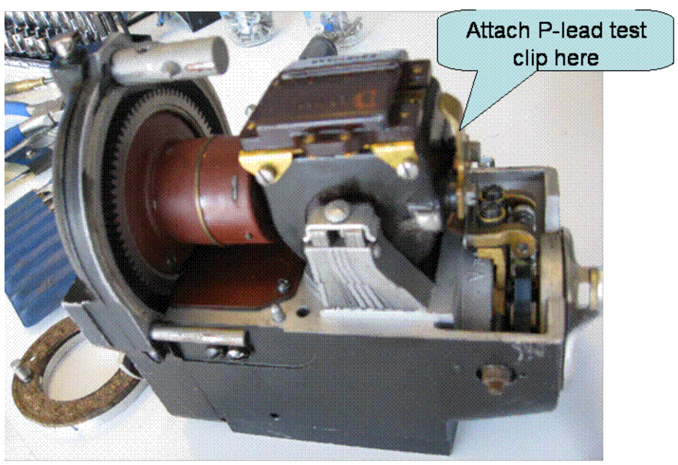
The following process was used to get the Warner in the right configuration for magneto mating follows:

1. Determine when #1 cylinder is top dead center on compression stroke. First remove all front plugs on the engine. Remove the valve covers on #1 cylinder and observe when the intake valve closes indicating that the next stroke would be the compression stroke. Hold a thumb over the empty spark plug hole on #1 cylinder and feel when that cylinder is compressing indicating the piston is on the way up.
2. A “TimeRite” instrument was used to determine when the cylinder was TDC. The tool screws into the front spark plug hole and has a probe that reaches in to contact the top of the rising cylinder. The probe pivots on the back of the instrument and the opposite end indicates on the front of the instrument when the piston has reached TDC and is starting back down. (The process is complicated by the fact that the propeller blade can strike the tool as installed in the front spark plug hole for the #1 cylinder and so the blade has to be past the tool when the tool is installed, yet with the piston far enough down to still allow the tool with probe to be inserted. Had the propeller been installed such that TDC occurred with the blade past the tool and the required advance point been with the prop blade before the tool, the tool could not be used. The WSSEH assumes the propeller is off the engine during timing.)
3. Once TDC is located, there is a slide indicator on the TimeRite which is used to record the TDC point of the probe. A scale calibrated for the Warner 145 HP engine is then moved so that it is “zero-referenced” to TDC. The propeller is backed off and the slide indicator moved to the proper number of degrees before TDC for firing—in this case 28^0. The propeller can then be advanced until the probe meets the slide indicator at which time the piston is positioned where the magneto points should be opening to fire the cylinder. In addition, there is a homemade tool that attaches over the front propeller flange. The tool has a protractor and a free-moving pointer that is weighted at the bottom. (The tool is fabricated from a large coffee can that fits snugly over the prop flange and provided the base for this tool. The plastic coffee can lid can be rotated on the can--it’s placed on the bottom in the figure--and taped in place when positioned. It’s crude looking, but accurate and easy to install and remove.)



4. The tool is attached at TDC and the protractor shifted until the pointer points to zero at TDC. The propeller can then be backed off to an indicated 28^0 BTDC for #1 cylinder.

5. A "Magneto Synchronizer" tool is used to determine that the magnetos are firing when required and that they fire together in synchronism. The synchronizer is attached to ground and left and right magneto leads are attached to the "P" lead to the corresponding magnetos. When setting the magneto timing, the left and right lead can be attached to the magneto P-lead circuit physically since the magneto will be uncovered. This instrument is used to validate the magneto timing; if the magnetos are out of time, the process described below has to be followed.



If testing the timing after the magneto is covered, it is convenient to attach to the "P" lead using a special homemade adapter shown in the following picture. It slips into the tubing the P-lead inserts into and can be installed with the capacitor in place.

6. If the synchronizer shows a magneto to be out of time, its timing can be adjusted, but the process requires that the magneto be decoupled from the engine to do so. The process is explained in the following section on magneto synchronization.

Magneto Timing and Synchronization

The magnetos are automatically synchronized when individually timed using the described procedure

Magneto installation has been described above including the flexible coupling and mating drive rings, engine and magneto. When timing the magneto, the engine is placed in position to fire #1 cylinder as described above. The magneto is also set to fire #1 cylinder and the two are coupled together via opposing bolts in the mating drive rings.

The Warner Engine Handbook and magneto manual (see below for PDF version) describe how the magneto is rotated to the point where it is about to fire #1 cylinder by matching markings on the inside magneto case and the geared disk just inside it at the front. (Note that the advance lever should be fully clockwise for normal operation when looking from the back of the magneto.) When a magneto synchronizer is set up, each magneto fires when the synchronizer lights and buzzer go out. Using this method avoids opening the magneto.

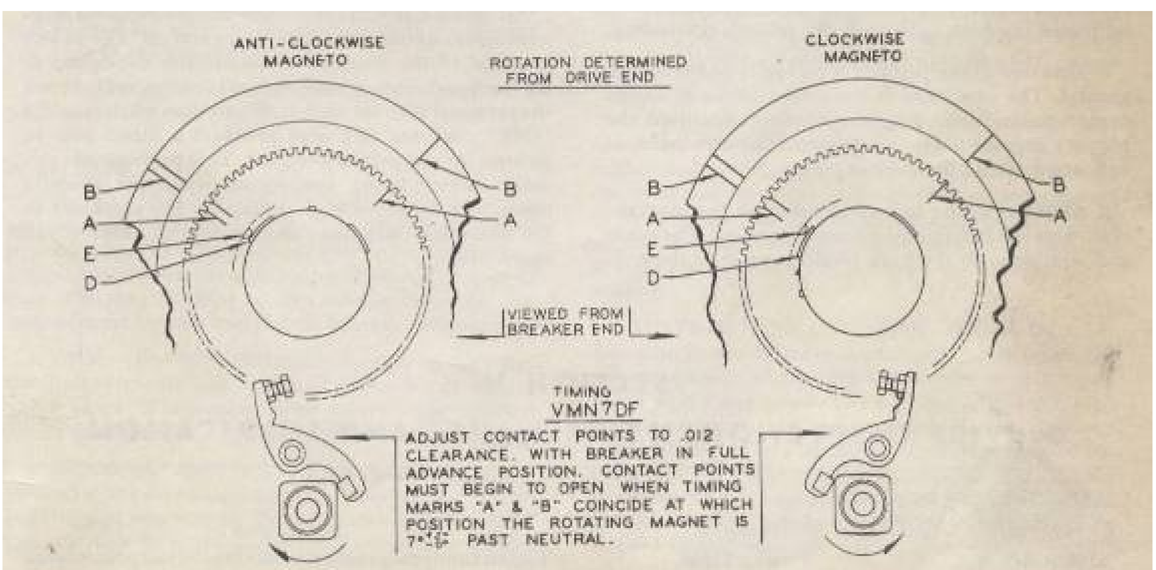
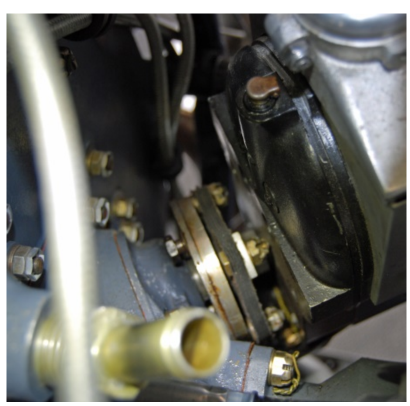


Figure 4—Timing Marks on Large Distributor Gear

The engine rotary drive ring and the magneto drive ring each have a pattern of holes around their circumference. (See the picture of the magneto drive ring below.)

When the magneto is aligned and installed on its base and the engine is positioned to the proper number of degrees BTDC for firing #1 cylinder, one set of the holes (180^0 apart in the rings) will line up so bolts can be inserted. (This is the alignment procedure.) In my case, one magneto ended up 1^0 early (e.g., 27^0) and the other 1^0 late (e.g. 29^0). This procedure is a LOT easier to describe than perform because the bolts that are inserted to hold the two rings together go in from the front where access is limited and well into the overall obstructions of oil and fuel lines, control rods, etc. that congest the area around and behind the magnetos. Once the timing is established and the bolts in, they still have to be safety wired in that constrained environment. (It is best not to have small children within earshot when this procedure is being performed.)

This procedure is easier if the engine-to-oil tank oil return line is first removed at the engine providing more clearance to get a hand and wrench on the bolts holding the drive ring to the magneto ring. The following picture shows the engine port where the return oil line has been disconnected and one bolt partially removed.



Once the bolts are removed, the two rings can be pried apart with a large knife blade. The magneto ring can then be moved relative to the drive ring. When the two rings are positioned to fire the magneto at the proper time, re-insertion of the bolts can be facilitated by first probing to determine which holes line up for bolt inserting. The following is a picture of a tool made from an allen wrench that can get between the drive housing and drive ring to probe for the aligned holes followed by a picture of it in use.

A “Magneto Synchronizer” tool is used to determine that the magnetos are firing when required and that they fire together in synchronism. The synchronizer is attached to ground and left and right magneto leads are attached to the “P” lead to the corresponding magnetos. When setting the magneto timing, the left and right lead can be attached to the magneto P-lead circuit physically since the magneto will be uncovered. This instrument was used to validate the magneto timing; the magnetos were timed by the physical alignment described above.

Magneto Maintenance

Magnetos need to be oiled every 25 hours of use. There is an oil cap (one only; literature specifying two has been supersede by later modifications and practice) on the top front of the magneto just ahead of the distributor cover through which the spark plug wires emanate. No specific maintenance period is specified in the manual other than “regular inspection intervals”. Twenty-five hours was a recommended interval for lubrication by Al Holloway, so that will also be the interval used for check of timing and synchronism.

A manual is available for these magnetos from the following PDF icon.

Magneto Manual

Spark Plugs

The spark plugs used are Champion REM-40E / FAA-PMA2M01. That plug is a resistor, two electrode massive, 18mm thread, ½" reach, 7/8" hex head, medium heat range, with a 5/8" shielded 24 thread barrel. Spark plugs threads are treated with anti-seize and tightened to 200 in-lb (16.6 ft-lb.) Plugs have 18mm base. Spark plug threads should be treated with anti-seize compound when inserted into the engine.

Starter

Overview

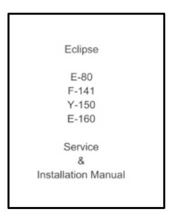
The starter is a Bendix Eclipse Y-150, three-tooth style. This is one of family of Bendix starters that includes the E-80 as well as the Y-150. The Y-150 and E-80 are of the same basic construction, but the Y-150 motor is mounted 90 degrees to the Bendix shaft while the E-80 motor is collinear with the Bendix shaft. Either starter can be 12 or 24 volts but the starter for N11259 is 12 volt.

The starter drives a Bendix connection the motor side of which is direct drive to the Warner SS-50 through gearing provided in the Warner accessory case. The starter mounts on an adapter (which Jack had made from plans) to the upper back of the Warner SS-50 accessory case so that the starter Bendix cogs can engage motor Bendix cogs when the starter is excited.

An Operating Manual and a Service & Installation Manual for the Y-150 are available via the following PDF icons. An Overhaul Manual for an E-80 starter is also available, but that manual is applicable only by analogy with deference to the differences between the E-80 and Y-150 cited above.


STARTER Y-150
OPERATORS MANUAL

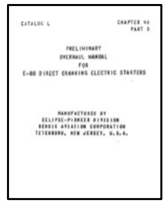
Y-150 Operator's Manual


Eclipse

E-80
F-141
Y-150
E-160

Service
&
Installation Manual

Eclipse Y-150 Service and Installation Manual


CATALOG L

CHAPTER 46
PART 8

PRELIMINARY
OVERHAUL MANUAL
FOR
E-80 DIRECT CRANKING ELECTRIC STARTERS

MANUFACTURED BY
ECLIPSE-PIONEER DIVISION
BENDIX AVIATION CORPORATION
TETERBORO, NEW JERSEY, U.S.A.

Starter E-80 Overhaul Manual

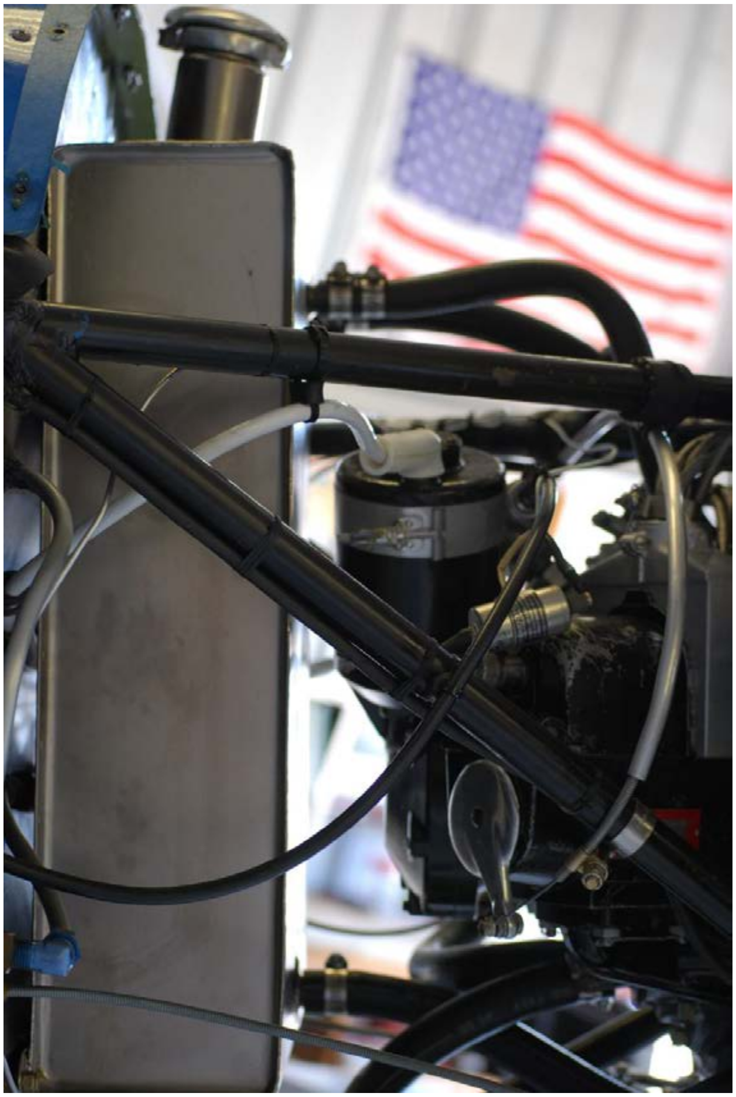
The started is fed by a 02 gauge cable from the starting contactor/solenoid on the upper port firewall which is, in turn fed by a 02 gauge cable from the positive pole of the aircraft battery mounted behind the firewall.

Starter Maintenance

The starter should not require maintenance. The starter on N11259 was found to be mis-constructed during the engine rebuild in October 2008. The rear starter shaft bushing was missing and the front cover / bell housing was the wrong part for this starter. The result was that gears were not meshing correctly and other wear was imminent. The starter was re-built by Al Hollowy.

The following is a picture of the starter dismounted from the engine with the Bendix gear showing.

The following picture shows the oil tank and relief between it and the starter motor. The oil tank was subsequently insulated with thin, stick-on insulation material because the oil was not heating up enough to purge moisture in it.



The starter was rebuilt Dec 2014 by Rick Benjamin at RB Aero [(818) 785-5459, 14711 Lull Street, Van Nuys, CA 91405] and operation verified at that time. Rick said this particular starter was manufactured in the 1920s. It has a weld repair in the case where the motor angles to the Bendix. Rick said the motor could draw as much as 200 amps during starting.

The starter pulls a lot of current and needs nearly a full 12v to crank the engine. There can be very little resistance in the starting circuit and the battery, since it does not have an in-flight recharging capability and the battery needs to have sufficient capacity for several starts. See "Electrical System / Starter" for details of the starting circuit and battery support.

Carburetor

The carburetor and its integration in the fuel system in described in the section System Components and Descriptions / Fuel and Oil Systems / Carburetor above in this manual.

Tachometer

Engine RPM is output is a mechanical shaft attached to a fitting on the back plate of the Warner engine. On N11259, the cable carrying the RPM rotation extends approximately 10" on a "pigtail" that ends in a splitter—a gear-driven junction where the single cable drive out of the engine divides into two cable rotary drives in opposite directions. The pigtail / splitter is shown in the following photo.

This pigtail has a bend of about 45° as shown in the following photo.

A bracket was fabricated that mounts to the starter flange and holds the RPM cable in the position shown. From the split end of the RPM pigtail, cables carry the RPM rotation to tachometer instruments in the front and rear cockpits.

Fuel and Oil Systems

Fuel and oil systems are described below including the sensors that support instruments indicating the condition of the gas and oil

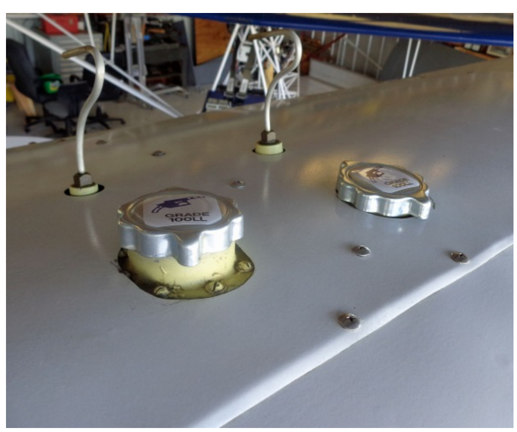
Fuel

The fuel system includes the gas tank, valves, gas lines, sensors, gascolator, and the filter (that is actually part of the gascolator with another filter screen in the carburetor.)

Tank

There are two 16 gallon gas tanks in the center section of the upper wing.

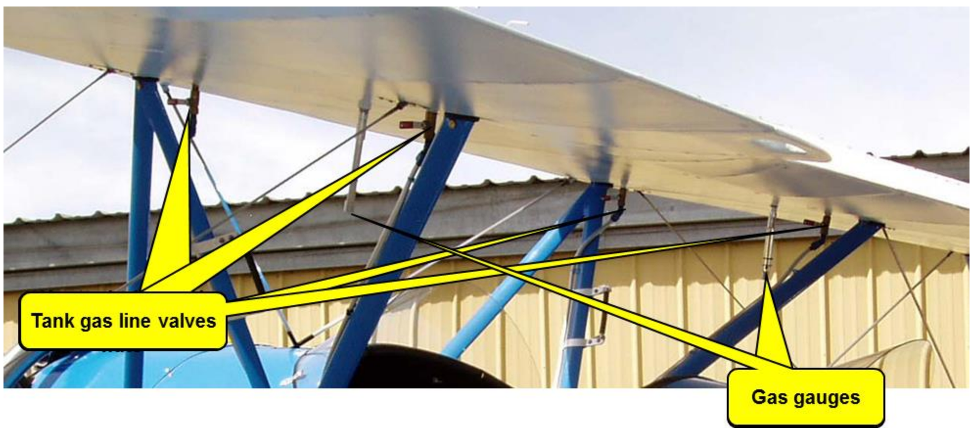
These tanks are held in by stainless steel straps padded with nylon liners. The stainless straps are fastened to the fore and aft center section spars. The tanks each have a fill cap forward and toward the wing center. There is a vent hole in each tank just behind the fill cap. The vent is extended by an aluminum tube that forms a question mark shape with the hole facing to the rear in contradiction to every book that says the vent should face forward to create positive pressure in the tank while flying. In this case the vent extends above the wing boundary layer and sufficiently out of the reduced pressure to be OK—and the rearward facing opening is not susceptible to clogging by ingesting foreign matter in flight.



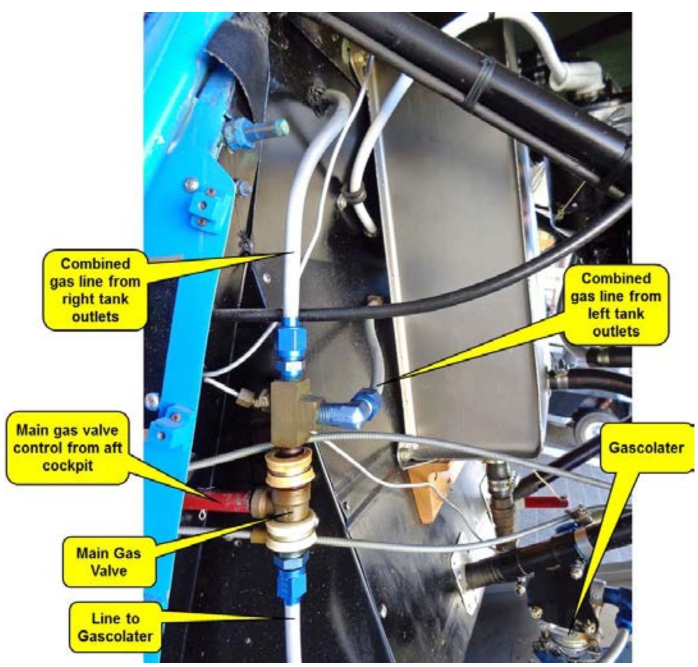
The center section over the tanks is covered with an aluminum sheet held down by screws set into barrel nuts sunk into the fore and aft spar and the middle and end ribs. This was done so the tanks could be removed for maintenance if necessary.

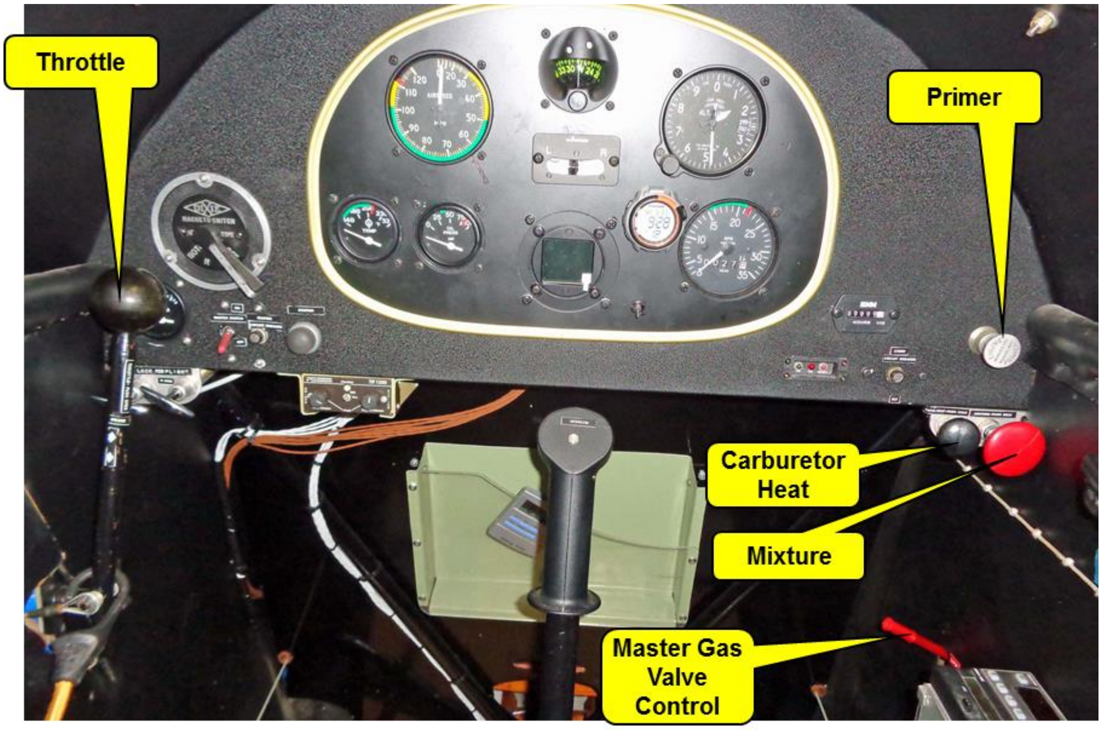
Fuel Shutoff Valves

There is a valve immediately below each of the four taps under the wing, one fore and aft for each tank. These valves are used to keep pressure on the lower sections of the fuel system (and therefore leaks) at a minimum during periods of storage) and to shut off gas in case tanks have to be removed for maintenance. Each valve is included in the pre- and post-flight check-lists to ensure they are turned on before flight. They are not turned off after flight and should not change.



In addition to the four individual tank tap valves, there is a master fuel valve immediately below the junction for port and starboard gas lines where they come together on the starboard front side of the firewall. This fuel valve is accessible from the rear cockpit only and is actuated by a lever on the lower starboard inboard side of the cockpit.





Gas Gauge

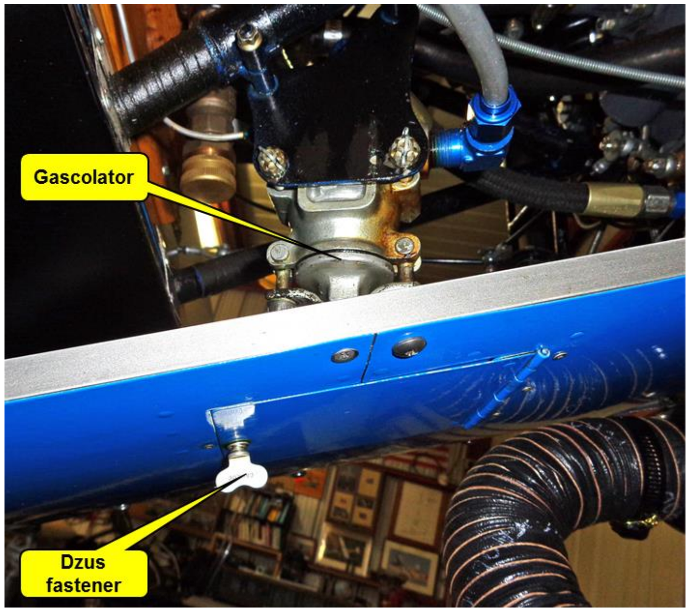
Each tank has a glass sight gauge protruding from the bottom of the upper wing center section. (See photos above for tank valves.) These gauges are not calibrated. They change position depending upon pitch attitude of the aircraft. At rest, the tanks are in a significant leading edge up attitude. Sticking the tanks with a dip stick is used to assure full tanks for takeoff. The fuel gauges are used mainly for backup assurance that the assumed 2 hour range with and hour reserve is not being met.

Fuel Lines

Fuel lines emanate from the fore and aft tank taps on both the port and starboard tanks. They are attached to the cabane struts and, at the bottom of the cabane struts, the fore and aft line from each tank is coupled together. Combined port and starboard gas lines proceed forward through the firewall. The port combined fuel line bends right immediately after passing through the firewall, crosses behind the oil tank to the starboard side, and couples to the starboard combined gas line where it passes through the firewall. The single, combined gas line immediately passes through the master fuel valve, and then goes into the gascolater. See picture above for master gas valve.

Gascolater

The gascolater is the lowest point in the fuel system with the single combined gas line proceeding up to the carburetor from there. The gascolater can be accessed for fuel drainage and test from a hatch secured with a Dzus fastener on the bottom of the cowl. The gascolater has a screen to filter out relatively coarse contaminants in the fuel. The screen can be removed for inspection and cleaning.

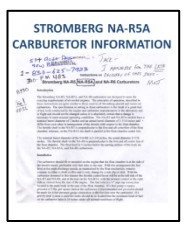


Carburetor

The carburetor is a Bendix Scintilla NA-R5A, Serial Number 4662609.

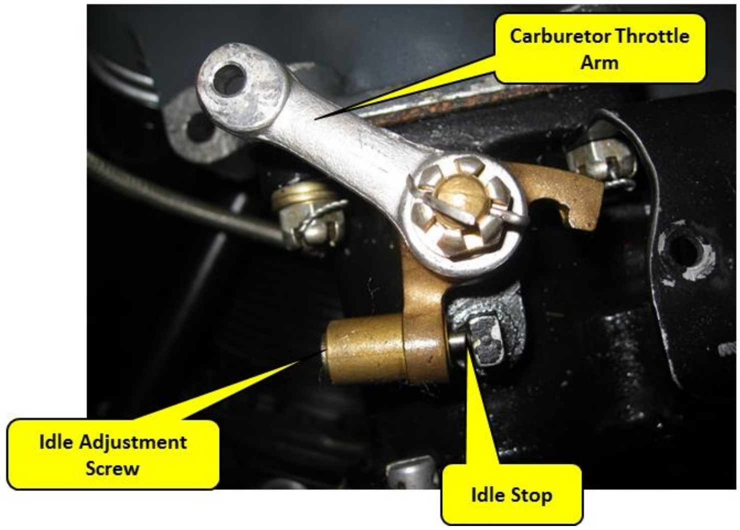
Carburetor heat and mixture are controlled via Bowden cables with control knobs on the lower starboard side of the instrument panel in the rear cockpit. The mixture knob is color-coded red and the carburetor heat knob is color-coded black.

There is a carburetor Instruction Manual Available via the following PDF icon.

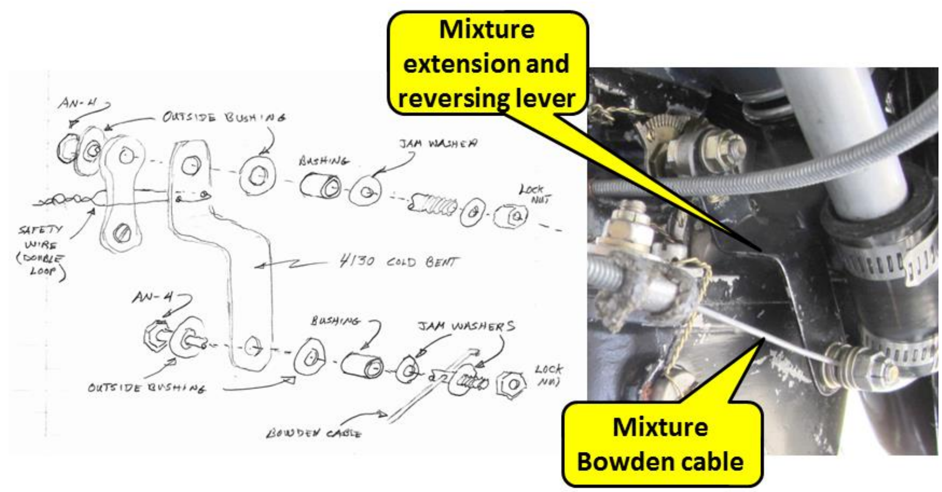


Stromberg NA-R5A Carburetor Information

The carburetor heat is controlled from the air intake assembly bolted to the bottom of the carburetor. The carburetor has a throttle arm at its rear that rotates laterally from left for idle to right for full power. There is an adjustable stop for idle that has been set to 500 RPM for a warm engine.

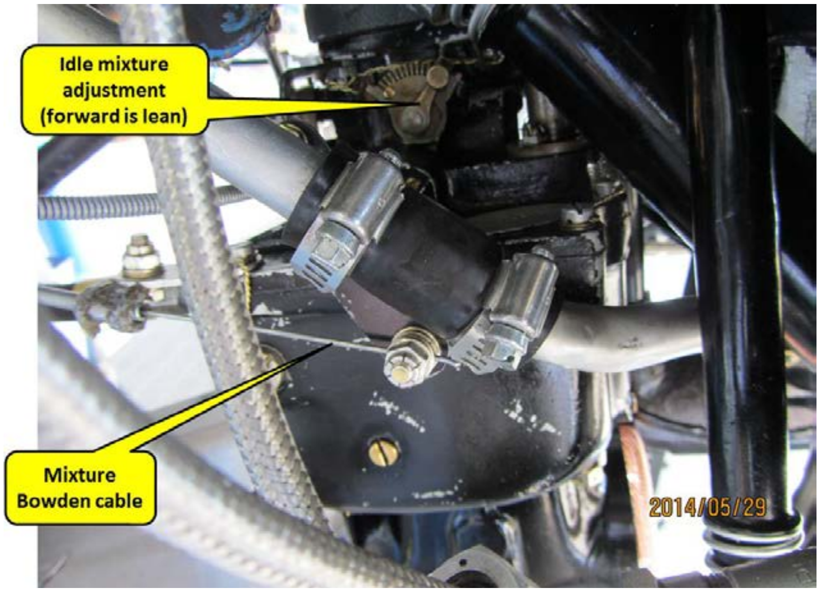


There is an idle mixture adjustment arm that has been set to a lean value for idle to help preclude carbon build-up on the spark plugs during idle engine operations and to help ensure the engine will shut down when the mixture is pulled full lean.



There is a mixture control arm on the right side of the carburetor. That arm was extended during restoration for better alignment with the Bowden cable that controls it and to provide standard direction for mixture control. The mixture control knob and mixture arm (as extended) moves forward for rich and back to a lean engine cutoff position.

Carburetor idle mixture is adjustable via an adjustment lever adjacent to the mixture control arm (shown in the picture below.) Mixture is adjusted for as lean running as practical at idle to help prevent the spark plugs from fouling and to assure the engine stops when full lean mixture is applied.



Primer

The primer is a manually operated pump on the rear cockpit panel on the right hand side. (See picture of cockpit above in fuel shutoff valves section.) The primer is fed by a 1/8" aluminum tube from the gascolater to the primer. From the primer the 1/8" aluminum tube goes to a primer AN/NPT fitting with a pin-hole emission on the top of the induction housing. The aluminum line is looped to provide flexibility between the tubing as tied to the motor mount and its termination at the AN/NPT fitting. The pin hole in the AN/NPT fitting is to atomize fuel as it is pushed into the induction housing under pressure from the primer pump.

Gas Filters

There is a screen filter in the gascolater and another in the gas intake to the carburetor. Both have provisions for removal, inspection, and cleaning.

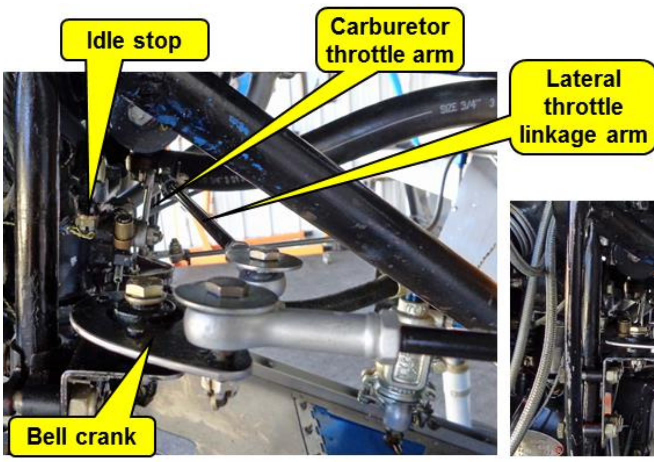
Air Intake

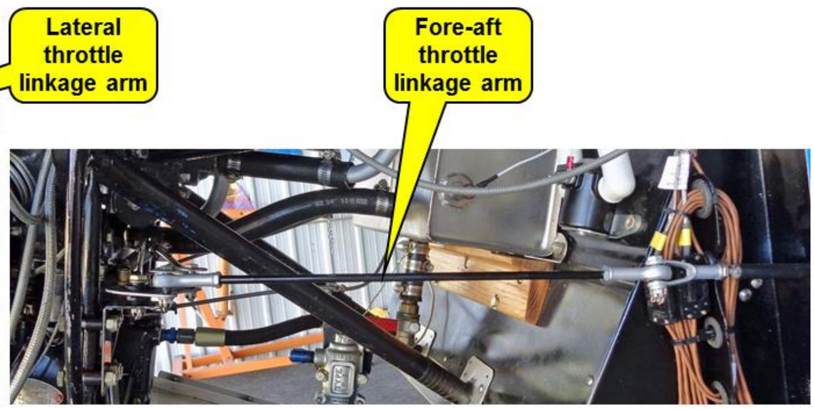
Air intake is described above in the section "Systems and Component Descriptions / Power Systems / Air Intake and Carburetor Heat".

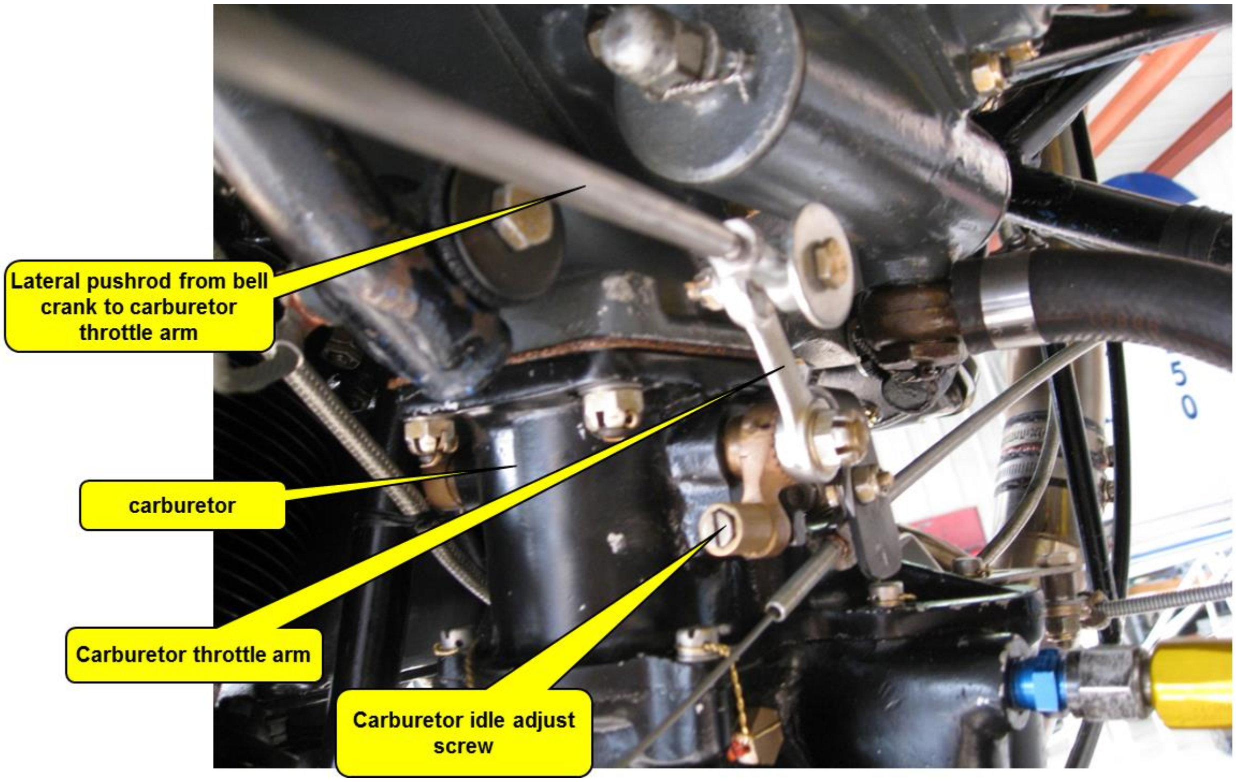
Throttle

The throttle is controlled by the pilot via the throttle handle on the left side of each cockpit. (See photo above in fuel shutoff valves section.) Longitudinal pushrods attached to the throttle handle levers penetrate the firewall on the port side and actuate the carburetor throttle arm through a lateral pushrod via a bell crank mounted on the cowl attach ring behind the motor mount.

The longitudinal pushrod from the throttle handle is attached below the throttle handle pivot and so moves aft when the throttle handle is pushed forward for acceleration. That motion is reversed at the throttle bell crank and the lateral pushrod from the bell crank to carburetor throttle arm is toward the middle as the throttle handle is moved forward and the longitudinal pushrod retreats. The carburetor throttle arm is mounted upward from its pivot point; it moves right in acceleration and left in deceleration. Full left position of the carburetor throttle handle is limited by the idle set screw contacting the idle stop on the carburetor throttle arm assembly; full forward throttle handle motion is stopped when the carburetor throttle valve full throttle stop hits the carburetor.







There is an idle adjust screw on the carburetor throttle arm that stops the low motion of the arm at the desired idle RPM.

Oil

The oil system includes the oil tank, oil lines, and sensors. The oil pumps could also be considered part of the oil system, but those are part of the engine and discussed as part of the power system.

At rated power and speed the specified maximum oil consumption is .025 lbs/hp/hr (0.48 gal/hr). At cruising power and speed specified oil consumption is 0.020 lbs/hp/hr (0.39 gal/hr). These values have not been verified in practice with N11259. It rarely uses oil and has gone 20 hours with less than a quart used.

The following values, as determined by flight testing, shall not be exceeded under any condition:

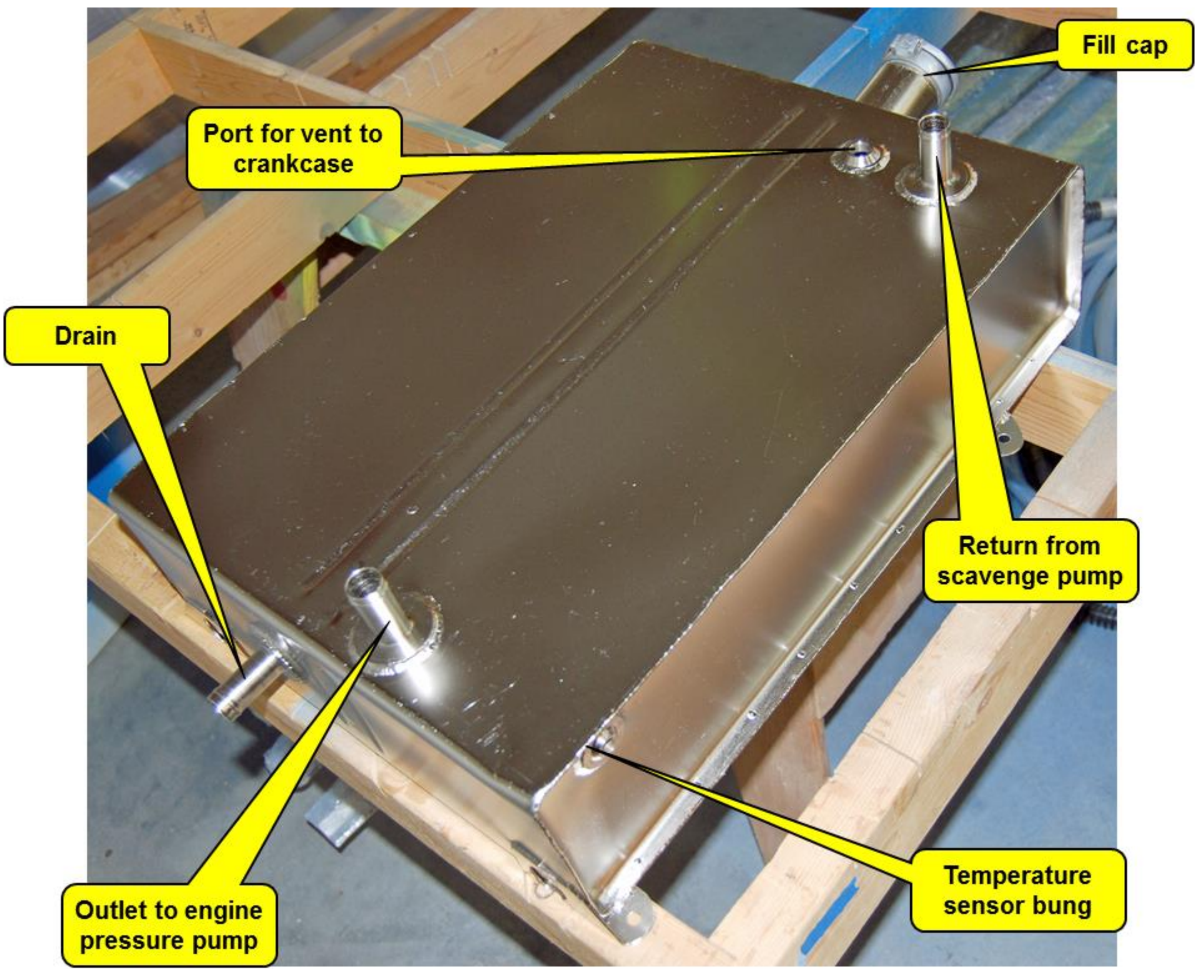
- Oil Pressure:
  - Minimum Idling - 40 pounds per square inch
  - Normal 50 to 90 pounds per square inch.
- Maximum Permissible Oil Inlet Temperatures:
  - The maximum permissible oil inlet temperature is 200 degrees F.

Oil runs almost too cool most of the time and oil cooling air outlets are blocked off to keep the temperature high enough to purge moisture from the oil in operation.

Tank

The oil tank has a 5 gallon gross capacity and is located immediately forward of the firewall. Practical fill limit is less than 4 gallons with 0.5 gallon left for expansion to the bottom of the oil return port. (In actuality, only 2 ½ gal of oil or less are used because if more is use the engine never heats it enough to eliminate moister in the oil under normal flying conditions.)

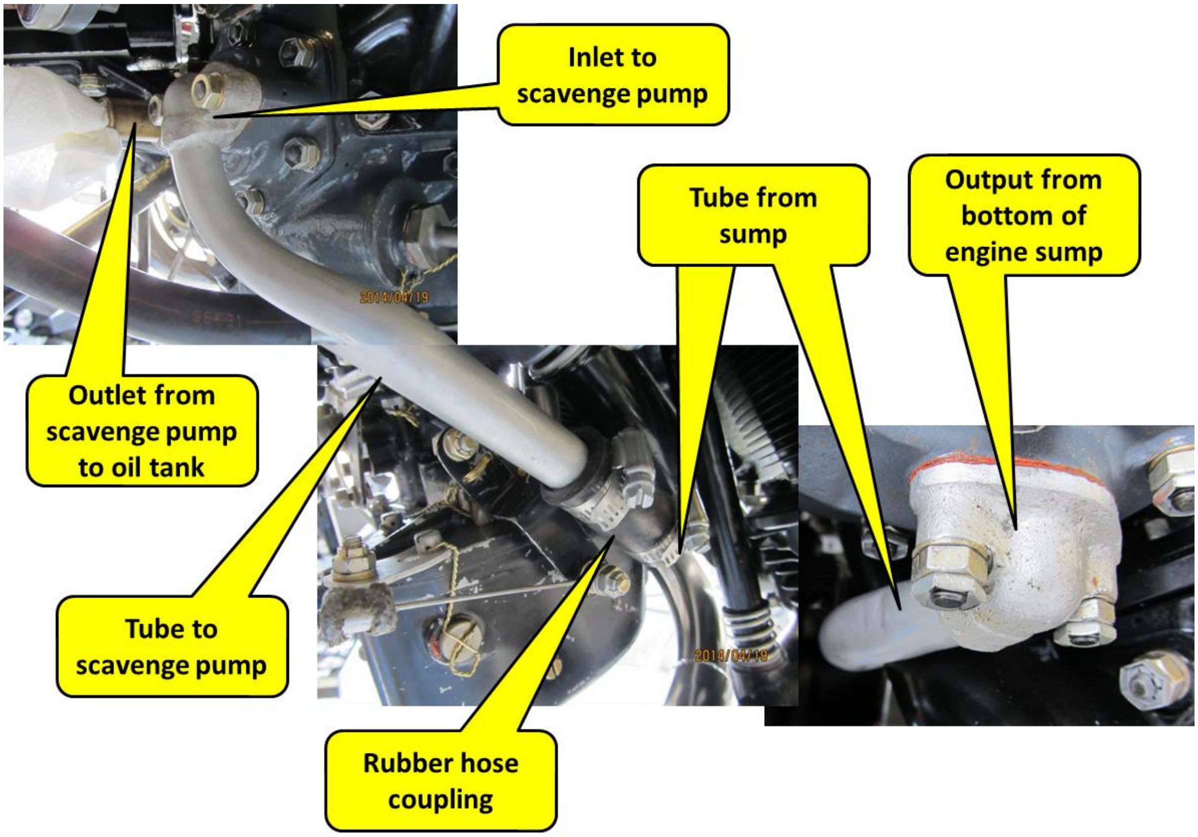
The tank uses four attach points and rests on a wooden support attached to the firewall. The wooden support is per original design, but was omitted from the restoration and added later. Installed the tank is connected to the engine by oil lines consisting of tubes and hoses.
The next view of the tank uninstalled identifies the various bungs and ports.



The oil tank cap protrudes through the upper cowl for filling.

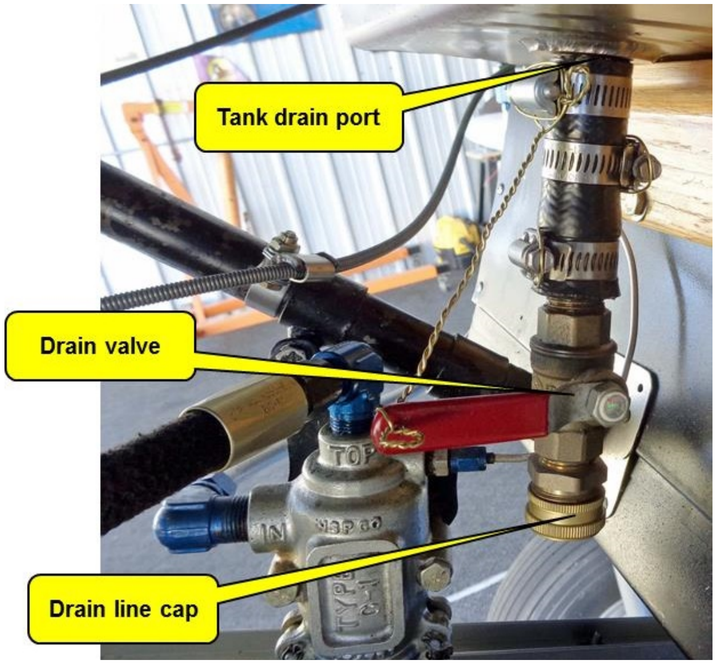
Lines

There are five oil lines, four from or to the tank and one from the engine sump to input of the scavenge pump. The line from the engine sump consists of two tubes with welded flanges connected by a short section of hose and shown in the pictures below.

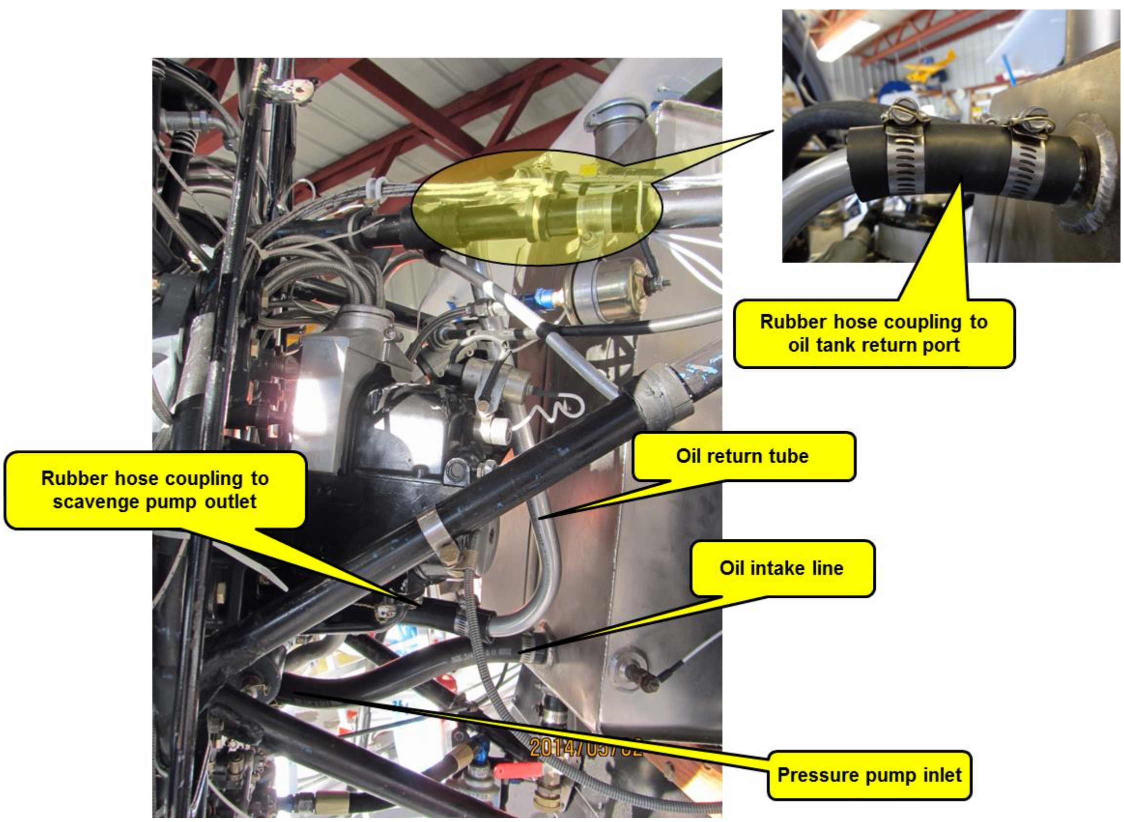


For the tank, there is a line from the bottom of the oil tank to input of the pressure pump engine via a banjo fitting, a line from the bottom of the oil tank that is a drain line, a line attached from the scavenge pump to the top of the tank for oil return, and one line that serves as a breather from the top of the engine crankcase back to the top of the oil tank.

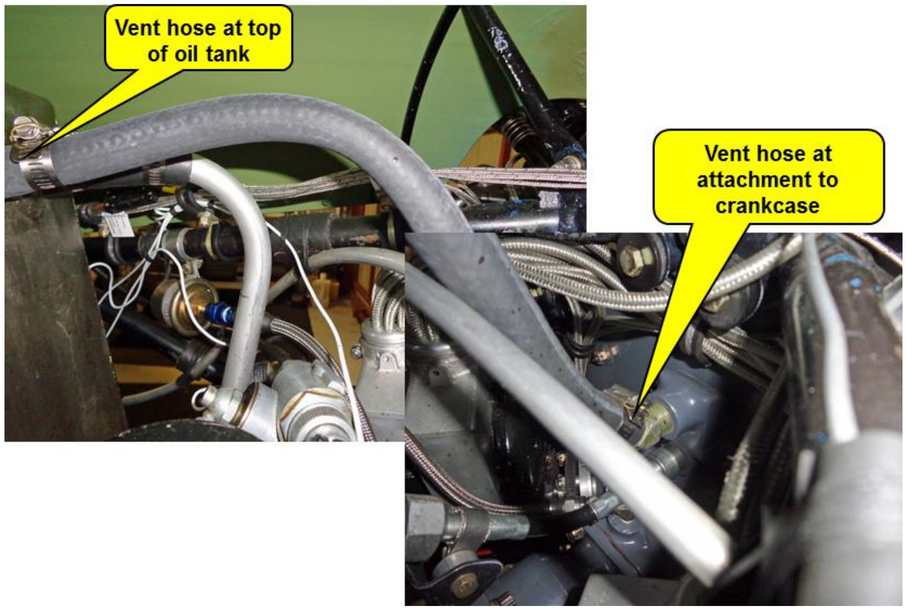
Oil drain and engine inlet lines can be seen below.



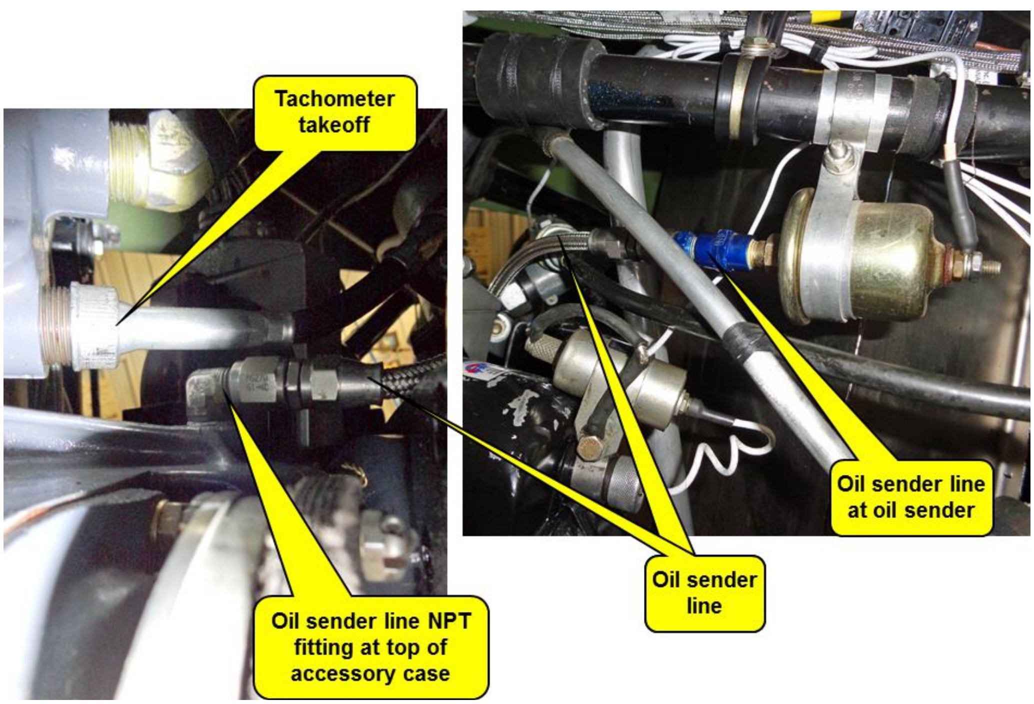
The following photo shows most of the oil lines and the oil pressure and temperature senders.



The following picture shows the tank to crankcase vent connection.



There is a sixth oil line that connects the oil pressure sender tap to the pressure sender sensor. The tap is at the top of the accessory case just below the tachometer cable takeoff. The line is attached to a ¼" NPT fitting that has been filled with braze metal and then drilled with a small hole. This reduces surge fluctuations in the oil pressure sender and restricts oil flow if the sender line should break. The oil sender is a piezoelectric type that sends pressure information to the cockpit instrument electrically. The following pictures show these components.



Oil Intake

The oil intake is through a cylindrical screen housed in a portion of the gear case. Oil enters via the line from the external tank, flows around the outside of the screen, and is taken from inside the screen by the oil intake pump.

The oil screen is held on by an acorn nut on the left side of the screen housing as shown below. The plug and screen are shown as removed from the housing. There is a cone-shaped plug at the other end of the housing to help center the screen as it is reinserted after cleaning. The copper washer is a tight fit on the threaded shaft and almost has to be screwed off and back on.

Oil Pumps

The following is from the Warner SS50 engine manual.

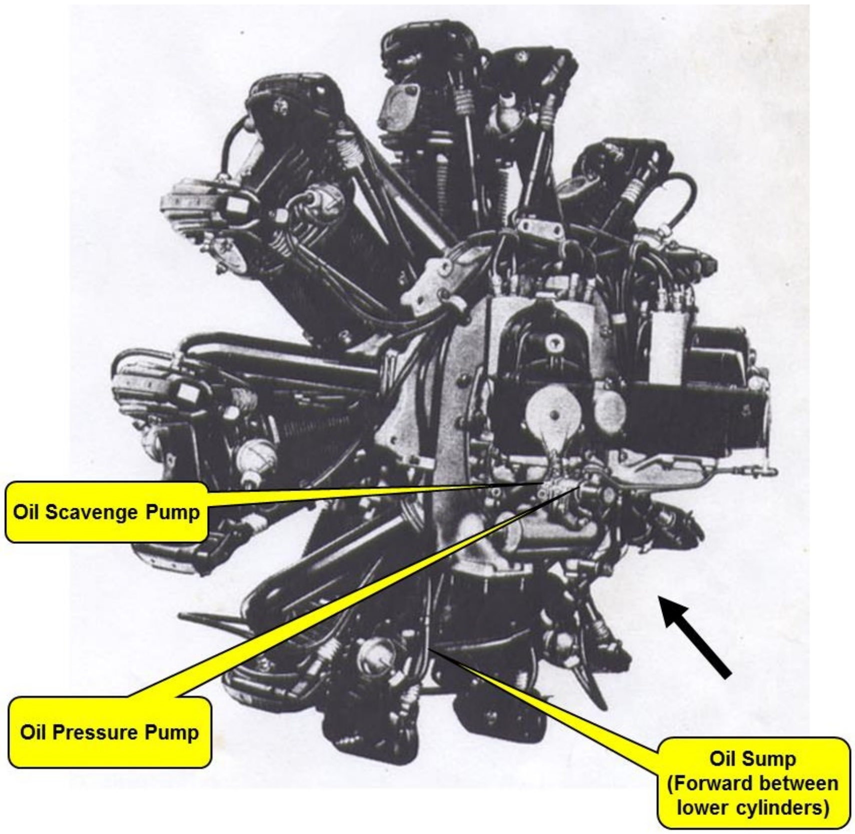
"An oil pump, consisting of one pressure pump and a scavenging pump built into one complete unit, is mounted below the starter mounting flange.

"The oil pump fits into a machined recess in the gear case at the rear of the engine. The pump is arranged in tandem with one drive shaft operating both the pressure pump and scavenger pump.

"The oil is drawn from the oil tank by the pressure pump and from there it is forced through and oil screen mounted in the gear case to the accessories drive shaft and thence to the crankshaft. It passes through drilled passages to the crankpin bearing and from there it is forced into each wrist pin bearing. The oil which is forced out of these bearings lubricates the remainder of the engine by splash and then collects in the oil sump which is located at the

bottom of the crankcase. The oil is returned from there through the oil tubes, to the oil tank by means of the scavenger pump."

The following diagram is from the Warner Engine Manual. It shows a rear view of the engine and the pump locations that cannot be easily seen from pictures and gives perspective to the as-installed configuration. The photos following this diagram show the as-installed configuration.



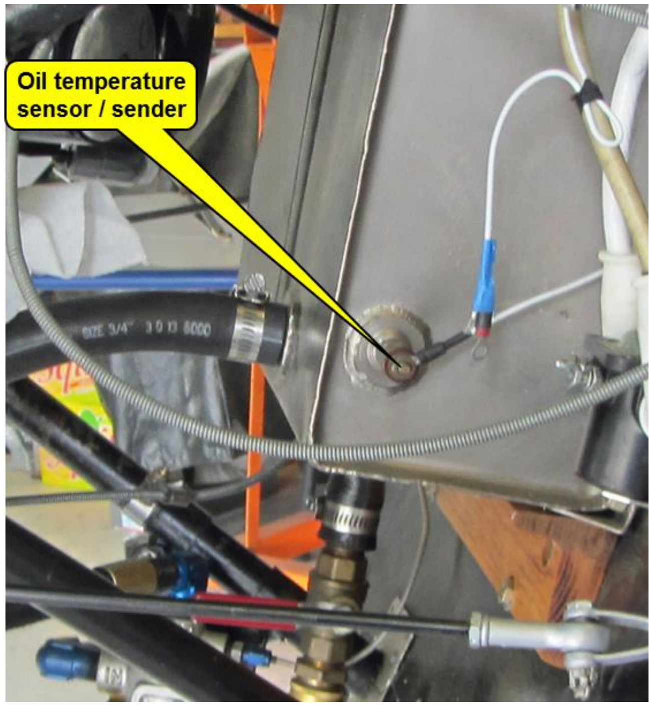
Pressure Sensor

The oil pressure sensor is attached via a pressure line near the pressure pump output through a tap in the accessory case housing. The oil pressure sensor is attached to a bracket suspended from the upper left motor mount ring support tube. (See photo above in "Lines" section.)

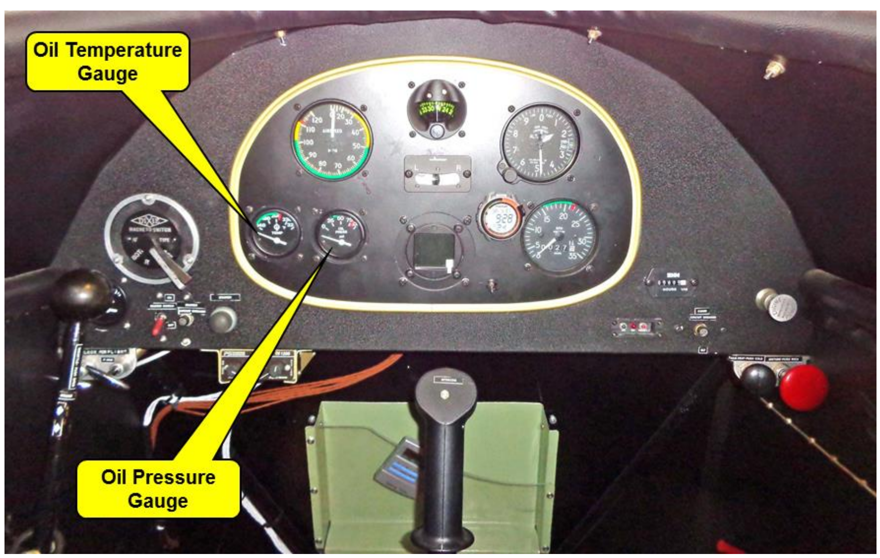
Oil pressure is displayed in the rear cockpit (only) on the instrument panel (see second photo below).

Temperature Sensor

Oil temperature is sensed from a sender in the lower left side of the oil tank close to the engine inlet port.



Oil temperature is displayed in the rear cockpit (only) on the instrument panel.



Electrical System

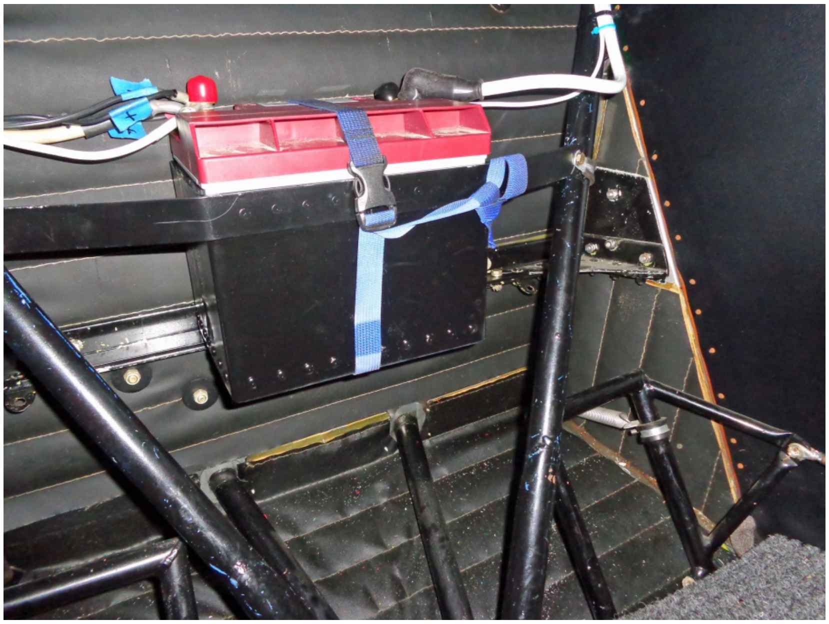
Waco N11259's electrical system consists of two main circuits, one for instruments and one for engine starting and ignition.

Battery

The battery is a 12v Concorde RG-25XC with the following characteristics:

- Cold cranking amps = 350.0
- 24 amp hours
- Female brass terminal w/M6 SS bolt
- Length = 7.71 1/16"
- Width = 5.18"
- Height = 6.81"
- Weight = 23.5 lbs
- Terminal bolts are 8 - 1.25 mm hex head

This is a certified battery installed in a custom made battery box.



The battery is mounted aft of the firewall in the forward cockpit above the rudder pedals. It fits in a custom box that is bolted to an “L” frame member behind the firewall and a bracket secured to fuselage diagonal brace tubes with Adel clamps. The battery positive terminal is connected to the main solenoid (forward of the rear instrument panel) with a 12 gauge wire lead and to the starting solenoid (on the forward port side upper firewall in the engine compartment) with a 2 gauge lead.

The battery negative is connected with a 2 gauge lead to a ground point on a frame member diagonal starboard inside the forward cockpit. The negative is also connected via a 2 gauge cable to a heavy metal tab attached to the upper right motor mount tube with a grounded Adel clamp. The battery is thus grounded to the aircraft frame in at least two places. From the heavy metal tab on the motor mount tube Adel clamp 2 gauge ground wires go to a mount bolt on the starter and to a lower right motor mount bolt. Both of these attach points ground the battery to the engine. Another ground strap from the engine lower left mounting bolt continues the ground back to the cowl attach ring

The battery also has wires to the positive and negative terminals for a charging plug that is accessible at the lower left rear of the cowl from outside the aircraft. In addition, a single wire goes to the positive battery terminal to monitor battery temperature during charging.

Starter

The starter is energized by the starter solenoid.

Power to the starter solenoid when engaged flows directly through the solenoid from the battery via the 2 gauge connection lead and grounds to the battery negative via 2 gauge cable attached to a starter mounting bolt. Power for *actuation* of the starter solenoid flows through the master solenoid. The master solenoid is enabled by the master switch and power to the starter solenoid is enabled by the starter switch on the aft cockpit instrument panel. (See starter circuit schematic under “Starting Circuit” below.) Both the master switch and the starter switch are grounded to the aircraft frame via a stud on a cross tube ahead of the instrument panel.

Switches and Breakers

There are three switches that aren’t dedicated to instruments (transceiver, transponder, intercom, and CHT gauge): the master switch, starter switch, and magneto switch. These are shown in the following photo.

The master switch is a two-position toggle switch.   The first position energizes only instruments; the second position energizes the starting circuit (starter solenoid.) The starter switch is a temporary push switch.   The magneto switch is a typical four-position magneto switch: off, left magneto only, right magneto only, and both magnetos.

There are two circuit breakers, a master and a communications breaker. The master breaker is 30 amps; the communication breaker is 10 amps.

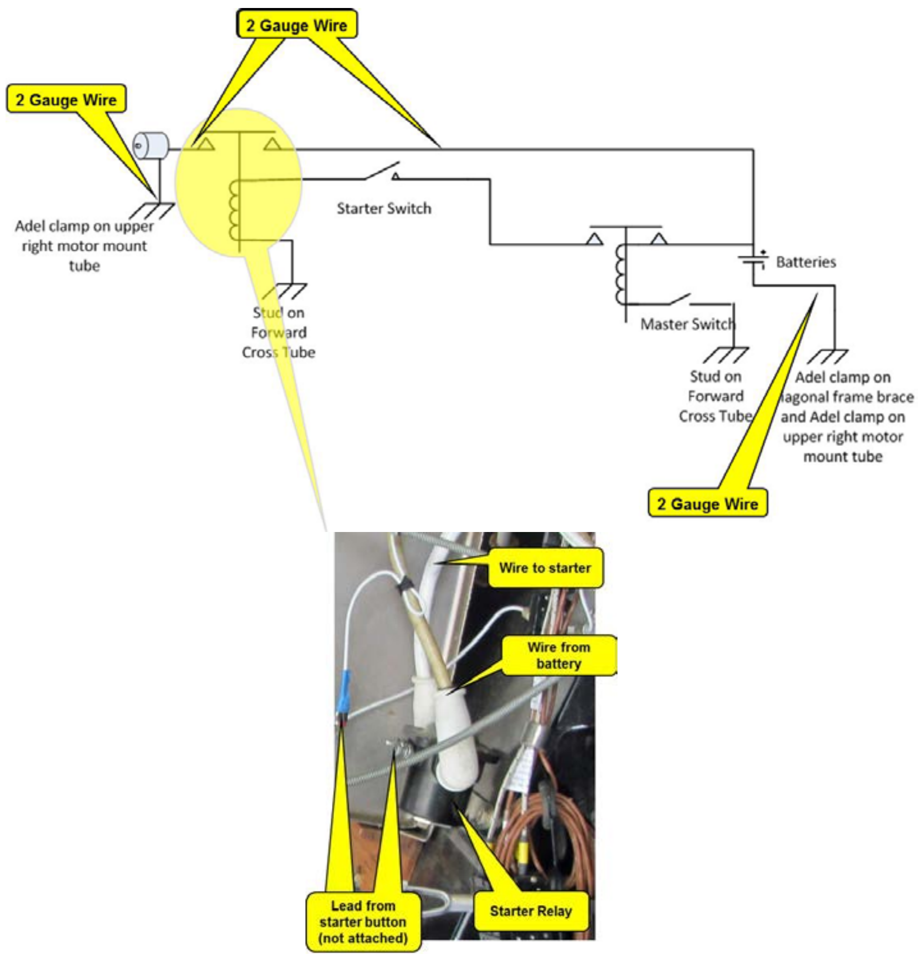
Instrument Circuit

The instrument circuit includes the oil and cylinder head temperature gauges, a volt meter, the oil pressure gauge, intercom, hour meter, transponder, and transceiver. The other instruments do not require electricity except for lighting. (Airspeed runs on pitot pressure, altimeter runs on barometric pressure, and the tachometer runs on mechanical drive from the engine. No front cockpit instruments require or receive electrical power.)

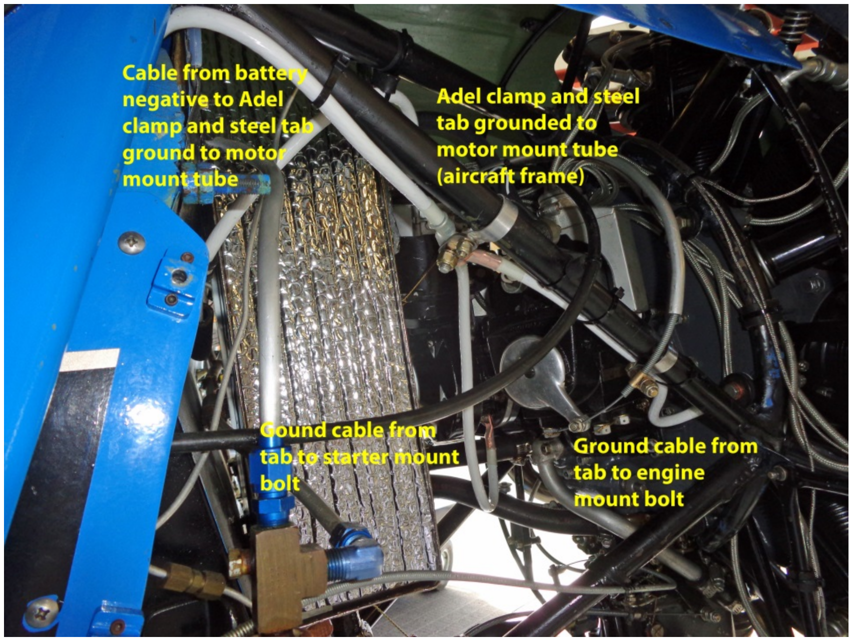
The CHT gauge, intercom, transponder, and transceiver each have their own power switch in addition to the master switch enabling power to the control switches of these units.

Starting Circuit

The starting circuit connects the battery direct to the starter through a large diameter lead via the starting solenoid. The solenoid is activated by the push button starting switch which is activated in the second "on" position of the master switch. The starter solenoid is located on the left side of the firewall near the base of the oil tank. It is fed with a #2 gauge cable direct from the battery positive terminal. A second #2 cable connects the solenoid to the starter positive terminal. This latter cable runs along the firewall behind the oil tank. The starter circuit schematic and solenoid and cables are shown in the pictures below. The master switch and starting switch are grounded to the frame via a stud on a cross tube immediately forward of the instrument panel.

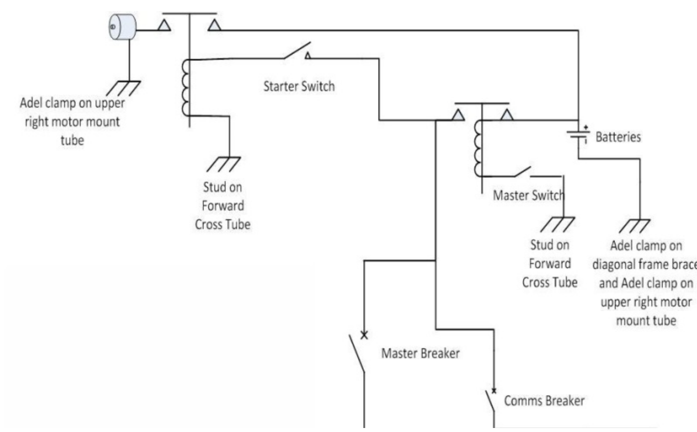


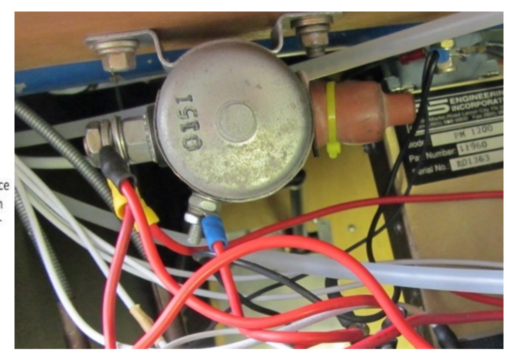
The ground side of the starting circuit is shown in the following picture.



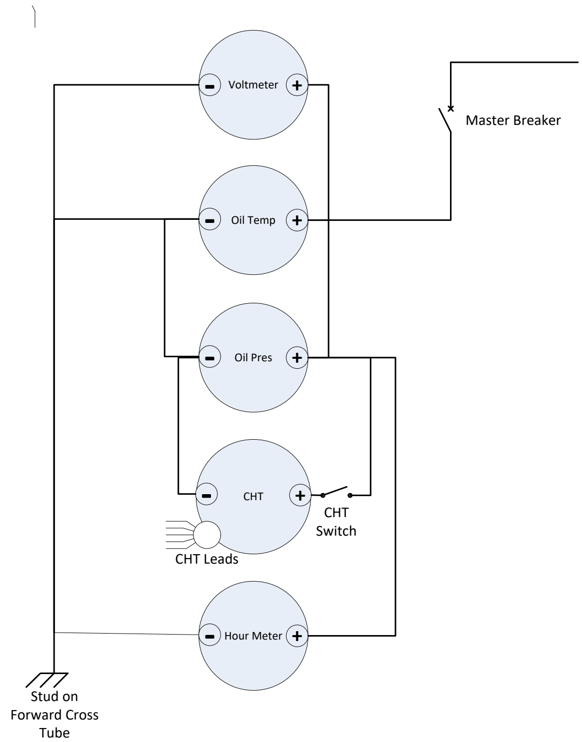
Master Circuit

The master circuit controls power to the instruments and the starting circuit. It does not affect the ignition circuit / magnetos. The master circuit switch activates power to the starter switch and to the instrument and communications circuit breakers via a master solenoid behind the rear cockpit instrument panel. The master circuit is illustrated schematically below along with a picture of the master solenoid mounted to the back of the front seat former just ahead of the rear instrument panel.



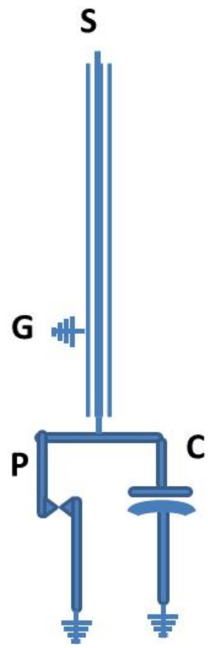


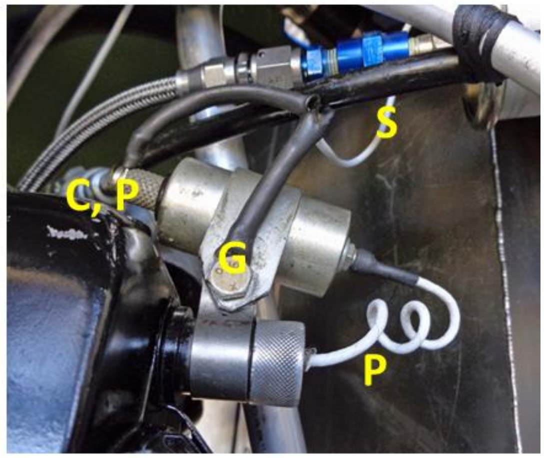
The master breaker feeds instruments on the instrument panel; the comms breaker feeds the intercom, transceiver, and transponder.



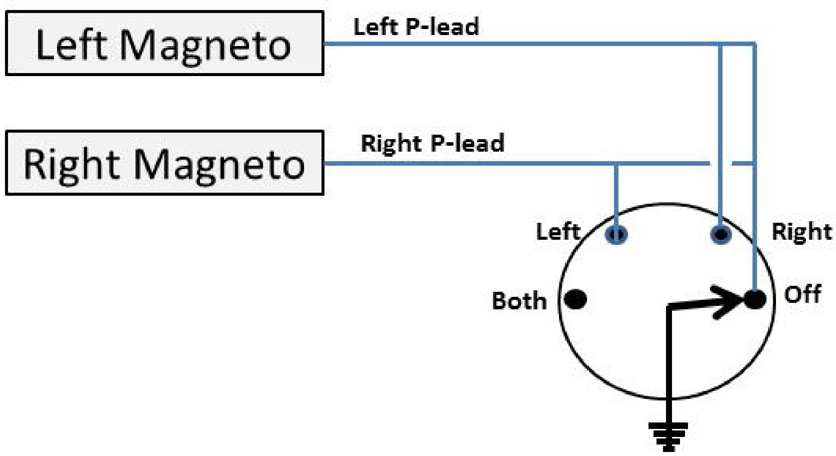
Ignition Circuit

The ignition circuit is totally separate from the instrument and starting circuits, including the on-board battery. The ignition circuit consists of the magneto switch, the magnetos, and the spark plugs and plug leads. Engine motion turning the magnetos creates a high voltage spike that drives a spark across the plug gaps and fires the engine if a fuel mixture is present. If a magneto is disabled by the magneto switch its spark is shunted to ground preventing the associated plug from firing. The right magneto fires the front plugs; the left magneto fires the rear plugs. Schematic and photo of the switch connection to one magneto is shown in the following drawing. Capacitance is between the capacitor center conductor and ground. (The capacitor case is grounded to the magneto case which is grounded to the engine and aircraft frame (G).) The center conductor of the capacitor passes through the capacitor case and the extension on the other end of the capacitor serves as attachment for the P-lead to the points (P). The lead from the magneto switch to the magneto (S) is a shrouded conductor and the shroud is tied to ground at point (G). The center conductor of the lead from the switch connects to the center conductor of the capacitor and, from the switch perspective, is the P-lead as well as attachment to the capacitor ©.





The magneto switch circuit to both magnetos is represented schematically below. When a P-Lead is grounded, that magneto cannot fire.



Controls

This section discusses all the controls for manually operating flight surfaces, engine, and brakes as well as gas line shut-off valves.

Overview

Control Surfaces

N11259 control surfaces are simple and standard: ailerons, rudder, and stabilizer/elevator.

Controlled Systems and Components

Controls for the flight surfaces are:

- Ailerons and elevator via control stick
- Rudder via foot pedals
- Horizontal stabilizer incidence / pitch trim via a sliding, knotted cord

Other controls include the following:

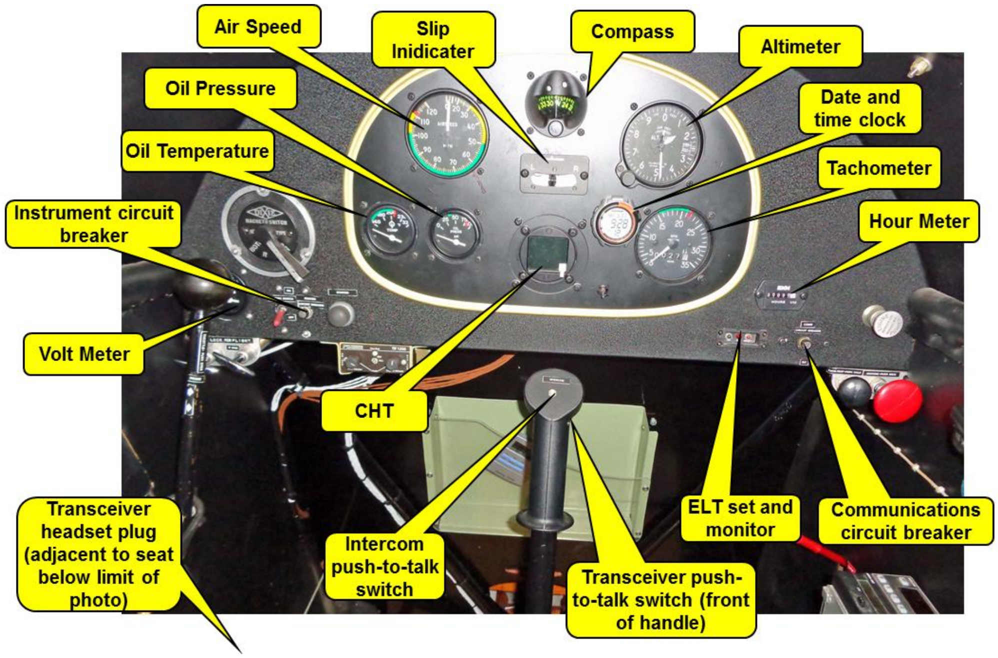
- Throttle / power
- Engine mixture via a sliding knob
- Carburetor heat via a sliding knob
- Brakes via lateral (inboard) pivot of the throttle arm
- Magneto timing via sliding "T" handle
- Instrument controls (switches)
    - Master electrical
    - Magneto
    - Radio transceiver
    - Transponder
    - Intercom
    - CHT on/off
    - ELT test and set

Cockpit Layout

N11259 can be flown from either cockpit, however full instrumentation and instrument controls are only available in the rear cockpit. The plane can be flown solo only from the rear cockpit.

Rear (Pilot)

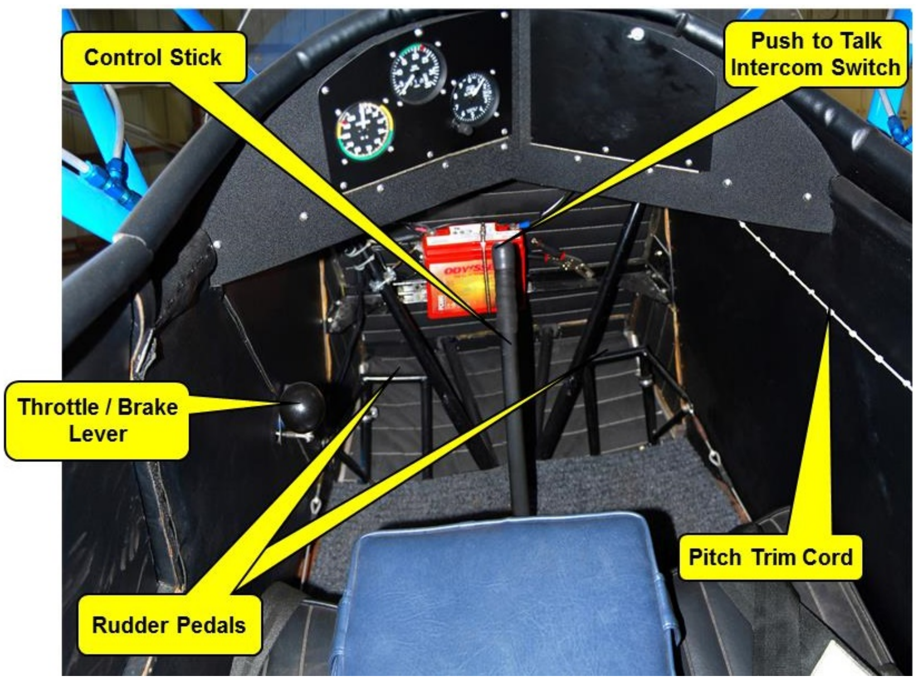
The following photos show the rear cockpit.



Individual controls are explained in following paragraphs.

Front

The following composite photo shows the front cockpit. (Note that original non-certified Odyssey battery was replaced with Concord battery referenced in electrical section.) The control stick installed has a push-to-talk switch like that control stick in the rear cockpit, but lacks the radio trigger switch that is on the control stick in the rear cockpit. (The battery shown in the following picture was replaced with a certified version.)

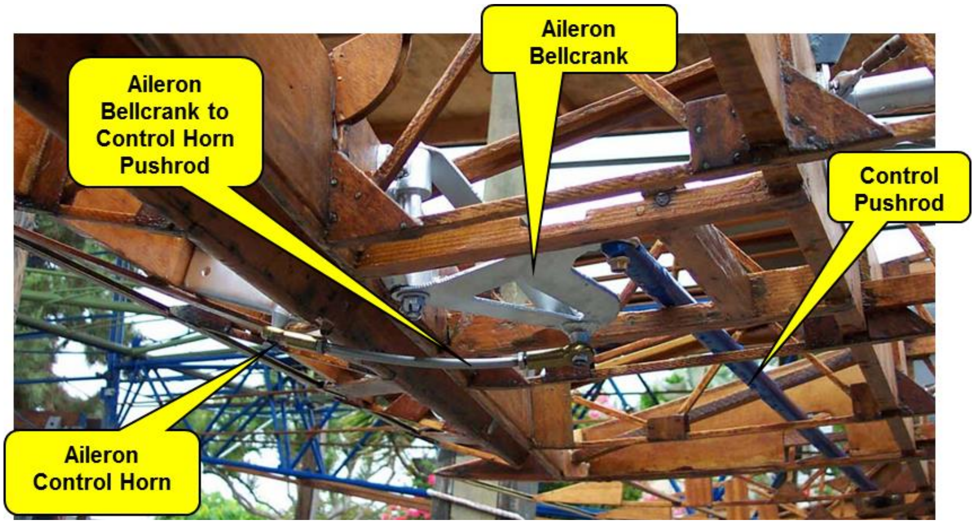


Individual controls are further explained in following paragraphs.

Control Descriptions

Ailerons

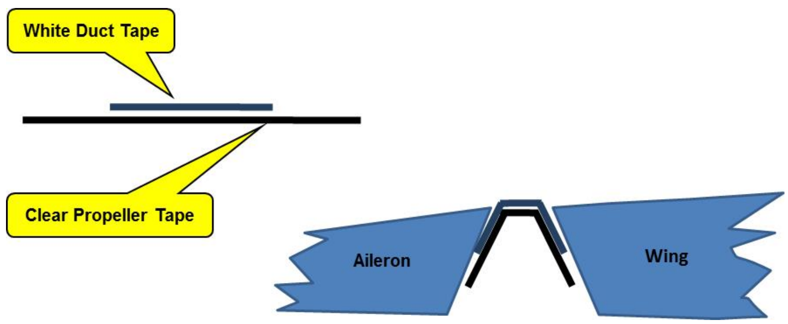
Ailerons are controlled by the control sticks. Lower ailerons are connected to the bottom of the rear control stick by push rods that extend out the wings to bellcranks mounted on the spar ahead of the ailerons. From the bellcrank a short push rod connects to the control horn on the lower bellcrank itself and shown in the following picture:



Each upper aileron is driven from its respective lower aileron by a rod connecting their trailing edges as shown below.

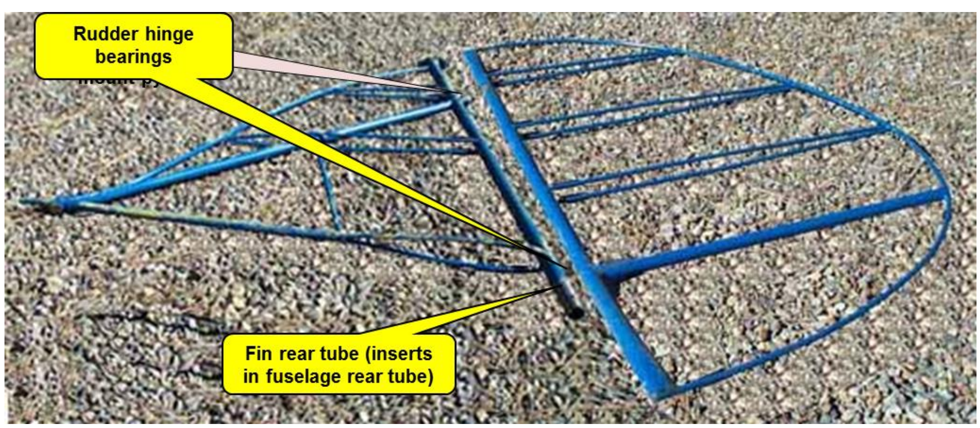
The ailerons are hinged to the wing aileron spar with four hinges that have pins with cotter keys in their ends.

The hinges leave rather large gaps between the wing aileron spar and the aileron leading edge. Air is diverted through that gap from the bottom to the top greatly reducing the aerodynamic effectiveness of the ailerons. For that reason gap seals were fabricated and placed in all four ailerons. The seals were made from a combination of propeller tape (3” wide) and white duct tape. The design used is illustrated in the following drawing.

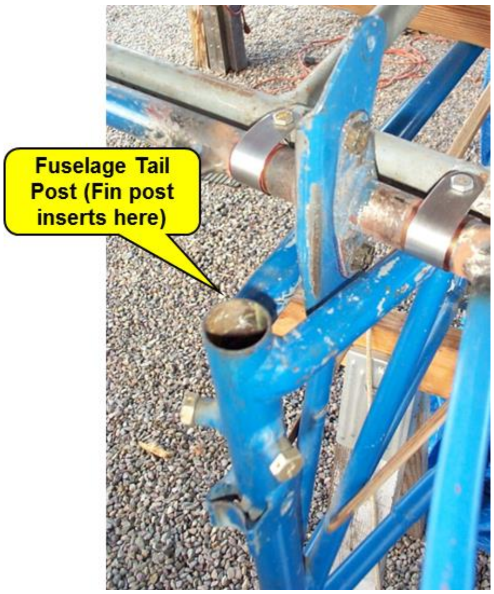


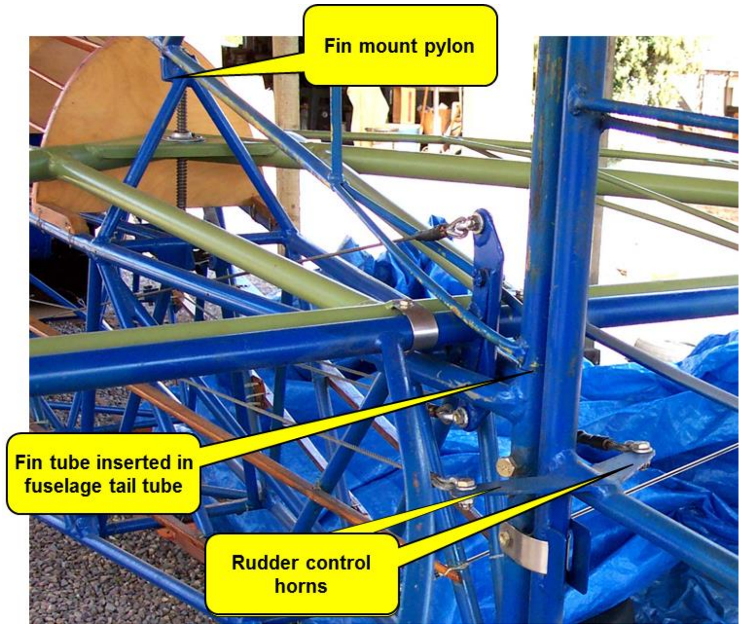
Rudder

The fin and rudder are welded tubing as shown in the following photo. Note that the photo was taken before restoration and does not yet have the control horns for tailwheel steering.



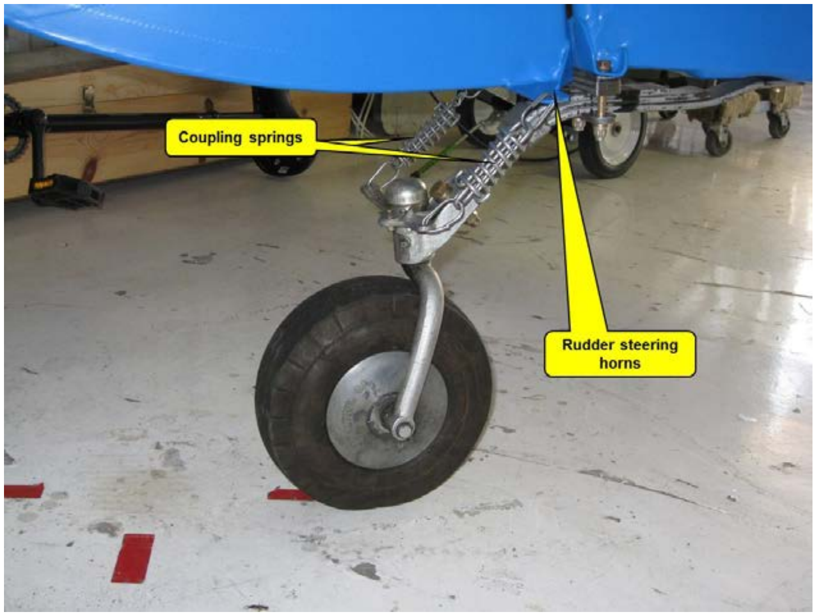
The fin is attached to the fuselage with its rear tube inserted in the fuselage tail tube and its front bolted to the fuselage pylon that also holds the stabilizer trim jack screw assembly. The following photos show the fuselage tail tube and fin mounted.





The rudder is held to the fin by simple strap hinges and control is via cables from the cockpit foot pedals to the rudder control horns also shown in the picture above. The rudder post bears on the fin tube against steal stand-off bearings like shown below (which was taken prior to restoration). The control surface is held to the bearing with a stainless steel strap such as shown in the following picture of the stabilizer. (Left photo taken before restoration.)

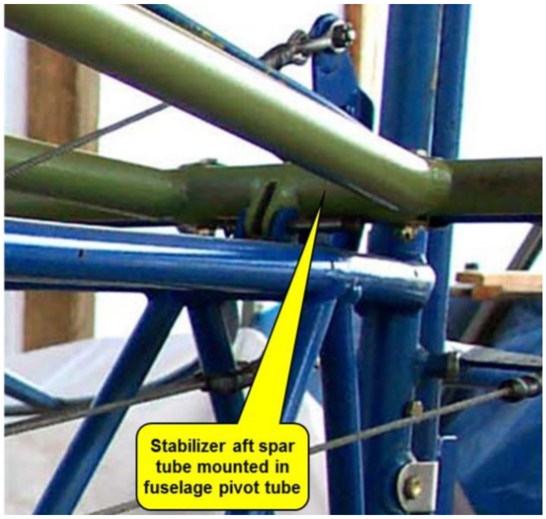
The rudder was modified with steering horns to mount spring links to steer the new tailwheel. The steering horns, springs, and tailwheel are shown in the photo below.



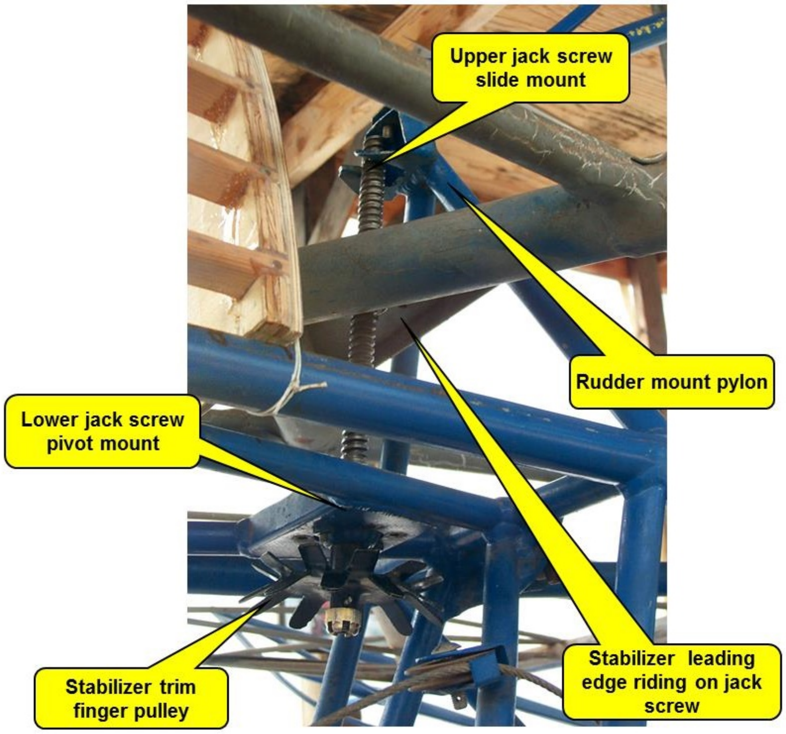
Elevator

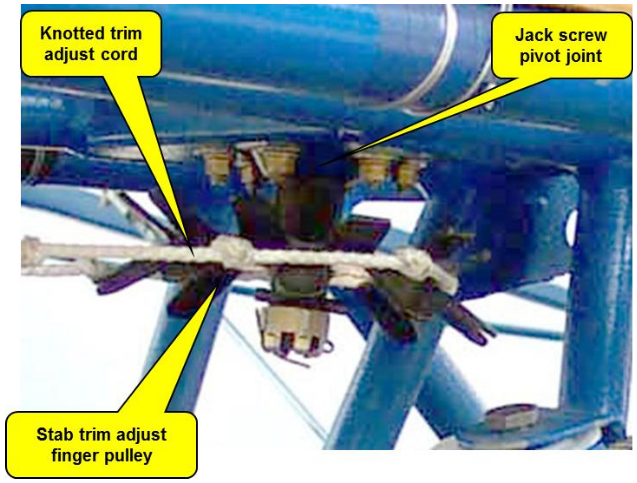
The horizontal stabilizer and elevator are welded steel structures as shown in the photos below (taken prior to restoration.)

The stabilizer attaches to the fuselage at its rear tube in a pivot as shown below.

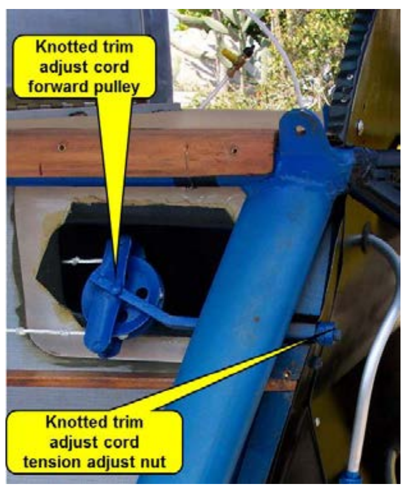


The front of the stabilizer contains a rotating nut assembly that rides on a jack screw. The jack screw mounts at its bottom to the fuselage with a pivot; the top slides in a slot at the top of the rudder mount pylon. The jack screw is driven by a finger pulley which is in turn driven by a knotted pitch trim chord that extends from the front cockpit to the finger pulley along the starboard side of the fuselage. The knots in the cord catch between the pulley fingers allowing the pulley to be rotated by moving the cord fore and aft from either cockpit. This configuration is illustrated in the following photos

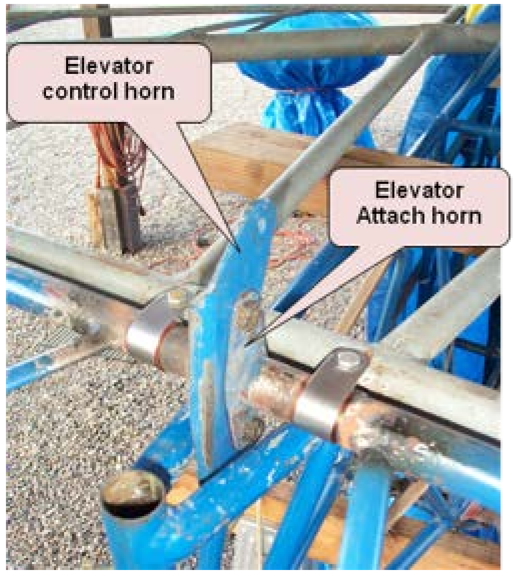




The knotted cord is a loop that goes around the finger pulley in back and around a regular pulley in the front. The cord was stretched for some time before being installed to preclude stretching and loosening during operation. The loop can be tightened by means an adjustment and stop nut forward of the firewall that extends or retracts the front pulley as shown in the following figure.



The elevator attaches to the stabilizer with simple strap hinges and steal bearing stand-offs as illustrated for the fin and rudder. The elevator is controlled from a control horn to which each elevator half connects with bolts through attach horns at each elevator half inner end as shown below. (Photo prior to restoration.)



Brakes

The brake controls on the RNF are a type referred to as “Johnson Bar”. The general meaning of this term is that the brakes are controlled from a single lever as opposed to independent heal or toe actuators like on modern aircraft. In the RNF the actuating lever is the throttle arm which, in addition to rotating fore and aft for throttle control, rotates inboard to actuate the brakes. Note that there is a thumb nut on the brake pivot portion of the throttle arm that allows the brake to be tightened in the “on” position to act as a parking brake.

Brake activation is not independent from rudder activation; braking is increased in the direction of applied rudder. It is highly inadvisable to apply brakes while landing until the aircraft is slow enough for sharp turns without tipping. Applying brakes while rolling out in a cross wind with rudder displaced to maintain straight track, for example, could cause an unexpectedly dramatic result. At taxi speeds, however, the brakes are very effective. Others who are experienced with the Johnson Bar brake system as implemented on the RNF advise to consider the brakes as “turn augmentation” while taxiing and that approach works well.

Engine

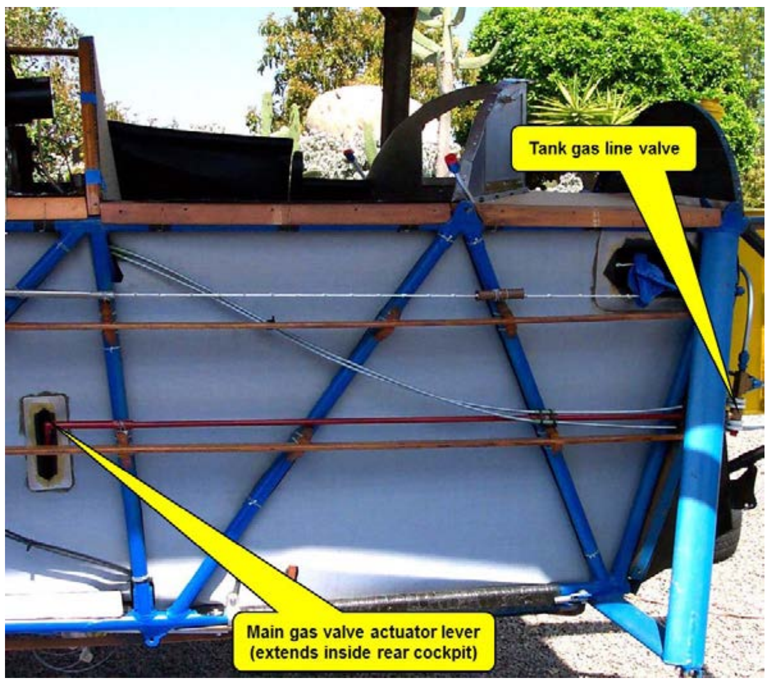
Engine controls include gas control valves, throttle, carburetor heat, mixture, primer, and magneto timing retard.

Gas Shutoff

There are five gas shutoff valves, one gate valve at the tank fuel line exit from the fore and aft of both the right and left gas tanks, and the master gas shutoff valve.

Each tank line valve is actuated at the valve where the line exits the tanks. (These were apparently put in during restoration in the event the gas tanks had to be removed for some reason.)

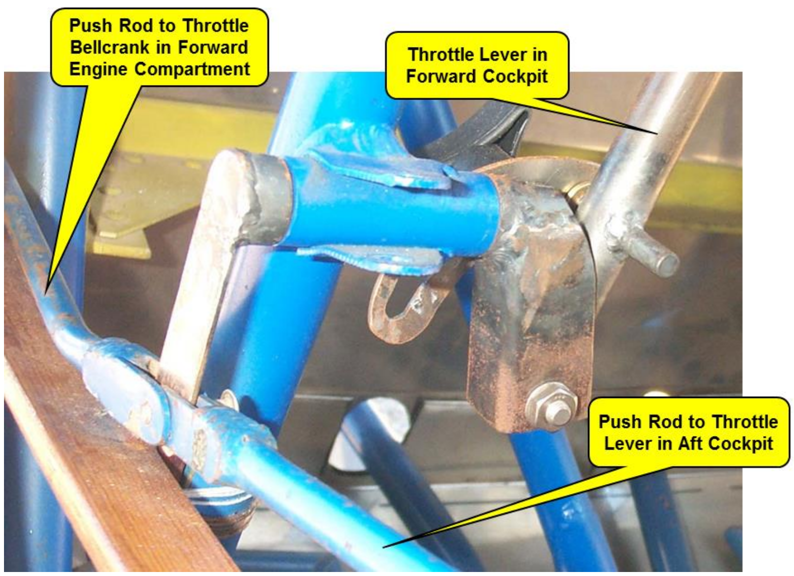
The master valve actuating handle is on the right lower side in the rear cockpit. It rotates a rod that extends forward to the master valve on the engine side of the firewall.



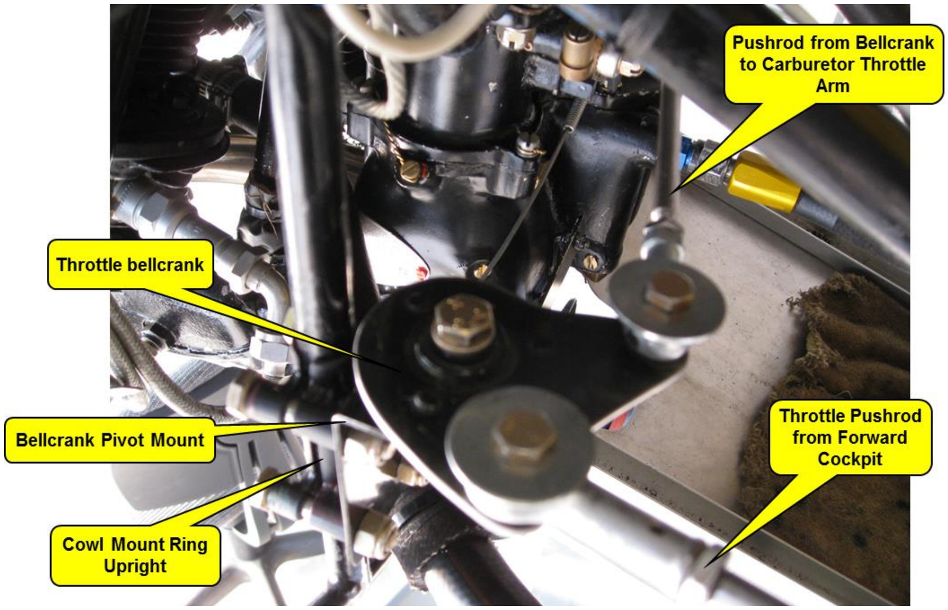
Throttle

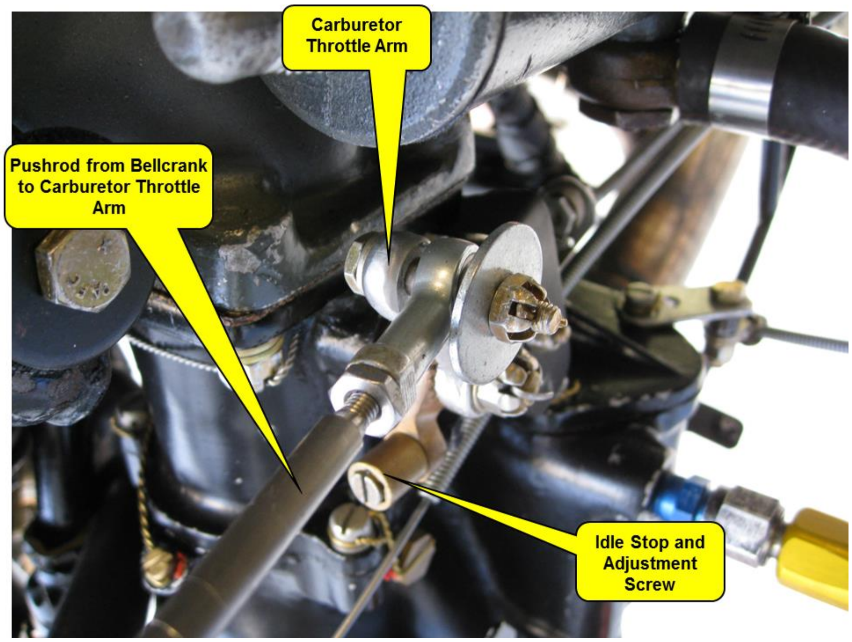
The throttle is controlled from levers on the left side of the rear and forward cockpit.

These levers pivot fore and aft for throttle control (and inboard for brake actuation.)



The fore / aft throttle lever motion is transferred to aft / forward motion in pushrods that connect the two throttle levers and the throttle bellcrank in the engine compartment. The bellcrank is mounted on a pivot platform attached to an upright brace on the cowl mounting ring of the motor mount. Another pushrod connects the bellcrank to the carburetor throttle arm.





Carburetor Heat

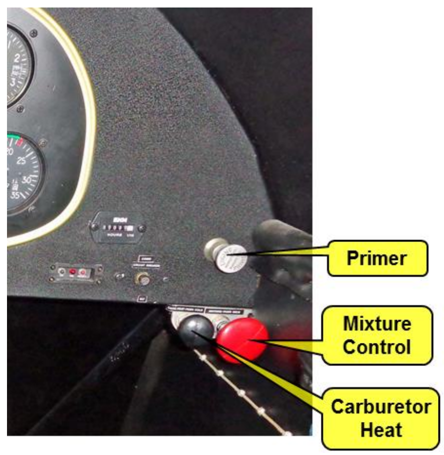
Carburetor heat is obtained from air passing between a shroud around the exhaust down-tube and the exhaust down-tube itself. Air enters the shroud through holes in the lower front of it and exits through scat ducting from the upper back of the shroud to the carburetor air intake assembly.

The carburetor air intake has a butterfly valve inside that either diverts air from the fresh air intake at the front of the intake assembly. When the butterfly valve is in this position, heated air from the carburetor heat shroud is vented out an opening at the lower rear of the intake assembly.

The arrangement is shown in the pictures in the section "System and Component Descriptions / Power System / Air Intake and Carburetor Heat."

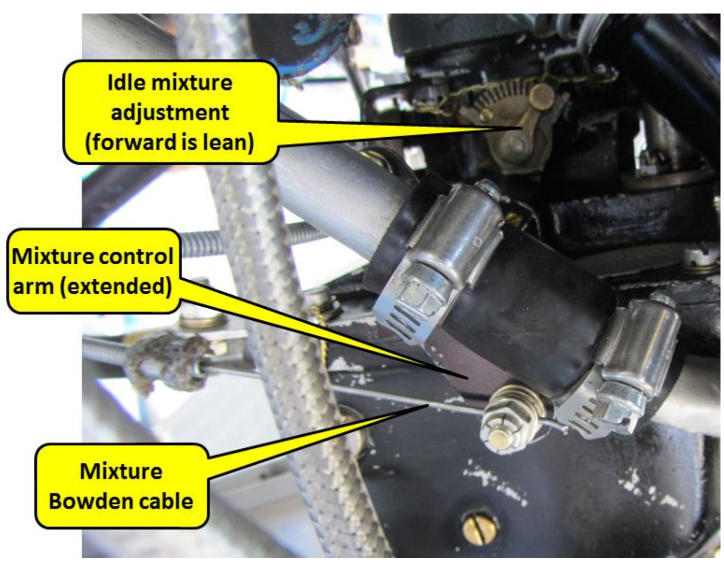
The butterfly valve is controlled through a Bowden cable actuated from a black knob in on the lower right side of the instrument panel in the rear cockpit. When the black knob is pulled, the butterfly valve rotates into a position blocking the flow of fresh air to the carburetor and diverting the heated air in instead. The heated air exhaust vent is also closed off by the butterfly valve in this position.

The carburetor heat actuation knob on the rear cockpit instrument panel is shown below.



Mixture

Fuel / air mixture is controlled via a Bowden cable actuated by a red knob on the lower right of the instrument panel in the rear cockpit. A picture of this knob can be seen in the photo above. The Bowden cable forward end is attached to an extension of the mixture control arm on the carburetor. (See picture under "System and Component Descriptions / Fuel and Oil Systems"



Idle mixture is also controlled by a set arm on the right side of the carburetor. It is not adjustable from the cockpit. This has been set to optimum lean for idle operation so the plugs do not load up while waiting for takeoff and so the engine can be stopped by leaning the mixture for shut down.

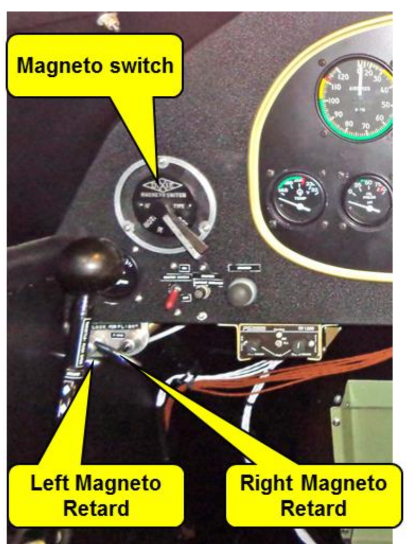
Primer

The primer is on the lower right of the aft cockpit instrument panel. (It can be seen in the picture above for carburetor heat and mixture knobs.) The primer pump draws fuel from the gascolater through a 1/8" OD aluminum line. It provides gas via a 1/8" OD aluminum line to a 1/8" NPT fitting on top of the engine intake manifold at the back of the engine. The NPT fitting has a tiny hole so that fuel forced through it into the intake manifold is atomized to some extent. The injection point to the engine intake manifold is shown in a picture in the Fuel and Oil Systems section of this manual.

Magneto Timing

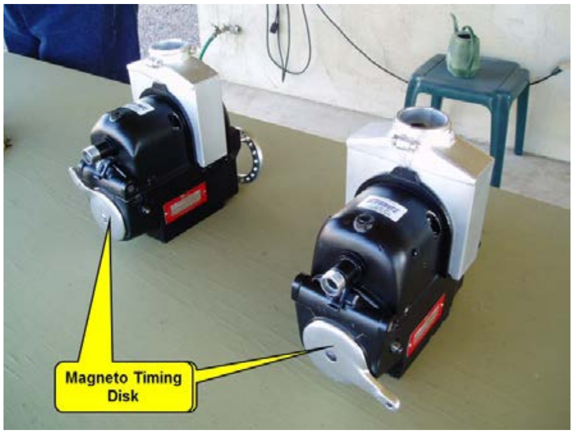
The magnetos have a disk on the back with an integral arm that allows adjustment of the ignition timing. The magneto is timed for normal operation with the adjustment ring in the full advanced position so the only adjustment is retard which is done when starting the engine to help prevent kickback and damage to the electric starter. (Cranking the engine through several blades with the magnetos switched off and turning the magnetos on while the starter is still cranking the engine also helps to prevent kickback by providing the momentum of the propeller to help carry through any premature ignition.)

The magneto timing arms are moved by Bowden cables actuated from "T" handles on the lower left side of the aft cockpit instrument panel. The left "T" handle is for the left magneto (forward spark plugs) and the right "T" handle is for the right magneto (rear spark plugs.) The "T" handles can be seen in the photo of the aft cockpit.



The photo below shows the magneto timing disks with the integral timing arm. The timing is retarded by movement of this arm when the cockpit Bowden cable handles are pulled.

Advancing the handles restores timing to the specified number of degrees in advance of top dead center. Magnetos are ALWAYS fully retarded for starting to avoid kick-back that can damage the accessory shaft and/or the starter.



Starter Switch

The starter switch is a push button lower left center on the instrument panel in the aft cockpit. When depressed, this push switch enables the starter solenoid that, in turn, provides cranking current to the starter through heavy cables.

Instrument Controls

Instrument controls include

- Master electric power switch
- Magneto switch
- Radio power switch and channel controls
- Transponder power switch and code controls
- Intercom power switch and mode control

In addition to these controls, there are two circuit breakers, one for the instruments (???? Amps) and one for the communication equipment (??? Amps).

Master

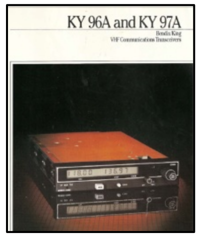
The master power switch is a toggle switch to the left center of the aft cockpit instrument panel as can be seen in the photo of the aft cockpit. It controls a solenoid enabling battery power to the electrical instruments and the starter button.

Magneto

The magneto electrical circuit is separate from the instrument electrical circuit. The magneto circuit is enabled from the magneto switch on the left side of the instrument panel in the aft cockpit as can be seen in the aft cockpit layout photo. The magneto switch is a pivoting arm with four positions: off, right (magneto only), left (magneto only), and both (magnetos.)

Radio

The radio is a transceiver on the right side panel of the aft cockpit with the radio face upward. The radio is turned on via a rotary switch on the right top side of the radio face. Other radio operations (channel selection, volume control, squelch, etc.) can be obtained from the following PDF icons.



Transceiver Information

KY-97A Transceiver Installation Manual

Transponder

The transponder is mounted against the radio transceiver on the right side of the aft cockpit with the transponder face up. Transponder power is controlled by a rotary switch on the face of the transponder. Additional transponder operation information is available via the following PDF icon.

KT-76C Transponder Information

Note that a transponder is not required in this aircraft because it was certified without an electrical system. Moreover, since the airplane runs only on battery, continual use of the transponder in addition to the radio jeopardizes the ability of the engine to be restarted after prolonged use. The transponder is therefore not used even though it is installed.

Intercom

Intercom controls are on the bottom left-center of the aft cockpit instrument panel. Information on operating the intercom can be obtained from the following PDF icon.

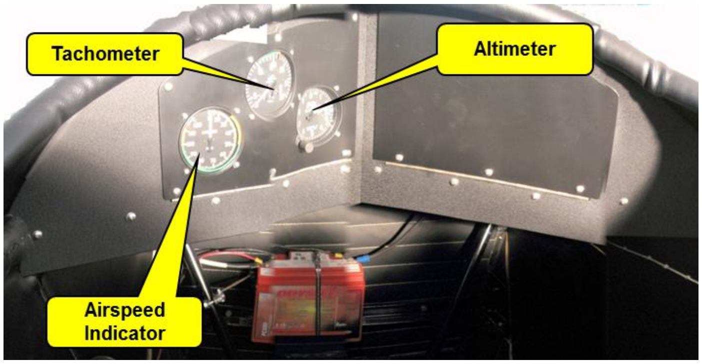
Intercom Information

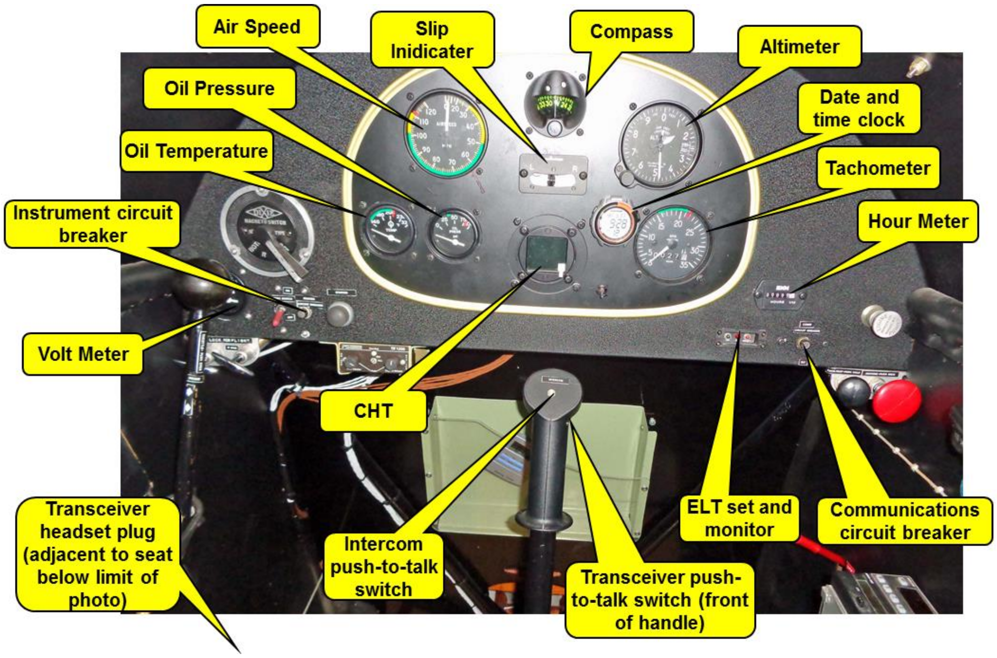
Instruments

N11259 has instruments for the following parameters. Unless otherwise noted, these instruments are available in the aft cockpit only.

- Fuel level (under upper wing, right and left on center section)
- Direction (Compass)
- Volt Meter
- Oil temperature
- Oil pressure
- Engine RPM (Tachometer) (forward and aft cockpits)
- Cylinder head temperature
- Air speed (forward and aft cockpits)
- Altitude (forward and aft cockpits)
- Turn coordination
- Emergency locator transmitter set and monitor
- Date and time clock (not permanently mounted)
- Hour meter

Refer to the following photos—the first of the forward cockpit instrument panel and the second of the aft cockpit instrument panel--in the following discussion.





Engine

The engine instruments are fuel gauge, oil temperature, oil pressure, tachometer, and cylinder head temperature.

Fuel Gauge

Fuel gauges are of the see-through tube design. They protrude from the bottom of the upper wing between the cabane struts. These gauges are inaccurate when the plane is at rest on its tailwheel erring toward a full indication. (The Waco Model "F" says that as little as 1/3 tank will register full at rest.) They are more useful (if not accurate) when the plane is in flying attitude.

Oil Temperature

Oil temperature is indicated in a gauge on the far left of the aft cockpit instrument panel. Oil temperature is sensed by a sender unit in the lower left side of the oil tank. The oil temperature gauge and instrument are Micro-1000 units. This unit is not approved for use in certified aircraft but N11259 was certified with this instrument in place and is therefore considered qualified for use in this specific aircraft.

Oil Pressure

Oil presser is indicated by a gauge immediately to the right of the oil temperature gauge on the aft cockpit instrument panel. Oil pressure is sensed by a sender unit mounted on the upper left motor mount ring support tube. The oil pressure gauge and instrument are Micro-1000 units. This unit is not approved for use in certified aircraft but N11259 was certified with this instrument in place and is therefore considered qualified for use in this specific aircraft.

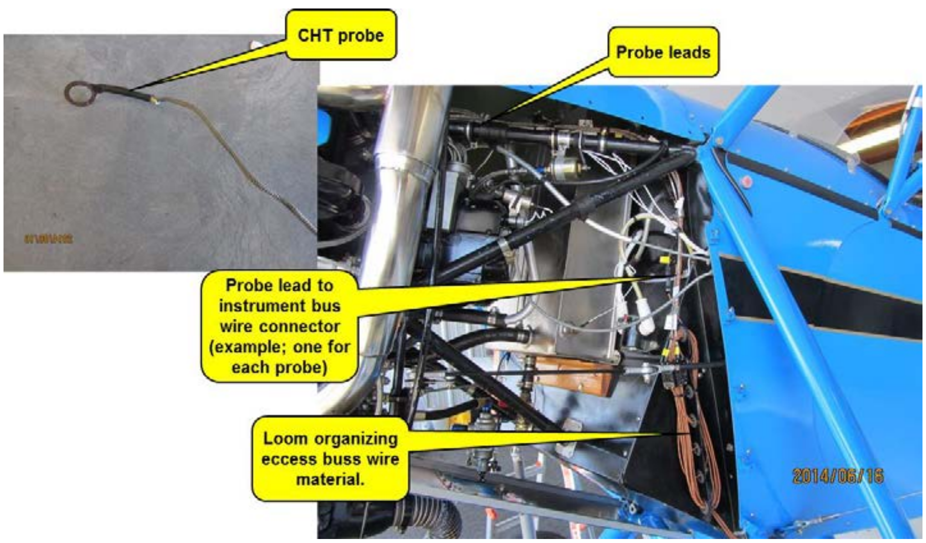
Tachometer

The tachometer is driven from a mechanical drive out of the back of the engine. There is a flexible pigtail about 10" in length that splits the tachometer drive at its end to drive separate tachometer cables to the right and left. The port cable goes to the forward cockpit; the starboard to the aft cockpit.

There is a hole in the compartment floor on the left side of the forward cockpit and the front panel on the forward cockpit can be unscrewed and tipped forward for access to the forward cockpit instruments. The tachometer connection must be removed through the hole before the front panel is tipped forward.

Cylinder Head Temperature

CHT is measured for each cylinder by an Aerospace Logic CHT gauge. Ungrounded J-type thermocouples which are washers under each rear spark plug provide signal through shielded wires to the gauge in the lower center of the rear cockpit.



The gauge is digital showing a graph of vertical bars, each proportional to the temperature of a cylinder head. In addition, the high and low cylinder head temperatures are shown digitally below the graph.

The vertical bar changes color depending upon whether the temperature of the cylinder head represented is in the normal (green), caution (yellow), or over temperature (red) range. The instrument was programmed to show caution starting at 400 ^{0}F (an Al Halloway suggested value) while the over temperature range begins at the 525 ^{0}F stated in the Warner Engine Handbook.

Volt Meter

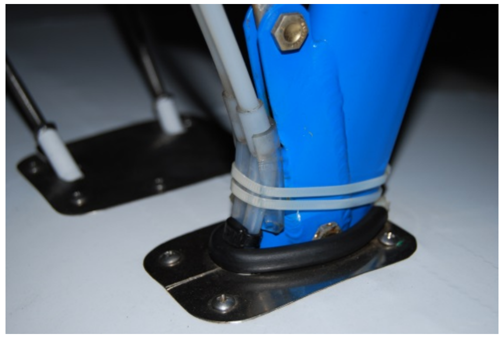
The voltmeter is a Westach unit wired to the battery in the front cockpit. The readout is on the lower left side of the rear cockpit instrument panel. This unit is not approved for use in certified aircraft but N11259 was certified with this instrument in place and is therefore considered qualified for use in this specific aircraft.

Air Speed

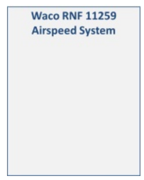
The airspeed gauge is shown in the pictures beginning this section. There is an airspeed gauge in both the front and rear cockpits. The gauge is fed by pitot and static lines that originate on the left forward interplane strut. Pitot and static pressure are fed down the interplane strut in NyloSeal tubes.

In the wing, pitot and static pressure is carried to the cockpit through NyloSeal plastic tubing that is secured multiple places in the leading edge of the left lower wing.

(The junction between aluminum and NyloSeal tubing is made with neoprene tubing that slips air tight over both the aluminum and NyloSeal. The neoprene tubing has cracked with age and produces erroneous speed reading when it does. Neoprene tubing should be an inspection item on any annual.)



At the junction of the lower left wing and fuselage the NyloSeal pitot and static tubes are split for distribution to the front and rear cockpits. A more complete picture essay of the pitot-static system is available via the following PDF icon.



Waco RNF N11259 Airspeed System

Altimeter

An altimeter is provided on the panel of both the front and rear cockpits. (See photos at beginning of section.) Static from the pitot-static system described above for the air speed indicator is also provided to the altimeter.

Compass

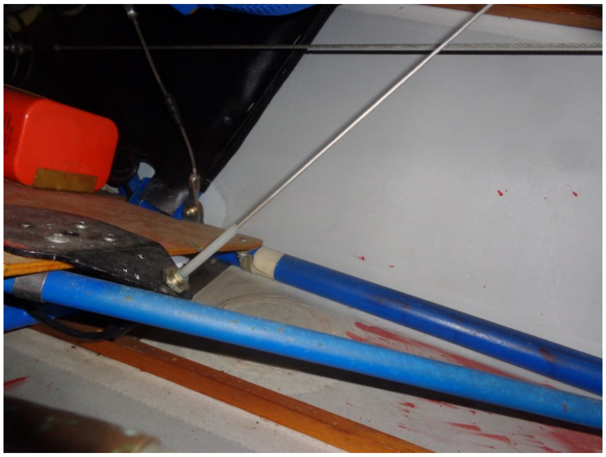
The compass is a liquid type positioned in the top center of the rear cockpit panel. A compass card is located nearby.

Hour Meter

An ENM hour meter is located lower right side of the rear cockpit control panel. It is activated any time the master switch is turned on (so electrical work with the master on accumulates time.) The hour meter was installed for recording of pilot operation time and has no correlation to tachometer time that is used to record the lifetime of airframe and engine.

Emergency Locator Transmitter

The emergency locator transmitter (ELT) is an Ameri-King Corporation brand. **<Model number ?>** It is installed on the floor to the right of the pilot seat in the aft cockpit. The antenna is attached to a bracket on the floorboard behind the pilot's seat in the aft cockpit. The ELT antenna is entirely inside the fuselage. The picture is taken through a rectangular inspection plate on the bottom of the fuselage aft of the pilot's seat.



Device

The ELT is located to the right of the pilot's seat on the wooden floorboard. The ELT is tested during annual inspections. The date of battery replacement is written on the ELT case.

Antenna

The ELT antenna is inside the aft fuselage.

Transponder

The transponder is a Bendix / King KC76C.

Instrument

Information on the transponder is available via the following PDF icon. (Note this reference has also been cited in the "Controls" section of this manual.)

KT-76V Transponder Information

Antenna

The transponder antenna is located on the bottom of the fuselage between the main wheels.

Certification

The transponder with altimeter input should be certified at annual inspections. However, since the aircraft does not require a transponder because it was originally certified without an electrical system and still does not have one, the transponder is not used and the expense of annual certification has been avoided in later years.

Radio

The communication radio is a Bendix / King KY97A.

Transceiver

Details of the transceiver can be seen via the following brochure and installation manual PDF icons. (Note these references have also been cited in the "Controls" section of this manual.)

KY-97A Transceiver Information

KY-97A Transceiver Installation Manual

Antenna

The transceiver antenna is located on the bottom center of the fuselage between the landing gear struts. (See picture above for transponder.)

Flying

This section contains impressions of the current owner (Dave Leedom) on flying the airplane. These impressions are by no means definitive and other—especially more experienced—pilots may be able to fly the plane in different and better ways.

At full power, the takeoff run seems to take about 500'. As the tail comes up rotation to the left (as will all tail draggers for which the engines run counter-clockwise) is mild and easily corrected with the rudder. The tail comes up at about 45 MPH. The only way to keep the aircraft centered on the runway during takeoff is to observe the triangles of runway view restricted by the runway edges, the wing leading edge, and the fuselage sides and keep the triangles on either side equal.

Liftoff is most comfortable at 75 MPH and climb can be sustained at that speed. Initial rate of climb is about 500 FPM but decreases after a 1000' or so.

Climb is generally continued at full throttle (~2000 RPM) until CHTs approach 390^0 at which time the throttle is reduced to 1900 RPM (95%) to keep CHT below the 400^0 recommended by the engine overhauler, Al Holloway. CHT will usually stabilize after throttle reduction but may begin to rise again after continued climb at 75 MPH. Higher speed can again stabilize or reduce CHT as can (counter-intuitively) reapplication of full throttle. (Full throttle engages the enrichment / economizer valve and the enriched mixture helps cool the cylinders.) My experience has been that I can achieve the altitude desired by taking time to climb according to CHT requirements. Maximum altitude ever achieved was 10,400'.

Landing is approached at 75-80 MPH. At that speed with reduced throttle the airplane sinks steadily. If the threshold is crossed at 75 MPH, flair and touchdown can be achieved with minimal float.

The landing is accomplished by flaring as if to achieve a three- point landing but generally results in a tail-low wheel landing that is very controllable with airflow over the rudder. Attempts to perform a true three point landing result in less control at touchdown, a significant loss of aileron authority at the high angle at touchdown. It is not recommended.

With a tail-low landing, the roll-out is continued until speed drops below 45 MPH at which time the tail can be lowered and control via tailwheel can be achieved positively. The view of the runway, of course, is significantly reduced when the tail is lowered and effort to keep the plane aligned is more lively, but not more difficult.

Because of the unique nature of the brake system, use of brakes is reserved for the end of rollout and usually reserved for straight-ahead braking only. This is just a precaution based on lack of experience with braking in turns. Brakes have occasionally been used to augment rudder in keeping the plane aligned on the runway but such use has been infrequent and conservative.

Maintenance Schedule, Log, and Check Lists

Required maintenance actions and a Maintenance Schedule and Log are separately maintained.

Aircraft Log

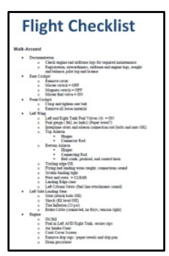
A log is maintained for the aircraft in binder format. The binder has a container for the actual log books, but contains in addition copies of Form 337s, ADs, the maintenance schedule and log, and other information relevant to maintenance of the aircraft. There is no reference to the log here since it's a living document continually being updated.

Flight Checklist

The pre- and post-flight check list includes items that assure

- Securing covers and loose items and readying the aircraft for inspection
- Inspecting aircraft integrity and readiness for flight
- Readying the engine for start and starting the engine
- Configuring systems and obtaining clearance for taxi
- Testing controls and gauges and readying aircraft for takeoff and obtaining clearance
- Readying aircraft for decent and landing
- Shutting down all systems and setting valves and switches for short-term storage

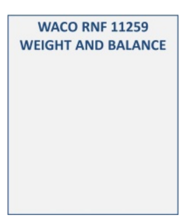
The detailed checklist is available via the following PDF icon.



Flight Checklist

Weight and Balance

A weight and balance calculator was constructed from an Excel spreadsheet. It can be accessed via the PDF icon below.



Waco RNF N11259 Weight and Balance Calculator

Center of Gravity

There appears to be no factory information available for center of gravity envelope of the RNF. There is a Form 337 for another Waco RNF (N11456) that describes the change of engine from a Warner S-50 125 hp to a Warner SS-50 145 hp engine. The weight and balance calculation in that form results in the following center of gravity comments relative to a datum at the leading edge of the lower wing, 18.25" behind the main gear axle center line. The datum used for W&B of N11259 was the engine thrust washer 48" in front of the main gear axle. Thus N11259 lower wing leading edge is 66.25" from the datum used for N11456.

The following table shows the CG calculations for N11456 relative to a lower wing leading edge datum and the thrust plate datum used for N11259. Negative values are toward nose and positive values are toward tail.

N11456	Lower Wing LE Datum	Engine Thrust Plate Datum
Most Forward CG	-5.06	61.19
Most Aft CG (within Gross)	-4.81	61.44
Actual Empty CG	-9.16	57.09

For comparison, N11259 actual empty CG is at 59.19" relative to the thrust pate datum.

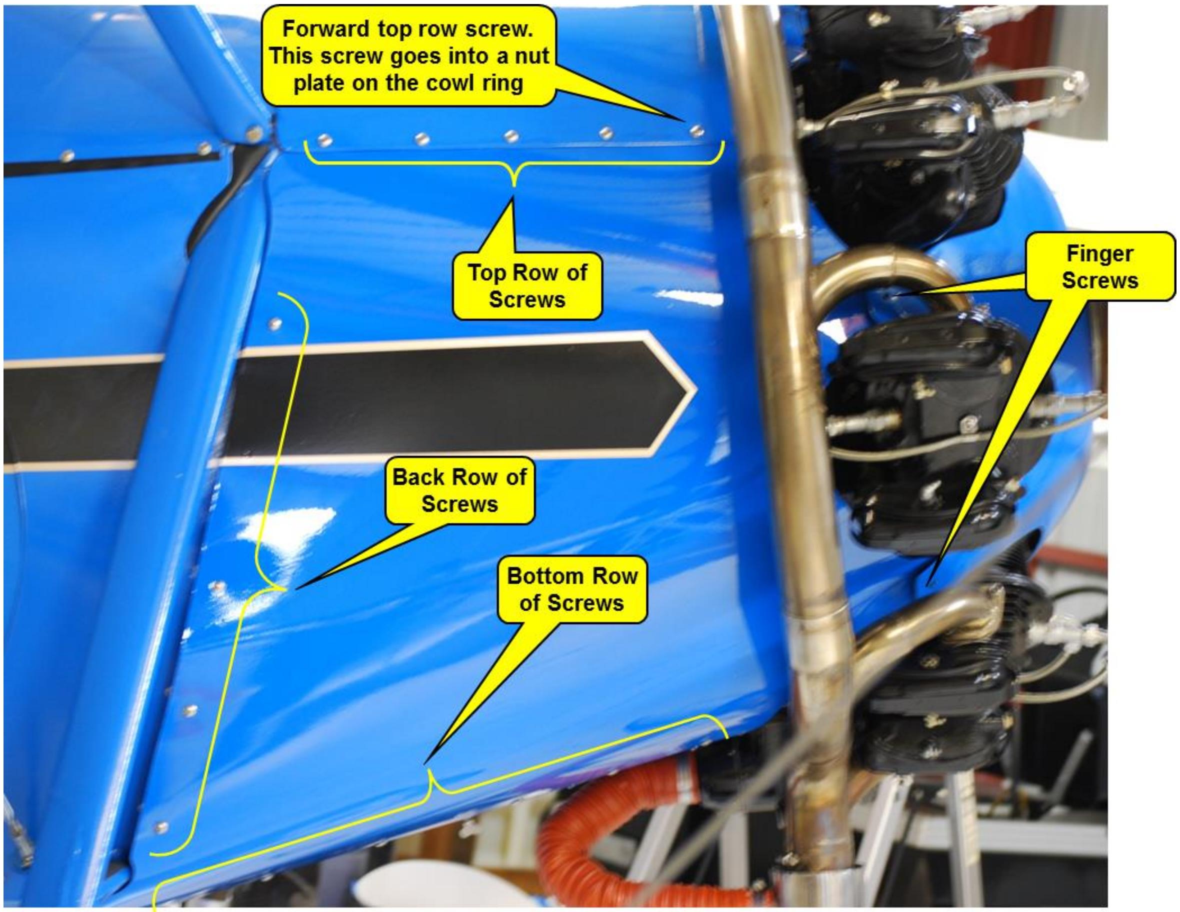
Cowl Removal and Replacement

The cowl as created by Jack when he restored the plane does not follow the original convention which involved studs protruding through the cowl pieces which were then held in place with piano wire passing through the studs as a sort of continuous cotter pin or clip. Instead, the cowl is held on with 10 x 32 stainless steel machine screws with truss heads. The screws go into nut plates fastened behind the attached panel. Anti-seize compound is used on the screw threads to prevent galling.

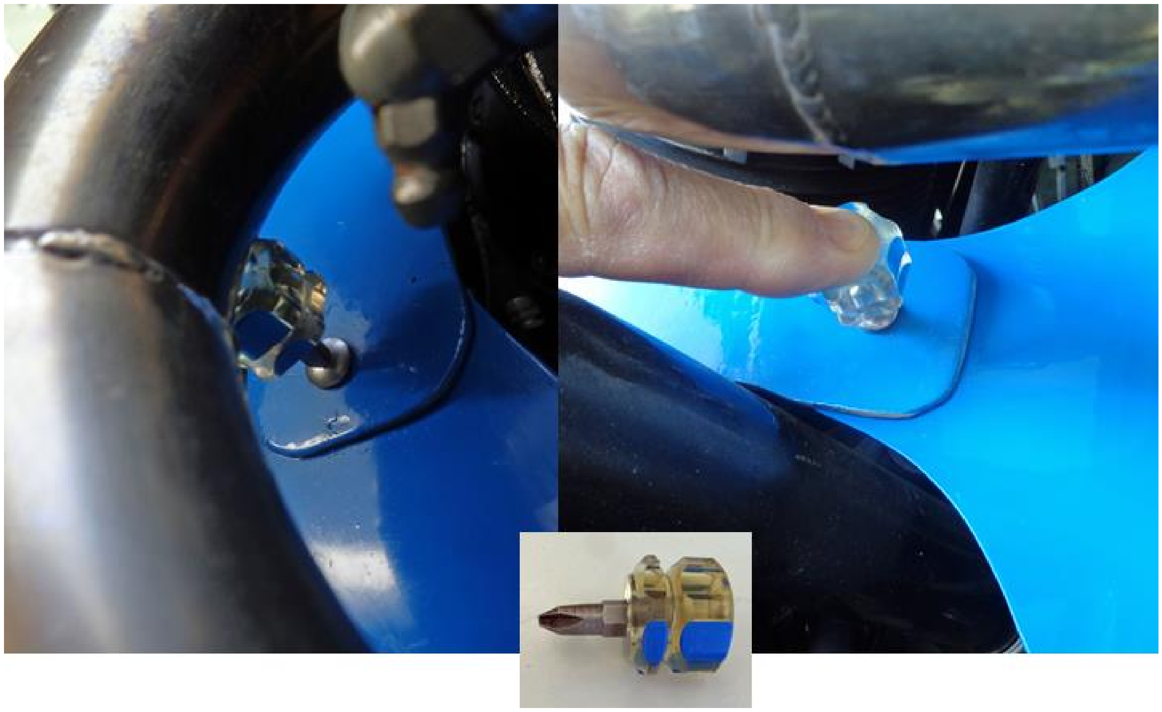
There are a lot of screws to remove to get the cowl off. Over time, a least painful sequence has evolved that makes cowl removal tolerable.

Side cowls are removed first. Side cowls slip under the top cowl, under the nose bowl, and over the bottom cowl and rear stand-offs on the fuselage sides. The side cowls have nut plates at the top and front where they fit under the other cowl pieces. The front top hole on the side cowl does not have a nut plate; instead, that screw passes through both the top cowl and side cowl and anchors into a nut plate on the cowl ring attached to the motor mount.

Side cowl removal is best accomplished in the following sequence:



- Remove the two front screws at the nose bowl. These two screws are obscured by the exhaust collection ring and must be removed using a stubby screw driver. Some care must be taken to prevent the screw driver from slipping off the screws and scarring the cowl.



Once the screws are loosened, they can be extracted the rest of the way by hand shifting the nose bowl "finger" as necessary.

- All the remaining screws (top row, back edge, and bottom row) can now be loosened (but not removed) using a hand screw driver and holding the point at the screw to prevent it from jumping out and scarring the cowl.
- With all the screws loosened, they can be removed using an electric screw driver. The best sequence seems to be bottom row, back row, top row (except as noted next). Note the order of the back row screws when extracting them. They are unequal length and it's nice to know the order in which to replace them.
- When removing the top row of screws, leave the front and back screws with a thread or two left in. This will suspend the cowl until a hand can grab it at the bottom while the other hand completes removal of the two screws.
- Remove the cowl carefully pulling out some and back so that the front "fingers" of the cowl slip out from under the fingers of the nose bowl without scraping the back of the cowl on the landing gear braces and scarring them.
- Don't stand the side cowls up; they WILL blow over.

When replacing the cowl, the removal order is not quite reversed. The best order has been found to be the following. Note that every screw should have a nylon washer so the screw heads do not mar the paint on the cowl.

- Slip the side cowl into position being careful to get the forward fingers over the cowl ring and under the nose bowl fingers and the cowl top edge under the top cowl piece. Hold the cowl in position while inserting the forward and rear screws in the top row by hand and tightening several turns. Insert the rear screw first because the forward screw has to go into the nut plate on the cowl ring and it's sometimes necessary to move the cowl or ring slightly to achieve alignment. It may go in too deep to tighten by hand and have to be started with a hand screw driver.

- With the cowl held (loosely) in place by the two top row screws, insert the bottom screw in the back row into the standoff so that the cowl is held in position. Then insert the two screws in the fingers by hand and tighten as much as possible by hand. The cowl and nose bowl fingers can be moved to improve alignment while tightening these screws. When they are hand tight, complete tightening them using the stubby screw driver.
- With the finger screws tightened, put all the other screws back in place by hand and start each by hand or with a hand screw driver. Occasionally it may be necessary to use a steel punch to align one or two of the holes in the bottom row.
- When all the screws are started, complete tightening them with an electric screw driver with the clutch set as lightly as possible. The light clutch setting gets the screws tight enough and helps preclude the screw driver jumping out of a screw and scarring the cowl. One hand is held around the driver bit and screw to further preclude the driver jumping off the screw.

All the cowl screws are stainless steel which can be prone to galling. Spark plug anti-seize compound has been applied to these screws to avoid the galling. When any sign of galling appears, a new screw is prepped with the anti-seize and the nut plate is reconditioned with a thread conditioning tool.

Annual Checklist

A checklist was drafted based on FAR Par 43 Appendix D and knowledge of RNF specifics of design, construction, and restoration that can be used during annual inspections. But the annual is performed by an A&P with Inspection Authority (IA) and each approaches the annual inspection with their own process regardless of what anyone else may have developed. Moreover, the independent approach has yielded discoveries that a standardized list would not. The draft was abandoned.

The owner, however, can do a lot to expedite the annual inspection by opening up the aircraft for inspection by removing the engine cowl, cowling over the elevator trim jack, and all the inspection plates (of which there are <u>a lot</u>.) There are a few covers at flying wire attach points that look like possible inspection plates but do not show any viewable items when removed. Hopefully, the picture essay of inspection plates and what is inside them can convince the IA that those few flying wire covers do not have to be remove.

The picture essay of inspection plates can be reviewed via the following PDF symbol in “System and Component Descriptions / Airframe / Inspection Covers” in this manual

Aircraft History

Waco manufactured 179 aircraft of the RNF type of which (as of this writing 29 Nov 2008) 43 are still on the FAA registry and 21 are in flying condition. The history of N11259 has been reconstructed as best possible from FAA airworthiness and registration documents.

N11259 initial manufacture was completed on 29 April 1931. It sold to its first owner on 13 June 1931 for a price of $4,450. Aircraft ownership, repairs and alterations are recorded in FAA documents that track up to 1946.

After 1946 there is a sequence of ownership changes with no intervening documentation of incidents, repairs, alterations, or renewal of airworthiness certificate. At some point in this period, the original engine was changed out to the Warner Super Scarab 50 (SS-50) that was "on" it when Jack Schifferer bought it as a restoration project.

The history of the aircraft and it's restoration by Jack is extensively documented in the addendum to this Owner's Manual. Available are the following:

- Initial configuration
- History (according to the FAA)
- Airworthiness directives applicable to the Waco RNFs and Warner SS-50
- EAA Sport Aviation article about the "completion" of Jack's restoration.

Reconstruction

The latest reconstruction of N11259 began in February 2000 when Jack moved the project to his shop in Escondido. Below this reconstruction is documented in photographs in three phases: initial state, Jack's reconstruction, and alterations and repairs effected subsequent to Jack's death during ownership by Dave Leedom.

Initial State

The Initial State PowerPoint presentation pictorially documents the initial condition of the airframe and engine prior to start of reconstruction.

Jack's Reconstruction

Jack's reconstruction was extensive and was extensively documented with photographs. The photographs were organized in files by major components / stages and then by date the photo was taken.

The PolyFiber process was used throughout the reconstruction. PolyFiber epoxy was used to prime the metal parts. Wood was primed with PolyFiber epoxy varnish. Wing internal metal parts were finished with Alumigrip aluminum paint. All aluminum cowls and fairings are new with PolyFiber epoxy primer on prior to paint.

At some point in the past, an incompatible varnish had been used over the existing wood and coating on the wings. The result was a bubbled, rough finish. All wood was scraped of this poor finish. All gussets were tested for strength and those that failed were repaired. Wing damage was repaired where necessary. All fuselage wood (floors, combing, and stringers) was new except for the forward cockpit door. All wood was covered with PolyFiber epoxy varnish.

The PolyFiber process was followed for covering and painting. The white is Juneau White sprayed over Polytone silver and the fuselage and rudder are Bahama Blue sprayed over Polytone silver.

Restoration Expenses

Jack's wife Barb kept a record of expenses for material and services used in the restoration of the RNF. That record is available but not included in this Owner's Manual

Post-Inheritance Alterations and Repairs

As noted at places throughout this Owner's Manual, Jack's restoration left some things that needed to be corrected—most concerned with the Warner engine overhaul.

The engine was found to have the magnetos incorrectly installed and the valves mistimed by over 22 degrees. These issues were corrected but with only 24 hours on the restored airframe and engine, the engine accessory shaft shear pins sheared precluding completion of an annual in February 2010. The engine was dismounted and taken to Holloway Engineering for another overhaul.

During the second overhaul, the engine was inspected and cylinders that had previously been bored out to near maximum were chromed and honed back to original dimensions. During this overhaul it was discovered that the pistons were of an uncertified and dangerous origin (experience with prior examples had cracked in under 200 hours operation.) With no replacement pistons available for this relatively rare engine, new pistons were eventually made and qualified by the FAA for use in N11259.

Other improvements were made during re-installation of the engine after second overhaul including the addition (via a field change) of a seven-cylinder CHT gauge to better monitor engine condition during flight.

Appendices

Flying Wires

Flying wire certificates are accessible via the following PDF icon.

Log Books

Log book entries for the Engine and Airframe Logs are documented below up to the time "normal" operations commenced. They include the initial entries documenting overhaul, certification, Jack's early flights, deinstallation, repair, and replacement of the engine, and the test flight. For subsequent entries, refer to the actual log books.

Note: there appears to be no standards for what is included in an engine log vs. an airframe log. For N11259, the convention will be that anything touching the engine will be added to the engine log including dismount or mount of the engine to the airframe. Anything else will be added to the airframe log.

N11259 Airframe Log

<Separately Maintained>

N11259 Engine Log

<Separately Maintained>

Initial Entries

The initial entry for Warner Super Scarab SS-50 S/N WW693E is:

3-21-2002
Total time unknown. Since Major overhaul 00.0. Engine overhauled in accordance with Warner Enine Handbook dated August 1945. All steel parts magnafluxed, all parts inspected and measured and comply with factory new limits. Crankshaft, rods, pistons, and pins match balanced. All new standard bearings. New 0.020 pistons, pins and rings. New valve guides and springs, new gaskets and seals. Cylinders ground +9.020. Magnetos serviced per Bendix-Scintilla service instructions. Carburetor serviced per Stomberg Sevice Manual. Installed new ignition harness and new spark plugs (REM40E). Engine preserved for long time storage. Engine inspected in accordance A/D#51-4-2 and found OK.
Signed Robert W. Von Willer Jr., A&P 564566928 I.A

When restorer Jack Schifferer applied for renewal of the aircraft certificate, the FAA demanded more information about the engine overhaul and specifically, about the valves, magneto, and carburetor overhaul. Jack went back to Bob Von Willer and got the following addition to the motor log book:

6-30-2005
At time of overhaul valves and seats were ground and hand lapped within service limits per engine overhaul manual. Carburetor disassembled, inspected, float and reset needle valve. Inspected and found to be within service limits per Stomberg manual. Carburetor reassembled with new gaskets and seals. Magnetos disassembled, inspected. New points and condenser installed. Unit tested and found to function OK per manufacturer manual.
Rober W. Von Willer Jr., A&P 564566928 I.A.

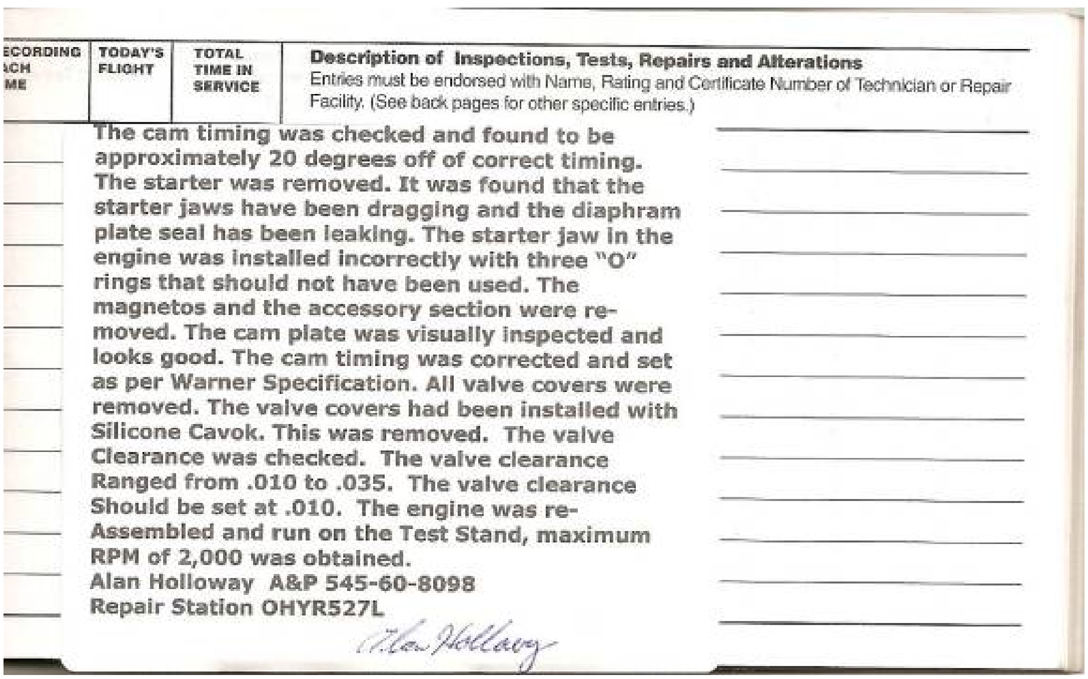
Jack has noted the following specifications:

Magneto Timing: 31^0.
Point Setting: 0.015
Firing Order: 1,3,5,7,2,4,6

Al Holloway Entries

The engine as originally overhauled did not run correctly. After several installation issues were resolved and the symptoms persisted, the engine was dismounted and taken to Al Holloway of Holloway Engineering for inspection and repair. All attached components and the propeller were taken along with the engine, but were not removed from the engine with the exception of the propeller.

Al got the engine running in a test stand to specifications. The records of his correction in the log book are as follows:



ECORDING ACH ME	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	**Description of Inspections, Tests, Repairs and Alterations** Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)

The cam timing was checked and found to be approximately 20 degrees off of correct timing. The starter was removed. It was found that the starter jaws have been dragging and the diaphram plate seal has been leaking. The starter jaw in the engine was installed incorrectly with three "O" rings that should not have been used. The magnetos and the accessory section were re-moved. The cam plate was visually inspected and looks good. The cam timing was corrected and set as per Warner Specification. All valve covers were removed. The valve covers had been installed with Silicone Cavok. This was removed. The valve Clearance was checked. The valve clearance Ranged from .010 to .035. The valve clearance Should be set at .010. The engine was re-Assembled and run on the Test Stand, maximum RPM of 2,000 was obtained.
Alan Holloway A&P 545-60-8098
Repair Station OHYR527L
Alan Holloway

The following entries are for reinstallation of the engine and maintenance after reinstallation and flying.

YEAR: 2009 DATE	RECORDING TACH TIME	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	**Description of Inspections, Tests, Repairs and Alterations** Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)
1/1/09	12.1		14.5	RE-INSTALLED ENGINE INTO AIRFRAME
				2829065 A&P IA
13 JAN 09	12.3		14.7	RAN ENGINE TO VERIFY OPERATION PRIOR TO
				ANNUAL, 2000 RPM ATTAINED, SMOOTH OPERATION

I certify that this aircraft has been inspected in accordance with an annual inspection and was determined to be in airworthy condition.

Date 1/22/09 Total time 477.7

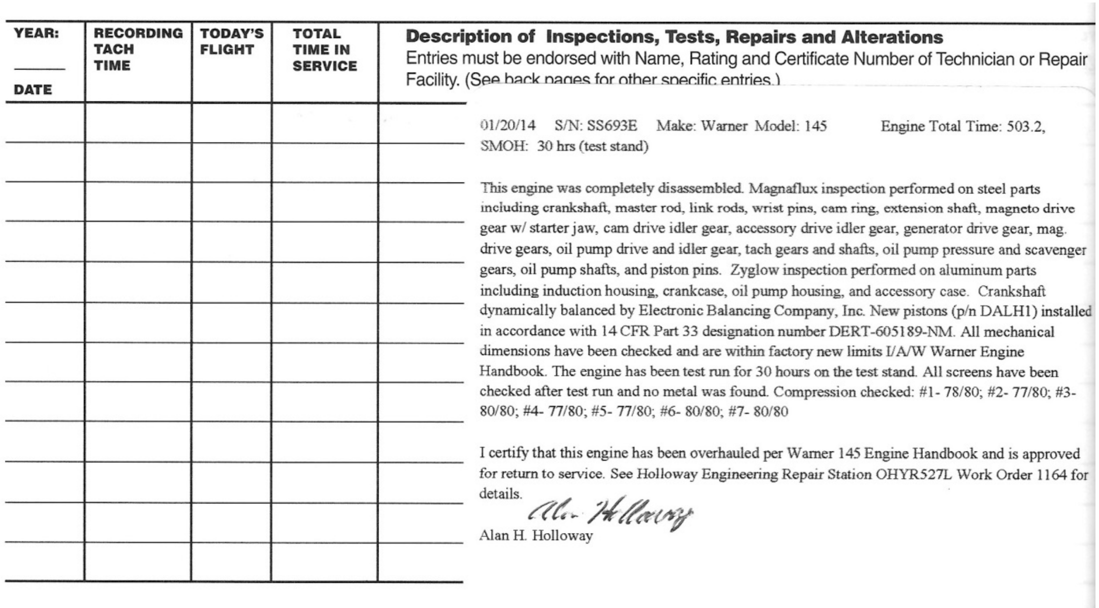
Time since SMOH 14.7

Signed Alan H Purdy I.A. 16113197

Alan H. Purdy

YEAR: 2009 DATE	RECORDING TACH TIME	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	**Description of Inspections, Tests, Repairs and Alterations** Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)
6 SEP	25.5			CHANGED OIL ~~TO~~ W100 FROM 100 GREASED ROCKER ARMS

After the second overhaul, the entry reads:



YEAR: ____ DATE	RECORDING TACH TIME	TODAY'S FLIGHT	TOTAL TIME IN SERVICE	Description of Inspections, Tests, Repairs and Alterations Entries must be endorsed with Name, Rating and Certificate Number of Technician or Repair Facility. (See back pages for other specific entries.)

01/20/14 S/N: SS693E Make: Warner Model: 145 Engine Total Time: 503.2, SMOH: 30 hrs (test stand)

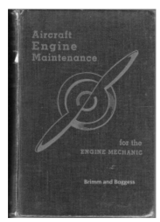
This engine was completely disassembled. Magnaflux inspection performed on steel parts including crankshaft, master rod, link rods, wrist pins, cam ring, extension shaft, magneto drive gear w/ starter jaw, cam drive idler gear, accessory drive idler gear, generator drive gear, mag. drive gears, oil pump drive and idler gear, tach gears and shafts, oil pump pressure and scavenger gears, oil pump shafts, and piston pins. Zyglow inspection performed on aluminum parts including induction housing, crankcase, oil pump housing, and accessory case. Crankshaft dynamically balanced by Electronic Balancing Company, Inc. New pistons (p/n DALH1) installed in accordance with 14 CFR Part 33 designation number DERT-605189-NM. All mechanical dimensions have been checked and are within factory new limits I/A/W Warner Engine Handbook. The engine has been test run for 30 hours on the test stand. All screens have been checked after test run and no metal was found. Compression checked: #1- 78/80; #2- 77/80; #3- 80/80; #4- 77/80; #5- 77/80; #6- 80/80; #7- 80/80

I certify that this engine has been overhauled per Warner 145 Engine Handbook and is approved for return to service. See Holloway Engineering Repair Station OHYR527L Work Order 1164 for details.

Alan H. Holloway

Radial Engine Information

General information on radial engines from "Aircraft Engine Maintenance for the Engine Mechanic" by Brimm and Boggess is accessible via the following PDF icon



Warner Engine Information

The following sections contain general information for Warner radial engines

Warner 145hp Problems and Solutions

Note: The following is from "145 and 165 HP Warner Engines, Problems and Solutions" by Dick Martin.

Hard Starting
Condensers are sometimes overheated; check to make sure the magnetos are adequately ventilated. If the magnetos are retarded too far for starting, the engine will not start.
High Oil Temperature
This is usually caused by worn main or rod bearings. If you have to use an oil cooler on a Warner (except in the tropics) something is wrong.
Bearings
Ball bearings on the crankshaft must be fit at least 0.001 tight and at least 0.0015 to 0.002 tight in the crankcase. If the retaining nut a the fron and rear of the crankshaft are not tightened properly, the bearings will come loose and ruin the crankshaft. Use a WRENCH,

not a drift pin and hammer! 0.004 undersize main bearings from a 185 engine will work on the 145 and 165.

Gears

If the engine was run with any generator other than the Eclipse type 308 or 309, check the generator drive gear and all the accessory drive gears for cracks. The Eclipse generator has a cushion built in the drive; without it the accessory gears will usually crack.

Push Rods

On the 145 HP engine, replace the graphite packings in the cam follower guides with “O” rings. Lubricate the push rods and rocker arms with any of the new high temperature greases designed for 400 plus degrees. You will eliminate most of the leakage around the cylinder heads and the rocker arm bearings and the valves will last longer.

Cylinders

Warner engines do not usually have excessive cylinder wear; however pitting and corrosion on the top 3 cylinders from inactivity or infrequent operation is a common problem. Cylinders can be bored 0.010 to 0.020 oversize. Recently many people have been chroming the cylinders and using automotive type rings with good success. Any company who can chrome Pratt and Whitney R0985 cylinders can do the Warner cylinders. Removing the cylinder heads from the cylinder barrel for chroming and valve guide and seat replacement is simple of you do it right. The secret is to heat the cylinder and head to 450 to 500 degrees for a minimum of one hour in an oven. (Do not use an acetylene torch.)

Warner 145hp Engine Tips

The following was taken off the internet; attribution of source was lost.

These tips were gathered from various folks who are knowledgeable about antique radials in general and Warners in particular. I make no guarantees for correctness, having not yet flown behind a 145HP Warner myself.

Radial Oil Hygiene

If you've never worked with radials before, there are few things about oil that you should know.

First, radials leak oil. Usually quite a lot of oil. They leak from case seams, they blow oil out the exhaust stacks and all over the airplane on startup. A Warner 145 not only will leak oil, it will leak grease from the rocker arm covers. The jokes go something like "radials are externally lubricated" and "if it stops leaking oil then you know something is wrong." So if you're not prepared to get greasy then a radial is probably not the right engine for you.

Unlike the traditional spam can engine where the cylinders are horizontally opposed, the radial engine configuration has half the cylinders pointed downward. Gravity being what it is, the oil which normally splashes around inside of the crankcase during operation will tend to collect in the downward-pointing cylinders when the engine is shut down. Not only will stray crankcase splash oil collect there, but radials also have external oil tanks that are located above the level of the engine. These tanks are usually measured in gallons of oil. The oil in the oil tank will often tend to leak out of the engine reservoir into the engine crankcase itself after shutdown.

The net of all this is that oil will end up pooling in the downward pointing cylinders of the engine. The oil will leak past the piston rings into the cylinder combustion chambers. Ok, what's the problem?

Piston engines work by using a piston to compress a gaseous fuel/air mix in the combustion chamber before igniting the mixture. That works fine when the compressed mixture is a gas. Unfortunately liquids like oil are not compressible. Oil is so incompressible that if you try to compress it by starting the engine and thus moving the pistons into a combustion chamber that's full of oil, some other part of the engine connected to that piston such as the piston link rod will give way first. The metal in the part will be overstressed. Once that happens, it is usually a short time before the overstressed rod cracks and ultimately breaks. Bad things happen when a rod breaks, and the engine stops running in short order.

The condition of a cylinder combustion chamber full of oil is called "hydraulic lock". The lock term comes from the inability to turn over the engine because the oil in the cylinders cannot be compressed. Hydraulic lock is an inherent danger in radials and you should always check for it.

The check is simple. Before starting the engine, check switches off, cut the fuel selector off, and then pull the propeller through by hand in the forward direction. I count 14 blades to be satisfied. If there is any significant resistance, you may have a hydraulic lock condition. Ask your mechanic to show you what is standard compression resistance to help calibrate your arm.

Usually a small amount of accumulated oil will drain out the exhaust valves and out the exhaust stack. It will start to dribble all over the ramp. If you're pulling the prop through outdoors be sure to park the plane so that it faces into the wind, otherwise the oil dribble will probably end up on your leg and shoes.

If you do feel any significant resistance, or if the propeller doesn't move at all, *absolutely do not attempt to force the propeller through*. Propellers are long lever arms and you can develop a huge amount of force and stress on the engine internals. If you feel resistance, stop turning and start removing the spark plugs on the lower cylinders. Start at the bottom-most cylinders and work your way upwards on both sides of the engine until you find dry cylinders. You should get a flood of oil from one or more of the bottom cylinders.

Do not turn the propeller backwards to try to "clear" any oil accumulations. This technique may seem to work, but all it is really doing is moving the oil back into the intake manifold pipes. When the engine does start, this oil will get sucked right back into the cylinder, which is now running at idling speeds. Lots of damage potential. The only solution to get rid of accumulated oil in the cylinders is to remove spark plugs.

Rocker Arms

The rocker arms and valves in the SS50A are not oil lubricated and require manual lubrication with grease.

Grease the rocker arms at least every 5 hours of operation. A recommended grease that is still available today is Texaco Marfak. This is a soap-based grease that will melt and slop around when hot.

Every 20 hours of operation, flush and re-lubricate the top end. This involves:

- Scooping out accumulated grease with a coffee stir stick
- Washing out the rocker box with liberal usage of a mixture of 1/3 Marvel Mystery Oil, 1/3 30 weight engine oil, and 1/3 castor oil. Work this mixture into the rocker arm roller and valve springs. The castor oil forms a varnish that helps prevent corrosion, because the rocker boxes will get a lot of condensation.
- The Warner manual recommends applying light machine oil to the rollers and the exhaust valve stems. Flushing with the mixture above should satisfy this requirement.
- The Warner manual recommends applying grease to pushrod tube ends every 20 hours.

While the top end is open, also check the valve clearance. Set the valve clearance approximately 0.002" loose. The valve clearance check procedure is described in the Warner Engine Handbook.

Gasoline

Mixing in Marvel Mystery Oil for top-end lube is recommended, or even required depending on who you ask.

Modern rebuilds should have steel exhaust valve seats, which are ok for use with 100LL avgas. Burning a gas with less lead, such as 80 octane avgas, or autogas with no alcohol content is recommended.

If 80 octane avgas is not available, mixing autogas and 100LL avgas about three parts autogas to one part 100LL will result in a mixture with a lead content close to that of 80 octane avgas.

Magneto Lubrication

The Warner 145 and 165 HP engines use Bendix Scintilla VMN7DF magnetos. These are old but well-built magnetos and they will serve you well if you maintain them.

The key maintenance activity is oiling the magneto distributor rotor bearing. If you do not oil your magneto every 25 hours the bearing will overheat and melt the magneto resulting in failure of the distributor rotor and potentially distributor gear. Needless to say this won't be a pleasant experience.

The VMN7DF magnetos have three bearings to worry about: two ball bearings at the front and rear of the case for the main rotor shaft, and one plain bearing for the distributor gear/rotor assembly. As designed, the VMN7DF magnetos had two oil cups to lubricate all of these bearings, one cup on the rear case cover for the rear main shaft ball bearing, and one on the front (or engine drive end) that lubricated the front main rotor shaft ball bearing and the distributor plain bearing. Passages within the magneto case connect the oil cups to the bearings.

Based on a service bulletin issued in 1955, the mags are modified to use packed grease lubrication for the main rotor shaft ball bearings, because the oil cups were providing too much lube to the main rotor ball bearings. This modification calls for plugging the oil passages from the external oil cups to the main rotor bearings.

It is important to note, however, that even with this modification you must still lubricate the distributor shaft plain bearing using the front oil cup. Don't be shy with the oil as you cannot over-oil this bearing. The excess oil will simply drain out of the magneto case. The Warner manual recommended oil intervals are 5 to 8 drops of 30 weight mineral oil every 25 hours, and 20 to 30 drops every 50 hours. Do not go past 25 hours between adding oil to the front cup or you risk distributor failure.

The rear oil cup only feeds the rear main rotor shaft ball bearing, and if the magneto has been modified this oil cup is plugged off. If not modified then the Warner manual recommends 5 to 8 drops every 50 hours in the rear cup. If your magneto has been modified then it won't hurt to put oil in the rear cup other than potentially making a mess, so better safe than sorry if you don't know for sure.

If you haven't run your engine for a long time, say at the beginning of the flying season or any kind of long storage, make sure you oil the magnetos before starting.

If you are in doubt about your magneto's modification state, I heartily recommending sending them to Sierra Magneto Service in Grass Valley, California. The folks at Savage really know these mags and vintage magnetos of all types and they will treat you right.

Ignition Timing Retard

Since aviation engines spend most of their life running at 60% to 75% power, the ignition systems are generally fixed at a fully advanced timing position, such as 22 degrees before top dead center, in order to make full power at cruise RPMs. Fully advanced timing is great for cruise but terrible for starting because the advanced firing of the spark is timed for when the crankshaft (and hence the piston) is moving quickly rather than moving slowly as at starter speeds. With full advance but slow RPMs the early firing will work against you for firing the engine because the cylinder charge burn can complete while the piston is still on the upstroke. In extreme cases the engine will "kick back" or violently turn backwards for a blade or two. This can really run your day if you're hand propping an engine, which is why you never wrap your fingertips around a prop edge when propping.

To work around this problem and make starting easier, most flat-engine magnetos use a spring-and-cam device called an impulse coupling. The impulse couplings wind up over several starter rotations and then "snap" to spin the magneto quickly for several rotations generating a hotter spark.

Unlike flat-engine magnetos, the Bendix Scintilla VMN7DF magnetos on all the Warners I've seen do not have impulse couplings to help with starting (there is at least one engine floating around with an impulse coupling according to Savage Magneto folks, but I've never seen one). Instead the Scintilla mags have an ignition retard lever. This unique automotive-like feature retards the ignition timing based on a lever so that the engine will run easier at low starting RPMs.

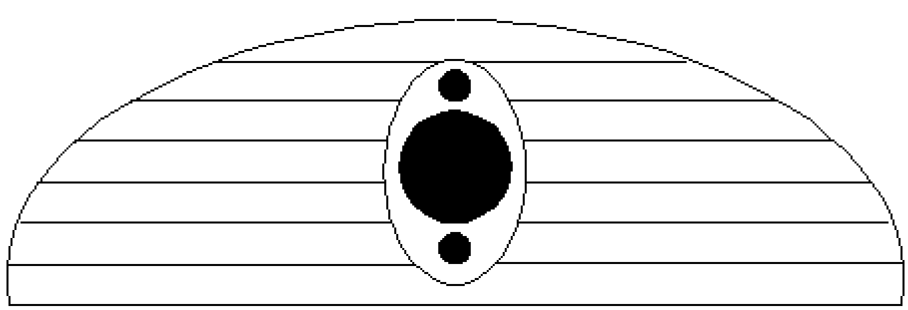
The efficacy of the retard lever is debated. Many folks use a booster coil on the magnetos for starting, which is supposed to work well. Regardless of whether you have a booster coil, if there's no retard lever hooked up then safety wire the retard level into the full advance (with the lever at the 10 o'clock position in most installations while looking down at the rear cover).

If you do use the retard lever, it should only be used for starting. I find it most effective to pull out or retard the timing about 1/2" before engaging the starter. While cranking, slowly advance the timing by pushing in the lever. If the engine doesn't start it is probably because you retarded the timing too far, and depending on your magneto this can dramatically weaken the spark. If the retard lever isn't pulled back far enough then the engine will kick back.

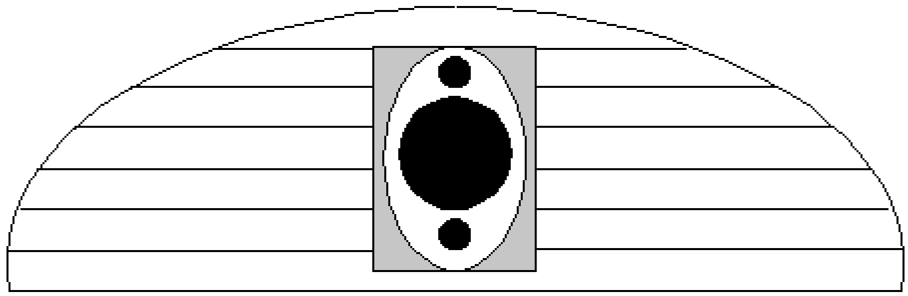
In all cases, after the engine catches make sure that you push the retard lever full in, or to the full advance position. If you don't do this then the engine will run ok but will not develop full power.

Cylinder Heads

There are two styles of Warner 145 HP cylinders heads, the heavy and light head. You can determine the difference by looking at the exhaust port. On the light head, the exhaust port boss is oval shaped.



On the heavy head there is a rectangular area of additional metal around the exhaust port.



Warner cylinders have a tendency to crack around the exhaust port, so this area should be inspected closely at regular intervals. The heavy heads are desired because the reinforcements help prevent cracks.

Parts

A good source of parts for Warner engines is Harman Dickerson. He can be contacted at 573-449-6428 or by email at hdaircraft@cs.com.

Overhauls

There aren't many people who do Warner overhauls. Forrest Lovely, in Jordan MN comes up as a good source. Radial Engines Ltd in Oklahoma does the occasional Warner.

Notes and Comments on Warner 165hp

This is not the engine in N11259, but the information is somewhat applicable by analogy.

(From "My Experience with the Warner 165 Engine" by Chalkie Stobbart)

The Sludge Trap: Old aircraft engines were designed to run on straight oil, which keeps sludge in suspension. Without the benefit of an oil filter (the mesh filter will only catch broken piston rings) this sludge is separated by centrifugal force in the crankshaft journal before the oil is pumped to the master rod bearing. If you have bought a used engine that has been idle for many years, this sludge will dry out. When starting the engine, this sludge could become dislodged and be pumped though the bearings, which is not good. Unfortunately to remove this sludge trap will required a complete engine rear down!

Running the engine in after a rebuild is a contentious issue. The modern thinking is to put it in the air and maintain a minimum of 75% power for the first few hours. With chrome cylinders fitted this 75% power should be maintained until a drop in oil temperature is noted. The Warner handbook recommends a ground run-in of about 10 hours. Modern thinkers will say that you will glaze the cylinders with continuous ground running of the engine, whilst this might be true on tightly cowled horizontally opposed engines this does not necessarily apply to an uncowled radial engine. I ran my engine of he ground for 8 hour on a hot Highveld day, following the manual's recommendation and then did the last two hours of full throttle work in the air, now after 30 hours I have no discernable oil burn—i.e., less than 1 pint in 15 hours. One engine shop in the USA (from experience) runs their engines in as per the manual EVEN WITH chrome cylinders. The reasoning is simple; if the if the rings do not seat, it is easier to change a cylinder than a spun bush in the master rod.

Ignition Timing: The Warner handbook recommends 28 degrees before TDC for 73 octane (minimum) fuel. As I use 100LL and fly on the Highveld with airport elevation in the vicinity of 5000 feet, I run 2 degrees more for the slower burning fuel and 2 degrees more advance for the altitude: i.e., 32 degrees advance. As the higher octane fuel burns slower, I run the exhaust valve tappets at 0.012 inch (0.002 larger gap than recommended) to delay the opening of the exhaust valve (for one complete combustion) yet I still see 1500 degrees F on my EGT gauge and a CHT of 300 to 350 degrees F. ON a hot day in the climb it might go to 375 degrees F but I have not seen 400 F yet. I also run my EGT at the peak during cruise.

Oil Control: I have been pleasantly surprised with the performance of the stock Warner piston rigns particularly the oil scraper rings. I had read in another publication that due to the flooding of some of the rocker boxes in the Warner engine one could expect to burn oil that was sucked into he engine via the inlet valve to guide clearance. This publication recommended an auto motive valve stem seal that needed to be reamed to size. (Perfect Circle PN2012 of kit VS4) Not having access to the part or a reamer, I looked for an alternate part. The Warner inlet valve stem is 0.401 inch (as measured on my engine(and the continental IO520 has inlet valves with a stem diameter of 0.431 inch. That means that the Continental valve stem seals (PN 646985) would be 0.030 inch too big but they fit perfectly onto the stock Warner inlet valve guide boss and do seal (only just) on the Warner valve stems. So far the results have been good. I fugure even a worn valve stem seal has to be better than no valve stem seal at all.

According to Jack Polk of Mason, TX the Warner 165 is the Rolls Royce of small radial engines, and I cannot agree more. Failures are rare. Bronze in the oil indicates a problem with a worn or spun bush in the master rod.: engine teardown time again (ask me, I know!) One other problem is caused by fitting the valve springs incorrectly (upside down!) this can lead to spring failure. If it is an exhaust valve spring, the engine will run rough and will sound as though you have blown a sparkplug out the head. If it is an inlet valve spring, the effect is much more dramatic and I quote. . .”When the defective cylinder fires, it backfires through the open intake valve into the induction housing (igniting the fuel) causing the next few cylinders not to fire. The engine goes whirrp-bang-silence-whirrp-bang long silence.

High oil temperature in a Warner engine is an indication that oil is passing through the engine too fast, thus could be caused by worn bushes or be caused by plugs (blank offs) not being fitted to bushes in the accessory case where accessory drive gears are not fitted.

The Warner oil scavenge pump is inefficient (I guess due to the height it has to lift the oil in a ¾” pipe) and this can result in flooding of the lower cylinders after long periods at idle (taxiing a long way). This can be avoided by running the engine up at about 1100 RPM for a minute before shutdown.

From “The Care, Feeding, and Behavior of the Warner Super Scarab ‘165’”, by Jack G Polk, ANTIQUE AIRPLANE NEWS, 4th Quarter 1975

Use straight mineral oil only (SAE 100 in the winter and SAE 120 in the summer.) Compound oils, despite anti-foaming agents, foam too much within this engine and the resulting cavitation will shorten bushing life. Change oil at 50 hours or six months, whichever comes first. Drain Oil with the engine hot. If our plane is not to be flown for an extended period, pull the prop through 10 or 12 blades once a week. Ground running during storage does more harm than good. It is impossible to ge the oil hot enough on the ground to remove the acids and water without overheating this engine and, therefore, leads only to the formation of more acids and water.

I find 1850 to 1900 RPM good for cruise. Don't be afraid to lean at any altitude or attitude of power setting PROVIDED cylinder head temperatures are kept within limits. The 165 was rated on 73 octane fuel and there is no way you can make it detonate when using 80/87 octane or higher octane fuel. If you are using an EGT, run it as near maximum temperature as possible with the engine running smoothly. At maximum the engine will probably run rough due to un even fuel distribution. Without and EGT, lean to 25 RPM drop beyond maximum PRM or, at the maximum, lean the engine till it runs smoothly whichever comes first. KEEP THE HEAD TEMPERATURES WITHIN THE LIMITS. The higher octane fuel we are forced to use today shortens exhaust valve life since it burns slower and tends to still be burning when the exhaust valve opens. To reduce this problem, I set my ignition at 31 degrees BTC instead of the recommended 28 degrees. Also, I set my exhaust rocker arm clearance (cold) at 0.012 instead of the recommended 0.010. This combination increases the effective rotations of the engine about 10 degrees prior to opening of the exhaust valve without affecting the intake cycle. (The intake clearance should be 0.010.

Valves, however, are not the limiting factor on the time between overhaul. Rings are the normal limiting factor for the top end and the master rod bushing is usually it for the bottom. Bad rings are noted by high oil consumption. Over a quart and hour and it is probably time. A worn master rod bushing is noted by a marked increase in oil temperature under normal operating conditions. The excessive clearance causes the oil to circulate too fast for proper cooling. Excessive clearance between the crankshaft and the extension shaft or in the coupling pin can give the same symptoms. Whatever the cause, high oil temperature combined with high engine time indicate you will probably need to rob the kid's piggy bank soon.

On a newly overhauled engine, the valve clearances, mag timing and mag point gap should be reset at 50 hours when everything has settled in. They probably won't change much in the future, but should be rechecked every 100 hours. Set mag points 0.012. DO NOT readjust points to "fine tuned" mag timing.

Warner Engine Handbook

The Warner Engine Handbook is available in a separate file.

Magneto Reference

The magneto manual is accessible in PDF format from the System and Component Descriptions / Power System / Magneto section of this manual.

The following is general information on magnetos that was gathered from the web:

Vintage Engine Magnetos

Like flat engines, most of the vintage radials and inline engines use magneto ignition systems (there are some exceptions, such as the Jacobs battery/distributor ignition used on one "half" of the ignition system). Older magnetos have some unique characteristics relative to more modern mags that you find on flat engines.

Magneto Service

The masters of vintage engine magnetos are at Savage Magneto Service, in Hayward California. Andy and the folks at Savage have always answered my questions, and on every plane that I've seen with a Savage overhaul the magnetos are well finished and run without

Magneto Lubrication - Scintilla VMN7 Series

The Warner 145 and 165 HP engines, and one half of the ignition on Jacobs engines, use Bendix Scintilla VMN7DF magnetos. These are old but well-built magnetos and they will serve you well if you maintain them.

The key maintenance activity is oiling the magneto distributor rotor bearing. If you do not oil your magneto every 25 hours the bearing will overheat and melt the magneto resulting in failure of the distributor rotor and potentially distributor gear. Needless to say this won't be a pleasant experience.

The VMN7DF magnetos have three bearings to worry about: two ball bearings at the front and rear of the case for the main rotor shaft, and one plain bearing for the distributor gear/rotor assembly. As designed, the VMN7DF magnetos had two oil cups to lubricate all of these bearings, one cup on the rear case cover for the rear main shaft ball bearing, and one on the front (or engine drive end) that lubricated the front main rotor shaft ball bearing and the distributor plain bearing. Passages within the magneto case connect the oil cups to the bearings.

Based on a service bulletin issued in 1955, the mags are modified to use packed grease lubrication for the main rotor shaft ball bearings, because the oil cups were providing too much lube to the main rotor ball bearings. This modification calls for plugging the oil passages from the external oil cups to the main rotor bearings.

It is important to note, however, that even with this modification you must still lubricate the distributor shaft plain bearing using the front oil cup. Don't be shy with the oil as you cannot over-oil this bearing. The excess oil will simply drain out of the magneto case. The Warner manual recommended oil intervals are 5 to 8 drops of 30 weight mineral oil every 25 hours, and 20 to 30 drops every 50 hours. Do not go past 25 hours between adding oil to the front cup or you risk distributor failure.

The rear oil cup only feeds the rear main rotor shaft ball bearing, and if the magneto has been modified this oil cup is plugged off. If not modified then the Warner manual recommends 5 to 8 drops every 50 hours in the rear cup. If your magneto has been modified then it won't hurt to put oil in the rear cup other than potentially making a mess, so better safe than sorry if you don't know for sure.

If you haven't run your engine for a long time, say at the beginning of the flying season or any kind of long storage, make sure you oil the magnetos before starting.

Ignition Timing Retard

Since aviation engines spend most of their life running at 60% to 75% power, the ignition systems are generally fixed at a fully advanced timing position, such as 25 to 30 degrees before top dead center, in order to make full power at cruise RPMs. Fully advanced timing is great for cruise but terrible for starting because the advanced firing of the spark is timed for when the crankshaft (and hence the piston) is moving quickly rather than moving slowly as at starter speeds. With full advance but slow RPMs the early firing will work against you for firing the engine because the cylinder charge burn can complete while the piston is still on the upstroke. In extreme cases the engine will "kick back" or violently turn backwards for a blade or two. This can really run your day if you're hand propping an engine, which is why you never wrap your fingertips around a prop edge when propping.

To work around this problem and make starting easier, most flat-engine magnetos use a spring-and-cam device called an impulse coupling. The impulse couplings wind up over several starter rotations and then "snap" to spin the magneto quickly for several rotations generating a hotter spark.

Unlike flat-engine magnetos, the Bendix Scintilla VMN7DF magnetos on Warner engines, as well as other types of Scintilla mags, do not have impulse couplings to help with starting. Some planes use booster coils, but most of the Scintilla mags have the ability to retard the ignition timing. This feature shifts the ignition timing of the magneto so that the magneto fires later in the power stroke. The result is that the engine will start easier at low starting RPMs.

The efficacy of the retard lever is debated. Many folks use a booster coil on the magnetos for starting, which is supposed to work well. Regardless of whether you have a booster coil, if there's no retard lever hooked up then safety wire the retard level into the full advance (with the lever at the 10 o'clock position in most installations while looking down at the rear cover).

If you do use the retard lever, it should only be used for starting. I find it most effective to pull out or retard the timing about 1/2" before engaging the starter. While cranking, slowly advance the timing by pushing in the lever. If the engine doesn't start it is probably because you retarded the timing too far, and depending on your magneto this can dramatically weaken the spark. If the retard lever isn't pulled back far enough then the engine will kick back.

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