Von Hoffmann Aircraft

Preparatory Course

Lambert – St. Louis Airport

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Airplane and Engine Mechanic Course

1931-32

Arthur Fisher

Von Hoffman

Air College

Robertson, MO.

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Notes on the Airplane Mechanic Course

Arthur Fisher

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Data and Instructions under the Airplane Mechanic Course

1. Cable splicing.
   1. Drawings.
   2. Instructions – specifications.
2. Construction of Airplane.
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   2. Woods – in airplane and propellers.
   3. Wings.
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      3. Trammeling after assembly.
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1.

Non-flexible cable terminal

Wind with 0.0104” soft tinned wire

Standard Thimble

A, B, C, D.

Std. Thimble

Soldered around thimble

Space

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Size of Cable | A | B | C | D |
| 1/16 | .09 | .36 | .7 | .032 |
| 1/8 | .13 | .35 | .7 | .032 |
| 3/16 | .21 | .50 | 1. | .032 |
| ¼ | .25 | .7 | 1.4 | .032 |
| 5/16 | .33 | .9 | 1.8 | .04 |
| 3/8 | .39 | 1. | 2. | .04 |

0.0410” Steel Tinned Wire

Specifications:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Diam. | No. Strands | L | Spaces | Wind | Cable Strength |
| 1/16 | 19 | 1 ½ | 1/8 | 1 | 500 lbs. |
| 3/32 | 19 | 2 | 1/8 | 1 ¼ | 1100 ” |
| 1/8 | 19 | 2 ¼ | 1/8 | 1 ½ | 2100 ” |
| 5/32 | 19 | 2 ¾ | 1/8 | 2 | 3200 ” |
| 3/16 | 19 | 3 | 3/16 | 2 ¼ | 4600 ” |
| 7/32 | 19 | 3 ½ | 3/16 | 2 ¼ | 6100 ” |
| ¼ | 19 | 4 | 1/4 | 1/4 | 8000 ” |

Standard Turnbuckle

Barrel

Eye end

Yoke end

Specifications

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Strength | A | B | C | D | E | F | G | H |
| 1 | 500 lbs. | 5/32 | 9/32 | 1/8 | 3/16 | 9/32 | 3/16 | 5/64 | 3/8 |
| 4 | 2000 ” | 13/64 | 11/32 | 3/16 | 3/16 | 11/32 | 5/16 | 7/64 | 7/16 |
| 7 | 3500 ” | 19/64 | 7/16 | ¼ | ¼ | 7/16 | 7/16 | 13/64 | ½ |
| 9 | 4500 ” | 21/64 | 7/16 | 9/32 | 9/32 | 7/16 | ½ | 13/64 | 9/16 |
| 12 | 7000 ” | 13/64 | 15/32 | 5/16 | 5/16 | 15/32 | 5/8 | 17/64 | 5/8 |
| 15 | 1000 ” | 29/64 | 9/16 | 3/8 | 3/8 | 9/16 | 11/16 | 21/64 | 11/16 |

Refer to page 1 of handwritten manuscript for diagrams.

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2.

Flexible cable terminal

Soldered under serving, full length of splice and around Thimble:

Standard Thimble

Shellacked harness thread

Specifications:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Diam | No. Strands | No. wires per strand | Splice | Service | A | Cable Strength |
| 3/32 | 7 | 14 | 1 ¼ | 1 | ½ | 800 lbs |
| 1/8 | 7 | 19 | 1 ½ | 1 | ½ | 2000 ” |
| 5/32 | 7 | 19 | 1 ¾ | 1 ¼ | ½ | 2800 ” |
| 3/16 | 7 | 19 | 1 7/8 | 1 ¼ | ¾ | 4200 ” |
| 7/32 | 7 | 19 | 2 5/8 | 1 ¼ | ¾ | 5600 ” |

Piano wire terminal

Specifications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Size of Wire |  |  |  |  |
| A | .128 | .102 | .081 | .064 |
| B | 9/16 | 13/32 | 13/32 | 13/32 |
| C | 23/64 | 9/32 | 17/64 | 17/64 |
| D | 5/64 | 1/32 | 1/32 | 1/32 |
| R | 13/64 | 9/64 | 9/64 | 9/64 |

Refer to page 2 of handwritten manuscript for diagrams.

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3.

Army Splice

1st Step.

No. 1 wire goes under 1, 2, 3 from L to R

No. 2 ” ” ” 1, 2 ” ” ” ”

No. 3 ” ” ” 1 ” ” ” ”

Heart ” ” ” 1, 2 ” ” ” ”

No. 6 ” ” ” 6, 5 ” ” ” ”

No. 5 ” ” ” 5 ” ” ” ”

” ” ” ” in where No. 6 came out

No. 4 ” ” under 6 from L to R

” ” ” ” in where No. 5 came out

2nd Step.

Tie heart wire to the cable.

Weave the wires over one and under one.

Repeat this three more times.

Next Steps

Weave every other wire over one and under two. Repeat this twice. This makes a total of seven tucks in all. After making each tuck hammer it down to make the splice tight. After making the second tuck cut out the heart wire. When finished cut off the remaining wires, then wrap with harness thread and shellack [sic]. Bend out the points of the thimble before starting, to make a neater splice.

\*Refer to diagram of splice in handwritten manuscript, page 3.

Navy Splice

Clamp in so that wires lay side by side. The shortest end to the right. Also bend up the point of the thimble, laying it on top.

No. 1 wire goes under 2 from R to L

No. 6 ” ” ” 1, 2, 3 ” ” ” ”

Heart ” ” ” 1, 2, 3 ” ” ” ”

Turn the clamp and splice over.

No. 5 wire goes under 5 from L to R

Turn over.

No. 2 wire ” ” 1 ” R ” L

No. 3 ” ” ” 6 ” L ” R

No. 4 ” ” ” 6 ” R ” L

Cut heart wire after the second tuck.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 7 x 19 Tinned Wire Cable | | | For both | Once | Twice | 7 x 7 Galvenized [sic] | |
| Diam | Breaking Strength (lbs.) | Proving  Load (lbs.) | Full  Strand | 2/3 | 1/3 | Breaking strength  (lbs.) | Proving Load  (lbs.) |
| 3/32 | 800 | 4800 | 3 | 1 | 1 | 920 | 552 |
| 1/8 | 2000 | 1200 | 3 | 1 | 1 | 1350 | 810 |
| 5/32 | 2800 | 1680 | 3 | 1 | 1 | 2600 | 1560 |
| 3/16 | 4200 | 2500 | 3 | 1 | 1 | 3200 | 1920 |
| 7/32 | 5600 | 3360 | 3 | 1 | 1 | 4600 | 2760 |
| ¼ | 7000 | 4200 | 4 | 1 | 1 | 5800 | 3480 |
| 9/32 | 8000 | 4800 | 4 | 1 | 1 | 7200 | 4220 |
| 5/16 | 9800 | 5880 | 4 | 1 | 1 | 9200 | 5520 |
| 11/32 | 12,500 | 2500 | 4 | 1 | 1 | 11,900 | 7,145 |
| 3/8 | 14,400 | 8640 | 4 | 1 | 1 | 12,800 | 9,640 |

4.

Metals used in Plane Construction.

1. Ferrous metals—iron and steel—Armco iron, Swedish and Armenian Swedish.
2. Alloys of Iron
3. Carbon steel
4. Chrome – molybdenum – steel tubing; also 1025
5. Alloys of aluminum
6. Solder
7. Copper – wire for safety wire
8. Steel wire
9. Sheet Aluminum – leading edges, gas tanks.
10. Cast al. – constructing 70% of motor parts
11. Dural al. – trailing edges
12. Cold rolled steel (1025) – making fittings.
13. Nickle [sic] steel – making nuts, bolts, clevis pins.
14. Chrome – molybdenum – used for making motor bed, truss type of fuselage.

Wires used in Construction.

1. Solid streamline wire: for exposed places, as interplane, landing gear and empennage braces.
2. Non-flexible cable: Alignment, interplane stays, drift wires, landing gear braces.
3. Flexible cable: Control wires.
4. Round swaged wire: Internal bracing of wings and fuselages.
5. Piano wire: alignment, internal braces or stays in fuselage and wings.
6. Copper wire: safty [sic] wire, and for wraping [sic] splices on non-flexible cable.

Woods used in Airplane Construction

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Wt. per cu. Ft. | Tensil [sic] Strength | Compression |
| Spruce | 32 lbs. | 12,000 lbs. | 5,000 lbs. |
| Poplar | 24 ” | 5,000 ” | 6,000 ” |
| Bass | 25 ” | 5,000 ” | 6,000 ” |
| Mahogany | 51 ” | 11,000 ” | 8,000 ” |
| Walnut | 42 ” | 9,000 ” | 5,000 ” |
| Birch | 35 ” | 10,000 ” | 8,000 ” |
| Ash | 43 ” | 11,000 ” | 7,000 ” |
| Oak | 52 ” | 10, 000 ” | 8,000 ” |
| Hickory | 43 ” | 12,000 ” | 9,000 ” |
| Balsa | 8 ” |  |  |

Wood propellers are made from walnut, mahogany, birch, apple if cut from a long enough tree; cherry, oak, and spruce (from 20 H.P. engine).

Airplanes are made of five things;

1. Wings—provides sustentation.
2. Fuselage— ” housing for crew and cargo.
3. Engine & propeller unit—maintains speed.
4. Control surfaces.
5. Landing gear.

An airplane is a self-propelled vehicle designed to fly through the air carrying a crew and cargo.

Thimble – a grooved ring of circular, pear-, or heart-shaped form, generally of metal, which is inserted in the eye of a rope of wire to prevent chafing or deformation of the eye.

5.

Glue

The kinds of glue are Casein, Hide, and Blood albumin glue.

Casein glue is the best and most used of all the glues. It is used cold thus doing away with all heating equipment. It will stand heat, moisture, and all weather conditions. It is one of the few glues approved by the Dept. of Agriculture. Add one part of dry glue powder to two parts cold water, by weight. Put the water in a can and keep stirring while adding the glue. Stir until the glue is dissolved, and let it sit for 20 mi. to aid chemical action, then stir again for a few minutes. Never mix in copper, brass, or aluminum. It can be mixed in tin, china-ware, or porcelain. Apply 1 ½ oz. to one sq. ft. of surface. In gluing end grain, size it first with a mixture of 3 to one. Let dry and then put on regular mixture of glue. After gluing you should put 125 to 150 lbs [sic] pressure to the sq. in. This pressure should remain on the glued wood at least 12 hours. Glue loses it 30% of its strength in 8 hours. Therefore it should be mixed new daily.

Blood albumin glue has to be heated to 140º. It is mixed in the same proportion as the Casein glue.

Types of Spars

Wood types—spruce wood.

-Solid spar

-Waco, P.T. 30% of small planes use them

-Box spar

-Plywood

-Fokker

-Built up I Beam spar

-Ryan

-Channel I beam spar

-Eaglerock

-Hollow spar

-Fravel air

-Laminated spars

-Laird sol.

-3/16 Plywood

-Fleet

Small pieces of wood are cut and glued together. There are 3 plys.

Metal types

-Corrigated [sic] Duraluminum

-Barling - 3/16”

-Tubular spars: Pratt Truss, Warren Truss  
 -Ford

-side view

-end

Specifications of spruce wood for spars.

It must have perfectly straight grains which number from one to fourteen to the inch. It is allowed one knot if not over 1/4” in diameter and cannot be seen from the other side of the board. It can have pitch pockets providing they are not over one inch long, 1/8” deep and two feet apart.

\*Refer to page 7 of handwritten manuscript.

6.

Trammeling a Wing

Turn the wing bottom side up. Then measure in (about 3 in.) equal distances on each spar from the butt. Find the center of the spars, then measure from those two points to about the centers of the next compression stations. Then find the center of the spars at those points. When you get the points located, tention [sic] the wires. Always trammel from the butt out. On a tapered wing the rear spar is at right angles to the ribs. To trammel it, lay a carpenter’s square in the rear corner and adjust the wires until square. On the center section of an Egal [sic] Rock, make the distance ½” inch longer, forward on only the first bay. The upper wing is trammeled square.

Assembling a Wing

Lay the spars on saw horses and slide the ribs on in the right order. After all the ribs are on the and in their right places, bolt on all the fittings, such as wing butt, drift wire, strut seat, and aileron fittings. Then glue and nail on the compression ribs, and after trammel the wing. Next glue and nail on the fowler ribs, and be sure to stagger the nails. Use No. 20, ¾” nails, on nailing ribs to spars,

and No. 20, ¼” nails for securing gussets to ribs. (Gussets are also glued). Never use too large of nails to split the wood. After this make and put on the leading edge, and next put on the nose webs. Then fasten on the wing tip and trailing edge. If you are making a lower wing put on a walk board. Next put on the safety wire or cotter keys on the turnbuckles, bolts, clevis pins, etc. Lastly put on a coat of line oil (Varnish or linseed oil). It is then ready to cover.

If you are make drift wire fittings, a ¼” hole must have ¼” on all sides. In other words all tention [sic] fittings must have a least the diameter of the hole of all sides of the hole.

Repairing a Wing

You are allowed to splice only 3 ribs per wing and the splice must be on 3 different ribs. It is permissible to splice both spars providing the splices are made with a ratio of 12 to 1. The two splices cannot be opposite each other, they must be at least two feet apart. You must use the scarf splice. The ratio 12 to 1 means that if the spar is 1” wide the splice must be at least 12” long.

7.

Covering a Wing

Materials used in covering wings are; plywood, duraluminum, mercerized cotton, pinked tape, herring-bone tape, lock-stitch cord, bee’s wax, rivets, and nails.

Specifications of grade A, mercerized cotton.

It must weigh 4 ½ oz. per sq. yd., have from 85-95 threads per sq. in. (both ways and filler), tensil [sic] strength of 95 pounds per lenial [sic] inch. The methods of covering are blanket or sheet, and envelope or pillow slip method.

Envelop method: First inspect the wing.

Then tape top and bottom of spars with pinked tape and tack to each rib.

There are two kinds of tape, one with four scallops to the inch used on spars and the other 8 scallops to the inch. It is best to use brass or copper tacks. Next take the measurement all the way around the rib and add ½” to it. Measure from the butt of the wing to the aileron cut-out, then from there to the tip. Cut out the fabric and sew the long pieces first, with English welt seam. Next sew the short pieces, and then sew them to the long pieces so that they will be on the middle of the large pieces (see small picture on page 7 of handwritten manuscript).

Then sew the trailing edge on only the long pannels [sic]. Turn up the wing so the bottom side will be up and take a pencil

and draw around the wing tips. Then cut out ½” outside of the mark. Next sew this using a single seam. Then slide it on and pull tight and tack across the butt. If it is an upper wing tack across the top, if a bottom wing tack the lower side; pull it tight across the aileron control and tuck it across the spar. Next take the necessary pieces of herring-bone tape and pin it across the trailing edge after putting it all the way around the ribs. Use tape the same width of the rib. Then lock-stitch around each rib. First 2” from the edge and then 3” all the rest of the way. To find where to lock-stitch mark the spaces first. Use lock-stitching cord 3 ½” times the chord of the wing and you will have enough string. Never put the seam of the fabric on top of the ribs. Always between the ribs. Next make the remaining procedure to have the wing completely covered. The wing is then prepared to “dope.”

8.

Covering Fuselage.

Lay the fabric over turtle-back and cut off along the center of the top longeron, allow 6” at each end. Pin the sides to the top fabric and also allow 6” at both ends. Sew the sides to the top with Eng. Welt seam. Cut off the sides along lower longeron then pin the bottom to the sides, slip off, and sew. E.W. seam. Slip it back on the fuselage and tack around front of turtle back, front, and along cowling strips. Sew up tail by hand. Tape proper places after 1st coat of dope (pinked tape).

When Vertical Fin is Welded.

When centering top fabric split it far enough to allow length for fin. Then sew on the sides. Cut only one side at lower longeron. Then sew on bottom; pull tight and pin then cut off and sew by hand.

Tacking Strips.

Leave a space on bottom of fuselage on the last bay if the tail skid projects out through there. Cut a piece of wood a little longer than the length of the hole and groove it to fit longeron. Tape it to longeron – dope. Use copper or brass nail to tack with. Leave the fabric a little longer on the sides where it is to be brought under and tacked.

Rudder

Lay the fabric on the table and place the rudder upon it and draw around the rudder. Cut fabric ½” outside of the line. Sew, using only one seam. Slip on and sew along the post by hand Then lockstitch as on a wing.

Aileron

Pull fabric around the aileron and tack to the spar using copper or brass tacks. Cover tacks with pinked tape. Proceed with stabilizers and elevators as with the rudder.

Patching

Cut the holes to be patched, square and scrape off old dope for 2” or 3”. Give one coat of clean dope. Then cut patch and fray the edges in ¼”. Dope sides of the hole and place on patch. When dry, dope the patch 3 or 4 times. Then sand it, put on color, and sand again. Then give it the final coat of color.

Repair damaged Wing Tip.

Cut the fabric about one inch outside the last good rib (leave old lockstitching [sic]). Tear off the remaining fabric where the repair is to be made. When repaired, place fabric 1”over the other side of same rib. Then lock-stitch all ribs (don’t sew). Next dope it. Put on pinked tape with 2nd coat.

Patches L + VC

Sew from outside in. Cover with tape. Note: Lay 1st piece parallel with front of wing.

Notice: —

If possible have an inspector look at all parts of the plane before covering.

To Repair One Rib

If on a top slit along center of rib on top. If on a lower wing slit the fabric along the center of the rib on the bottom. After the rib is repaired sew up the fabric and then put on the pinked tape.

9.

Doping the Fabric of an Airplane.

There are two kinds of dope used, one is acetate and the other nitrate. The nitrate is the best and most high powered dope. It is also used and approved by the army and navy. Dope increases the tensil [sic] strength approximately 20% after all the coats have been applied. Apply the dope with a brush. The first coat should be thinned with about 20% of dope thinner. When applying this first coat be sure to keep it from running through the fabric and forming “icicles.” If it does this it will decrease the tensil [sic] strength instead of increasing it.

The 2nd, 3rd, and 4th coats are put on full strength. Next, give it one coat of pigmented, aluminum-bronze dope. Then you are ready for color. Pigmented dope is better than lacquer. It (lacquer) deadens the fabric, checks cracks, and becomes dull quicker than pigmented dope. The average life of doped plane is 2 years. To mix the pigmented dope for the 5th coat, dissolve 5 oz. of aluminum-bronze powder in ½ pt. of thinner. Then mix that in one gal. of clear dope. If you are going to spray on pigmented dope, after the other procedure, it will have to be thinned with 30 to 40% reducer. Never use a red

priming coat; use grey. To make a good finish: after the first coat of dope, put on the pinked tape and add the 2nd coat of dope. After the right number of coats of dope have been applied, give the surface a good sanding. Use water-proof sandpaper. Dip the sandpaper in water and don’t rub over lock-stitches or high spots. The water is used so the sandpaper won’t cut but will make a smooth polished finish. It also reduces friction (safty [sic] factor) and stops static electricity (it is also sometimes grounded). After sanding give it a coat of aluminum-bronze dope, then sand it again. It is then ready for color. If you use a spray, it should have 50 lbs. pressure. Spray up and down about 3 bays and then across them. Each coat of dope should be allowed to dry 45 mi. at least. There should be a constant temp. of 80º. If the weather is damp a thinner should be used. Never more than 20%. If there is too much moisture the dope will blush. To eliminate this mix 4 oz. of anti-blush to clean or pigmented dope. If it is still blushed take a rag and dampen with a reducer and wipe over the whole surface, after dry, not rub, and it will take off blush.

Emergency repair of fabric: mix up flour, water, salt, and a little soda. Use this solution to dope on a piece of old sheet or other fine cloth. If a spar is broke or cracked nail and glue a piece of wood on either side. Fill in broken out place.

\*This page: Von Hoffman Aircraft Logo

10.

Nomenclature

1. Leading edge
2. Trailing edge
3. Rear spar
4. Front spar
5. Former ribs
6. Nose web
7. Wing tip
8. Drift wires
9. Wing butt
10. Wing butt fittings
11. Compression strut
12. Walk board
13. Aileron
14. Tunbuckle
15. Aileron control horn
16. Aileron hinges

\*See page 10 of handwritten manuscript for diagram of wing with numbered components.

1. Filler strips
2. Aileron false spar
3. Drift wire fitting
4. Aileron control rod
5. Front strut seat fitting
6. Rear strut seat fitting
7. Aileron horn

11.

History of Aviation

1. The Henson was one of the first airplanes to operate on airplane principles. It was devised by an Englishman named Henson. It was built in 1843 and consisted of a light framework of wood and covered with silk. It was 100 ft. wide and 30 ft. long and was slightly bent upward at the front. The rudder was shaped like a bird tail and was 50 ft. long. A car was placed below the main plane and contained the steam power plant and also provided room for passengers. Propulsion was obtained by two propellers which were placed on either side of the car. By having the propellers mounted on universal joints, it was supposed to assist in turning the machine to right and left, so thrust would be exerted on an angle instead of in a straight line. Owing to very low horse-power and great weight of power plant, which only produced 20 H.P., the machine was not capable of leaving the ground.
2. Phillip’s Multiplane: An Englishman also built this very peculiar form of plane, in 1862. This machine

had a supporting wing area composed of a very large number of very narrow surfaces all fastened to a long advancing edge. The plurality of planes being carried in a frame so that the entire contrivance resembled a huge Venetian blind. The height of the frame work was about 10 ft. and the width only 1 foot. The whole was mounted on a wheeled carriage, shaped like a boat, which was 25 ft. long. It was operated over a circular board track. Owing to trouble with the power plant it failed to fly.

1. Maxim Flying Machine: Maxim carried out some very interesting experiments in 1881. He built a very large flying machine which is said to have cost over $100,000. It consisted of one large wing with a number of smaller aerofoils fastened to the right and left. The whole having an avaible [sic] supporting aread of 3,876 sq. ft. Planes were connected to a platform 40 ft. by 8 ft. by means of a framework of thin-walled steel tubing. This platform supported the boiler

12.

(hist. of aviation cont.)

and engine. The diameter of the propellers was 17ft. The weight of the machine was 7,000 lbs. The machine was mounted on four flanged wheels and operated on a railroad track. In order to control the upward motion of the machine, an overhead rail was placed 35 ft. from the ground. The machine was also anchored by a rope. The engine had a steam pressure of 300 lbs. The machine rose from the rails and broke through the upper rail and flew across the field and was partially destroyed.

Daily inspection of an airplane.

1. Center section and brace wires.
2. Propeller and cowling.
3. Fuselage, thoroughly.
4. Landing gear and wheels.
5. Control surfaces and control cables.
6. Turnbuckles.
7. Tail unit, fittings, hinges.
8. Fabric.
9. Clevis pins, nuts, bolts.
10. All safety devices, cotter keys, safety belts, etc.

Two Types of Ribs.

1. Compression: it takes the stress from the internal drag wires and keeps the spars at an equal distance apart.
2. Former – it gives the wing shape and the fabric its correct profile and also transfers its stress to the spars.

Three Types of Wings.

1. Cantilever – it carries the full load or stress. Used on Fords and Fokkers.
2. Semi – cantilever – it needs external bracing. Used on the Ryan.
3. Externally braced – requires both struts and wires. Used on the majority of biplanes.

13.

Definitions and Facts.

1. Things that determine the power requirements of an airplane.
2. Panels or Wings – 80 to 25%
3. Wing accessories – 5 to 25%
4. Landing gear – 3 to 17%
5. Tail units – 2 to 15%
6. Fuselage – 10 to 45%
7. Relative wind is the wind an airplane comes into contact with when in flight.
8. Safety factor is the ratio of the ultimate strength of a member to the maximum probable load which will be put on it in actual use.
9. Useful load consists of the crew, fuel, oil, ballast, and other portable equipment.
10. The proportion of useful load to gross weight is 40 – 60%
11. Lift – drag ratio is the ratio of the amount of “drag” a plane has to the amount of “lift.” The list is in a vertical plane and the drag is in a horizontal plane. Lift must exceed drag.
12. Critical angle is the angle at which the drag exceeds the lift and the plane stalls.
13. Parasite resistance is that which produces and no lift.
14. Induced drag is the drag resulting from the generation of lift. Downwash of plane.
15. There is no most efficient airfoil.

Propeller Terms.

1. Propeller disk area: The total area swept by a propeller; the area of a circle having a diameter equal to the propeller diameter.
2. Propeller thrust: It is the component parallel to the propeller axis of the total air force on the propeller.
3. Propeller torque: The moment produced on the propeller by the engine shaft.
4. Propeller interference: The amount by which the torque and thrust of a propeller are changed by the modification of the air-flow in the slipstream produced by bodies placed near the propeller. Namely the engine radiator.
5. Propeller load curve: A curve representing engine power necessary to drive any given propeller at various speeds. The power required varies directly as the cube of the speed in R.P.M. provided the V|N|D remains constant.
6. Effective Pitch: The distance an aircraft advances along its flight path from one revolution of the propeller.
7. Geometric Pitch: The distance an element of propeller would advance if it were turning in a solid.
8. Mean Geometric Pitch : It is the mean geometric pitch at several elements.

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14.

Propeller Terms (cont.)

1. Standard pitch : It is the geometric pitch taken at 2/3 of the radius.
2. Pitch ratio: It is the ratio of the pitch to the diameter.
3. Pitch speed: The speed of an aircraft would make if there were no slip.
4. Slip: The difference between the mean geometric pitch and the effective pitch.
5. Blade face: the surface of a propeller which corresponds to the lower surface of an airfoil.
6. Blade back: The cambered side of a propeller blade corresponding to the upper side of an airfoil.
7. Propeller root: It is the part of the propeller blade near the base.
8. Propeller hub: The metal fitting inserted in a propeller for the purpose of mounting it on an engine shaft.
9. Propeller boss: The central portion of a propeller in which the hub is mounted.
10. Pusher propeller: It is placed at the rear end of the shaft and pushes against the thrust bearing.
11. Tractor propeller: It is placed at the forward end of its shaft and pulls on the thrust bearing.
12. (In-draft) Inflow: the flow of air from in front of the propeller into the blades.
13. Slipstream: The stream of air driven upstem [question] by the propeller.
14. Race rotation: The rotation of the air influenced by a propeller. This rotation is much more marked in the slipstream than in front of the propeller.

Aerodynamical [sic] Terms

1. Propeller section: A cross section of a propeller blade made at any point by a plane perpendicular to the blade axis.
2. Propeller camber ratio; The ratio of the maximum thickness of a propeller on its chord.
3. Aspect ratio of a propeller: It is the ratio of the propeller radius to the maximum blade width.
4. Angle of propeller blade: The acute angle between the chord of a propeller section and a plane perpendicular to the axis of rotation of the propeller.
5. Propeller blade area: The area of the blade force exclusive of the boss and root; a portion which is usually taken as extending 1/3 of the radius from the axis of the shaft.

15.

Propellers.

The three kinds of propellers are wood, metal, and micarta. The three types are: fixed pitch, adjustable pitch and variable pitch. If you decrease the pitch it speeds up the motor, and if you increase the pitch it slows down the motor but the plane has more speed.

Balancing a propeller (wood).

Slip mandrel in hub. It is set on two knife edges. If one side is heavier give the other blade an extra coat of varnish. You can also put a dent in the metal tip and fill with solder. If there isn’t a metal tip, rasp and file the heavy blade at the root.

Tracking a wood propeller on ship.

Clamp a stick on landing hear strut. Give the propeller a half turn. The blades are to touch the stick (allowed 1/16”). If out of track tighten up on the 4 bolts that is away from the stick. You can also use a shim of paper under the hub. You can also scrape off part of the boss on the side away from the stick. If the hub is removed it should be put back as it was removed or it should set at 11 o’clock, which is correct for compression.

Be sure to put cup grease between the hub and shaft. To fit a new prop hub on an engine shaft put valve grounding compound on the shaft and then put on propeller and turn it on the shaft, with the lock pin out.

Balancing a steel propeller (fixed pitch).

Drill a hole at the root of propeller about 3/8”, next to boss, right in center, and pound the hole full of lead. Another method is to file off a little bit of the tip. When inspecting a wood propeller examine for cracks and see if tips are loose. There are 6 tiny holes in metal tips to let the moisture escape. These should be kept open. Examine for open laminations. To find depth of a cracks use a thin instrument. If over 3/8” deep send to the factory to be repaired. You can fill cracks with glue and clamp tight. To make a balancing stand use tubing and angle iron for knife edges. A propeller should be tracked and inspected three or four times a year.

Wood used in Propellers.

Birch – To be used engine of not over 200 H.P.

Oak – ” ” ” ” ” ” ” 425 H.P.

Walnut – ” ” ” ” ” ” ” 120 H.P.

Mahogany – ” ” ” ” ” ” ” 120 H.P.

Cherry – ” ” ” ” ” ” ” 60 H.P.

Spruce – ” ” ” ” ” ” ” 35 H.P.

To Etch a metal Propeller.

Nitric acid solution. Put on the prop evenly to eliminate wavyness [sic]. Next wash in solution of costic [sic] soda and H2O. Then wash in H2O or vinegar. You are allowed three tiny cracks in a steel propeller. If they are just surface cracks etch again.

16.

Materials for Fuselages.

Ash – used for longerons; birch – used for vertical struts (takes compression); plywood.

Metals: Duraluminum; 1025; and chrome – molybdenum, it is used for motor mount, landing hear, and 1st and 2nd bays on the fuselage. The way to tell the difference between 1025 and chrome tubing is to hammer the ends. The 1025 will flatten out and the chrome will split.

Types of Fuselages.

1. Truss – both wood and metal, braced with wire and diagonal struts.
2. Veneer – all wood, 4 and sometimes 6 longerons. They begin at the nose 3/16” and get thinner at the tail, 1/16”. Fittings are made like gussets of 1025 metal (sheet). Plywood is glued and nailed on the fuselage.
3. Monocoque: (both wood and metal) Lockheed is all wood; Bull pup is all metal.

Necessary parts of a Fuselage.

Walking beam (control assembly under the floor boards), floor boards, control cables, tacking strips, fairing (turtle back, etc.) seats, instrument board (tape all the wires and tubes to the fuselage allowing play for vibration. Be sure olives are put in all connections). Put in throttle or throttles, stabilizer adjustments, wobble pump, fire wall, gas tanks, oil tank (front of the fire wall), covering, cowling, landing gear, safty [sic] belts, brackets for fire extinguisher and first aid kit, rubber insulators in fire wall for wires, etc. from instrument board.

Aligning Truss type of Fuselage.

Turn bottom side up and measure in equal distance (nose) on both lower longerons and from these points to the next compression stations. Then trammel (adjust the wires until the diagonal distances are the same). Measure to next compression stations and proceed as before, to the tail. After the bottom is squared, turn the fuselage right side up and align the sides. Get a large carpenters square. Find center of 1st vertical strut and draw line. Seat the square on top and down the line. Adjust the wires until the square centers on the line. Then take off the square and get small equal cubes and place over each compression station. Then stretch a string across the cubes. Then work from the square bay back, until the cubes touch the string.

Then come back and work from the squared bay to the front. Then do the other side.

Another method when you know the stagger: use a level, across horizontal strut, and drop a plumb bulb from the center of fitting and measure from string on bottom to center of next fitting and measure from string on bottom to center of next fitting. After both sides are aligned, square the tope over the bottom, place a level over the horizontal strut of each leg. After this trammel the top.

In the first method you also use a level and a plumb line to square up the fuselage.

17.

Aligning Steel Fuselages Slightly Warped.

First remove the tail surfaces. Then cut the fabric along the center of one lower longeron, from the front cockpit to the tail. Next cut the fabric along an upper longeron, the same way only diagonal to the bottom. Then pull the cover off and lay it back. Then check the bottom for trammel from the tail forward. If the bay is out of trammel, saw the diagonal strut next to the weld. Check the next bay, etc. up to the rear or front cockpit. If a bay is only out 1/8” let it alone. Next trammel the sides. Use a square along the longeron and down the 1st vertical strut. You can proceed thus, back to the tail. If a bay is out, saw the diagonal strut. Square the other side the same way. Then square the top over the bottom with a plumb bulb, or find the center of each horizontal strut and stretch a string from the cockpit to the tail. If a bay is out of line the diagonal strut. Now you are ready to align the fuselage and weld the struts that were sawed. Start on the bottom and work from the cockpit back to the tail. If the longerons are too close together, use a couple of 2 x 4’s and a hydraulic jack to square them. To pull longerons closer put a chain around them and tighten up, but be sure to put wood between the longerons and chain. To straighten a bent tubing cut out 2 x 4 and clamp over so the 2 x 4 rests on the compression station.

\*refer to page 17 of handwritten manuscript for small diagram

After you have the sawed places on the struts welded, leave the jack or chain on until the welds are cold. Align the whole fuselage and proceed in that manner. After the fuselage is aligned and all places are welded, paint the welds. Then try to put the old covering back on. Sew with baseball stitch, cover with pinked tape and dope the whole covering. On a wood fuselage the only place you are allowed to splice longerons is on the bay back of the rear cockpit.

Two types of Landing Gears

1. Truss
2. V shape type

To align a truss type, trammel it or square. The V type is aligned in the factory. You can check wheels on V type. If holes for fittings are too large, fill with bronze welding rod and drill over again.

Three kinds of splices on steel tubing are: Butt, fish mouth, and scarf splice. All have smaller steel tubes placed inside the splice and 3 small holes are drilled on each side of splice and these are welded. 3” is the space left on each side of the splice (the small tube on the inside).

\*refer to the flipside of page 17 of handwritten manuscript for small diagram

18.

Side View of Fuselage

\*refer to page 17 of handwritten manuscript for drawings – the following is to allow terms and components within manuscript to be searchable.

-Clamp

-Tail Post   
-Bottom

-Station No. 1

-Station No. 2

-Station No. 4

-Bay No. 1

-Bay No. 2

-Bay No. 4

-Motor Bed

-Adjust wires until upper longerons rest evenly on straight-edge

-Top

-Square

-Plumb line

-Table

-Cube of Straight-edge

-To align top of fuselage use a square at each station and adjust wires until top is square over bottom.

-To locate centers at top and bottom of each station level fuselage and drop plumb line. Adjust wires until plumb.

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19.

Bottom View

\*refer to page 19 of handwritten manuscript for drawings.

Bottom View

A B C D

Level

To trammel motor bed measure from A to B then C to D and adjust wired until both are equal

Square bottom by adjusting wires until measurements from A to B and from C to D are equal. Continue back for first three bays then locate center and adjust wires until all remaining centers are in line with stations first squared.

To level motor bed with fuselage level as shown above (\*refer to page 19). Adjust wires until motor bed is level with fuselage.

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20.

To rig a truss type landing gear measure from A to B then from C to D and adjust wires until both measurements are equal or locate center of bottom fuselage strut also spreader bar at bottom of landing gear and drop plumb line so that rides over the center line then adjust wires until the plumb line registers plumb over center line on spreader bar. Fuselage must be level to rig by plumb line method.

Searchable terms:

Axle

Wheel

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21.

Rigging—Definitions

1. Center of pressure of an airfoil or body exposed to the wind may be considered as the part or point where the resultant force or lift acts.
2. Lift to drag ratio – any airfoil projected through the air is subjected to two positive forces acting at right angles. (1) The lifting force acting up in a vertical plane. (2) The drag or resistance to its passage through the air acting in a horizontal plane. It is necessary to have lift greater than drag, and the greater the difference between the two the more effective the lifting ability of the plane becomes. The difference between these two forces is expressed as the lift to drag ratio.
3. Varble [sic] point – this is a condition of an airfoil which takes place at about 14 to 20º angle of attack; at this point a pronounced change takes place in the lift values. The lift being sharply reduced and the drag greatly increased. This sudden change of lift values is known as the varble [sic] point or critical angle.
4. Angle of attack: it is the acute angle between the chord of the wing and the direction of the relative wind.
5. Angle of incidence—it is the acute angle formed between the chord of an airfoil and the line of thrust.

1. Dihedral angle – the upward inclination of the wings toward their tips.
2. Longitudinal dihedral angle – it is the difference in the angles of incidence between the horizontal stabilizer and the main supporting plane.
3. Decalage – it is the difference between the angles of incidence in the wings of a biplane; positive when the lower wing has a greater angle than the upper.
4. Cathedral – It is the downward inclination of wigs toward their tips.
5. Aspect ratio – The ratio of the span to the mean chord of an airfoil.
6. Camber – The convexity of rise of the curve of an airfoil from its chord.
7. Stagger – The amount of leading edge of one wing advances over that of another. Positive when the upper wing is advanced.
8. Cabane – A permintal [sic] framework to which wires or cables are secured.
9. Gap – It is the distance or span between the wings of a biplane or triplane.
10. Wash – The disturbance in the air produced by the passage of an airfoil.
11. Wash-in: A perminant [sic] increase in the angle of attack near the tips of a wing.
12. Wash-out: A perminant [sic] decrease in the angle of attack near the wing tips.

22.

1. Wind Tunnel – It is the elongated chamber diverged at both ends through which a steady stream of air is either drawn or forced.
2. An airplane is a self-propelled vehicle designed to fly through the air carrying a crew and cargo.
3. A fuselage is the body of an airplane designed to carry and support passengers, crew, gas, oil, controls, wings, motor, landing gear and tail surfaces.
4. Airplanes are made of five things.
   * 1. Wings – to provide sustentation.
     2. Fuselage or hull – provides housing for the crew and cargo, etc.
     3. Engine and propeller unit – to maintain speed.
     4. Control surfaces.
     5. Landing gear.
5. Airplanes are classed by construction as: Land planes; sea planes; monoplane; biplane; triplane; pusher type; single, twin or multi motors.
6. Axis of an airplane: Longitudinal axis is the axis that runs from the nose to the tail about which the airplane rolls, and is controlled by the airplane by the ailerons. Lateral axis is the axis from wing tip to wing tip, and about which the airplane

pitches and is controlled by the elevators. Vertical axis is the axis that runs from the top to the bottom of the plane and about which the plane turns or yaws and is controlled by the ailerons.

1. The four external forces working on an airplane are:

(when in flight)

1. Lift
2. Gravity
3. Thrust
4. Drag
5. The four internal forces on an airplane in flight are:
6. Tension
7. Compression
8. Sheer
9. Torsion
10. Sweepback – the backward, angle or, inclination of the wings toward their tips.
11. The chord of a wing is the distance of a straight line from the leading to the trailing edge (width).

23.

Sight Method of Rigging an Airplane.

First step: Trammel the center section. Use a tape measure and measure the distance from the center of one clevis pin to the center of the opposite pin on the same wire. Then measure the distance between the other clevis pins; as before. These distances should be equal.

Second: Set the stagger in the center section. If you don’t know the stagger, take ½ the adjustment on the stagger struts.

Third: Set the dihedral in the wings. Measure the length of the front landing wires. If you don’t know what the dihedral should be, take 1/2 the adjustment.

Fourth: Set the angle of incidence: Sight across the bottom of lower wing. If low make adjustments with rear landing wires.

Fifth: Wash-in the left wing: Make a turn and a half or rear landing wire adjustment; if the propeller turns clockwise. If counter-clockwise, right wing.

Sixth: Set stagger in the wings. Sight the leading edges and make adjustments with rear and front flying wires.

Seventh: connect stagger struts.

Eighth: Properly tention [sic] wires – The landing wires should have more tension than the flying wires.

Ninth: Align ailerons – If the control is a push and pull operation; when the stick is in a neutral position, streamline the ailerons with the trailing edges of the wings. If the ship is controlled by cables, adjust the turnbuckles so the trailing edges of the ailerons is ¼” lower than the trailing edges of the wings.

Tenth: Horizontal stabilizer – sight front or rear spar of stabilizer with front upper interplane strut seat fittings, and make adjustments.

Eleventh: Vertical stabilizer – it is set 3/8” to the left if the propeller turns clockwise. The rudder is streamlined with the center of the fuselage. The elevators are streamlined with the horizontal stabilizers.

24.

Rigging an Airplane by Instrument.

First: Level the airplane lateral and longitudinally. For lat. use a level on the cross member in the front cockpit. For long. use a level on the longerons or motor bed. Thread the plumb line through the horizontal strut on top of fuselage, and drop plumb bob.

Second: Level center section – use a straight edge long enough to cover at least three ribs. Place it over the top of the front spar. Put the level on the straight edge and adjust the center section brace wires until the level registers level.

Three: Get the stagger in the center section. In order to rig by instrument you must have blue prints with specifications or you must know the stagger, angle of incidence, and dihedral, etc. Hang a plumb bob over the center section, next to the fuselage, and adjust stagger struts or wires until the stagger is correct. Measure from the string to the center of the leading edge of the lower wing.

Fourth: The dihedral on the wings – Place the straight edge on the front spar of the lower wing. Set your protractor to the correct dihedral you want, and place it on the straight edge. Then adjust the front landing wires until the level on the protractor registers level.

Fifth: Angle of incidence. – Take the straight edge and put underneath the wing at the butt and adjust the protractor so you will have the correct

25.

angle of incidence, (when you don’t know it). Then place the straight edge on the wing, underneath, by the interplane struts. Next put the protractor on the straight edge and adjust the rear landing wires until the level protractor registers level. You then have the correct angle of incidence. Repeat on the other wing.

Sixth: Wash-in the left wing if the propeller turns clockwise. About 3/16” or a turn and ½ on the rear landing wire adjustment.

Seventh: Put the stagger in the wings – Hang the plumb bob over the leading edge at the interplane struts then adjust the front and rear flying wires until you have the correct amount of stagger.

Eighth: Secure the stagger struts.

Ninth: Streamline or droop the ailerons as should be done, the same as in the sight method.

Tenth: Horizontal stabilizer – Lay the straight edge on the front or rear spar and place the level on the straight edge and then adjust the stabilizer brace wires until the level shows level.

The remaining control surfaces are rigged as in the right method.

Causes and Correction for Nose Heaviness

Not enough stagger: To correct this, first disconnect the stagger struts in the outer bay, slack off on all flying wires, and sometimes the center section wires. If the stagger struts are in front make them short. If they are in the middle, lengthen them. For ordinary heaviness make two turns on the adjustment. If very heavy, use your own judgment. You will then have to retrammel the center section, after you get the correct stagger. Also, proceed as in rigging the whole ship.

Another method is to increase the angles of incidence out toward the tips of the wings. Another method is to use weights to correct for nose or tail heaviness. Sand bags are used.

For wing heaviness: if the left wing is heavy, the right wing has too much lift; so, wash-out the right wing or wash-in the left wing or work on both wings is necessary.

For wing heaviness on a Ford, or full cantilever wing, use weights. On a Fokker cut out a section of plywood and put in weights.

If a ship is tail heavy decrease the stagger.

Empennage – the tail unit, which includes the horizontal stabilizer, elevators, vertical fin, and rudder.

Things that would cause vibration in an airplane beside the motor are:

1. The prop out of track or balance.
2. Internal brace wire loose or broken.
3. A broken longeron.
4. A broken or loose landing or flying wire.
5. A loose landing gear or parts of it.
6. A torn place in the fabric.
7. A broken or loose member brace wire in the wing.

Wing loading is the ratio of the total gross weight of an airplane, fully loaded, to the total square area of lifting surface of the wings.

Power loading is the ratio of the gross weight to the H.P. actually produced by the engine. Balanced control is when a portion of the control surface is situated in front of the control axis.

Center of pressure moved closer to the axis.

26.

Washington Navy Yard Wind Tunnel

A – Motor

B – Fan

C – Experiment chamber

D – Air Screen

E – Return Pipe

F – Observation floor and instruments

\*refer to page 26 of handwritten manuscript for top and side view of wind tunnel.

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27.

RIGGING INSTRUCTIONS

First: To level ship laterally and longitudinally—In the front cockpit there is a small hole drilled vertically through center of arched cross tube at top of fuselage. Thread plumb line through this hole. When bob point center is over center, punch mark in square tube below. The fuselage is level both ways. Second: Leave both adjustable stagger end struts disconnected until incidence and stagger are adjusted. Measure dihedral by using straight edge 10 ft. long. Place straight edge under side of lower wing at fuselage, parallel with front spar and level end at fuselage touching spar. Measure at outer end. Bring this measurement to 3 1/4” by adjusting front landing wire. Repeat on opposite wing. Third: Measure incidence of lower wings at fuselage as shown. Correct incidence at end struts by adjusting flying and rear landing wires. Fourth: Check stagger as shown and hook up stagger struts. Fifth: Tension drift wires.

Flying wires

Landing wires

Dihedral

Straight edge

Level

\*refer to page 27 of handwritten manuscript for front view of aircraft.

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28.

To check stagger when ship is level as shown.

Drop plumb line from leading edge of upper wing near side of ship. Then take level measurement from plumb line to leading edge of lower wing. Repeat out at end of wing near end of strut.

Plumb line

Stagger 11 11/16”

Plumb bob

Front hinge and spar center

Rear hinge and spar center

Incidence ¼”

SIDE VIEW OF EAGLEROCK LEVELED FOR RIGGING.

\*refer to page 28 of handwritten manuscript for left side view of aircraft.

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29.

Place one end of spirit level at center of lower edge of rear spar at side of fuselage. Bring to level with block at front spar as shown. Apply level in same way to wing at end strut. Bring to level by adjusting flying and rear landing wires.

Center of front spar

Block

Center of rear spar

Level

\*refer to page 29 of handwritten manuscript diagram of airfoil

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30.

Figure 1.

Vertical Component

Horizontal Component

Lift

Total Force

Drag

Direction of Motion

P – L is the cross-section of a plane or airfoil.

Figure 2.

Lift

Total Force

Drag

Line of thrust

V F R P L H

\*refer to page 30 of handwritten manuscript for diagrams.

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31.

Figure 3

9 units

21 units

30 units

Figure 4

Direction of Motion

Rarified Area

Figure 5

Chord (A)

Chord

\*refer to page 31 of handwritten manuscript for airfoil diagrams.

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32.

Figure 6.

Wing area = 150 square feet

Aspect ratio = 30’/5’ = 6.

\*refer to page 32 of handwritten manuscript for top view of aircraft.

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33.

Figure 7 and 15

Tractor Type Land Biplane

Thrust

Drag

Lift

Gravity

Figure 8

Direction of motion

Slip

Actual Distance

Designed Pitch

Actual Distance/Designed Pitch = Efficiency.

\*refer to page 33 of handwritten manuscript for diagrams.

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34.

Figure 9

Metal tip

a = blade length

b = maximum blade width

a/b = aspect ratio

Direction

Plane of rotation

x = maximum camber

y = minimum camber

x + y / 2 = mean camber

I=maximum camber

Figure 10

Top View

Longitudinal axis

Vertical axis appears as a point

Lateral axis

\*refer to page 34 of handwritten manuscript for diagrams.

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35.

Figure 10 continued

Side view

Lateral axis appears as a point

Longitudinal axis

Vertical axis

Front View

Lateral axis

Vertical axis

Longitudinal axis appears as a point

\*refer to page 35 of handwritten manuscript for diagrams.

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36.

Figure 11

Longitudinal axis

F

R

Direction of Horizontal Flight

Figure 12

Neutral “lift” line

Chord

Figure 13

V

R

F

H

C.P.

Figure 14

Point of application

10 ft.

1 ft.

100 lbs.

1000 lbs.

\*refer to page 36 of handwritten manuscript for diagrams.

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37.

Figure 16

Thrust

Weight

Lift

Drag

Common Center

Figure 18

Chord

Gap-chord ratio

Gap

90º

\*refer to page 37 of handwritten manuscript for diagrams.

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38.

Figure 17

Lift

Thrust

Drag

Gravity

Common Center

\*refer to page 38 of handwritten manuscript for diagrams.

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39.

Figure 19 and 26

Cabane Strut

Center Section Wing

Flying Wire

Strut

Landing wire

Bay or Panel

Overhang

Landing Gear Struts

Figure 20

Struts with diagonal stagger wires

Longitudinal axis (level)

Stagger

Struts with diagonal stagger strut.

\*refer to page 39 of handwritten manuscript for diagrams.

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40.

Figure 21

Chord line – angle of incidence 2º

Difference = Decalage – 3º

Longitudinal Axis (Level)

Chord line – angle of incidence 5º

This line parallel to upper chord line

Figure 22

Longitudinal Dihedral

Longitudinal Axis

Stabilizer Chord

Line 2º Incidence

Wing chord line 4º incidence

178º Parallel to Stabilizer Chord

\*refer to page 40 of handwritten manuscript for diagrams.

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41.

Figure 23

Sweepback in degrees or inches

Wing center tip.

Figure 28

* + - 1. High lift wing curve
      2. Speed wing curve
      3. Wing curve with both high lift and speed qualities

\*refer to page 41 of handwritten manuscript for diagrams.

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42.

Figure 24

Positive lateral dihedral

Angle 174º

3º

No dihedral lower wing

Figure 25

Wash-out: dotted line shows trailing edge raised

Wash-in: lower line shows trailing dropped

\*refer to page 41 of handwritten manuscript for diagrams.

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43.

Figure 27

Cabin type

Oleo or Pneumatic shock absorber on split type landing gear.

Cantilever wing type monoplane showing internal wing bracing. No External wing struts are used.

Cabin type

Strut

Externally braced wing type monoplane showing combination flying and landing tention [sic] and compression struts.

Open cockpit type

Strut

Low wing externally braced monoplane. Low wing monoplane type may also be of cantilever design.

\*refer to page 43 of handwritten manuscript for diagrams.

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44.

Figure 29

Balanced Aileron

Plain or unbalanced Aileron

Horizontal Stabilizer

Balanced Elevator

Unbalanced Elevator

Balanced rudder

Vertical Fin

Fuselage

Unbalanced Rudder

\*refer to page 44 of handwritten manuscript for diagrams.

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45.

Figure 29 Continued.

Top View – Rudder and Rudder Bar

Rudder Bar

Pivot

Stick

Fin

Rudder

Side View – Elevators and stick

Horizontal stabilizer

Elevator

End View – Looking Forward

Balance wire

Aileron

Left wing

Right wing

Sketch shows stick moved to left, raising left aileron to depress wing and lowering right aileron to raise wing.

\*refer to page 45 of handwritten manuscript for diagrams.

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46.

Society of Automotive Engineer’s Standard Deperdussin Control.

Depress Left Wing

Wing to Aileron

Wires to Elevators

Wires to Elevator

Depress Right Wing

Control wheel

Control Bridge

Down

Up

Steer left

Steer right

Rudder Bar

Ailerons

Elevators

Stabilizer

Wiring of cables for Deperdussin Control

Society of Automotive Engineer’s Standard Stick Control

Balancing control (ailerons)

Left side of machine down

Right side of machine down

To Elevator

To Aileron

To Rudder

View from pilot’s seat

Altitude control (elevators)

Down

Up

Right and Left Control

Right

Left

Side view

Plan View

Right and Left Control (rudder)

Control Devices as used on the Curtiss Model JN4B

\*refer to page 46 of handwritten manuscript for diagrams.

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46 – A

Questions given on the Airplane Mechanic Course – Weekly Exams.

1. Name all the metals you can used for the construction of an airplane and tell what each is used for.
2. Name and describe two kinds of splices used on control cables.
3. What is a thimble? Draw a diagram of a thimble.
4. Name all the wires you can, that are used on an airplane and tell what they are used for.
5. Name two kinds of steel tubing.
6. Who does the term airmen include?
7. What qualifications are necessary for an application for a mechanic’s license?
8. What is the duration of a mechanic’s license? Can a mechanic’s license be renewed? If so for how long?
9. Must a mechanic have this license in his personal possession at all times, and must he display it on demand?
10. For what reason can a mechanic’s license be suspended or revoked?
11. Can a mechanic hold a plurality of licenses?
12. Do all licensed aircraft carry markings? If so, where, and in what dimensions?
13. How may a license aircraft be told from an unlicensed plane?
14. How large, and where are the markings placed on an airplane?
15. How are government owned planes marked?
16. Name and describe two types of ribs.
17. Name and describe three types of wings.
18. Name eight kinds of wood used in the construction of planes.
19. Name eight kinds of spars and draw diagrams of each.
20. Name and describe two early flying machines.
21. Name three kinds of glue and describe the kind used the most.
22. What kinds of material would you pick for a spar?
23. Define critical angle and lift to drag ratio?

46 – B

Examination Questions (cont.)

1. What determines the power requirements of an airplane?
2. Define factor of safty [sic] and relative wind?
3. Draw a diagram of a scarf splice and give the desired ratio.
4. Define critical angle.
5. Define lift to drag ratio.
6. Define relative wind.
7. Define useful load.
8. Draw a diagram showing the pressure distribution on an airfoil at a high angle of incidence.
9. Define chord and camber of an airfoil.
10. Name and describe two types of ribs.
11. What determines the power requirements of an airplane?
12. Tell all you know about Casien [sic] glue.
13. Draw a diagram of a propeller and label the parts.
14. Define a propeller.
15. Name three types and three kinds of a propeller.
16. Explain in detail how to balance a propeller.
17. Explain in detail how to track a propeller. Draw diagram.
18. Define geometrical and effective pitch.
19. Is a three blade as efficient as a two blade propeller?
20. Define blade angle and disc area.
21. Name the kinds of woods and metals used in a propeller.
22. How would you inspect a propeller and what would you look for?
23. What effect has dope on fabric?
24. What materials are used for covering?
25. Explain in detail how you would cover a wing.
26. Give the specifications for cotton fabric.
27. Name the different methods of covering.
28. Name two kinds of dope used.
29. How many coats of dope should be applied to a covering job, and how should it be put on?

46 – C

Examination Questions (cont.)

1. Name and describe three types of fuselages.
2. Explain how you would align a steel fuselage of the truss design. Draw a diagram.
3. What materials are used in fuselage construction?
4. Give assembly of the fuselage.
5. How would you replace a broken member in a steel fuselage?
6. Name three kinds of splices used on steel tubing and draw diagrams of each.
7. Name two types of landing gears. Tell how to align one.
8. How would you make a field repair on a landing gear shock absorber?
9. What method is used to prevent rusting on the inside of a fuselage?
10. What is a fuselage?
11. Explain in detail how you would rig an airplane by the instrument method.
12. Name eight forces working on an airplane while in flight.
13. Name the axes of an airplane and tell how they are controlled.
14. Draw a diagram of all the control surfaces.
15. Define: decalage; angle of incidence; stagger; sweepback; and angle of attack.

46 – D

Final Examination Questions given on the Airplane Course.

1. Draw a diagram of a wing and give complete nomenclature. Tell how to trammel a wing.
2. Name and describe three types of wings.
3. Name and describe two types of ribs.
4. Name and draw diagrams of eight kinds of spars.
5. Name the woods and metals used in airplane construction.
6. Explain negative and positive pressure on an airfoil. Illustrate.
7. Name the axes of an airplane and tell how they are controlled.
8. What are eight forces working on an airplane when in flight?
9. What things most affect the speed of an airplane in flight?
10. (a) Define a thimble and draw diagram

(b) Define empennage.

1. What would you check most on a three place biplane? Why?
2. Name six things that would cause vibration in an airplane, eliminating the motor vibration.
3. Define: Decalage and give its advantage; wing loading; and power loading.
4. Explain in detail how you would cover a wing.
5. Explain how you would repair an L shaped tear in the fabric of a plane.
6. What is meant by balanced control? Illustrate. Of what use is the vertical fin?
7. What are the causes for nose heaviness; left wing heaviness; ground looping?
8. Define: center of pressure; center of gravity, lift to gravity ratio.
9. Define: lift; gravity; thrust; drag; & torque.
10. Rig an Airplane by the sight method.
11. How would you align a steel fuselage that was bent, or a member broken?
12. Define: a geometrical pitch; effective pitch; and blade angle.
13. Define: riggers angle of incidence; longitudinal dihedral; induced drag; and parasitic resistance.
14. Name and describe three types of fuselages.
15. How would you replace a broken member in a steel fuselage? How is steel fuselage treated to prevent rust?
16. Define: wash-in; wash-out; stagger; and lift strut.
17. How is the prop. pitch set in flying out a small field. Describe scarf splice.
18. Explain stability in detail.
19. Give the daily inspection of an airplane. How would you inspect a control cable?
20. Tell how to balance and track a propeller.

46 – E

Grades on the Airplane and Engine Mechanic Course

E – 100 to 97%

S – 97 to 85%

M – 85 to 75%

I – 75% —

Airplane Mechanic Course – Av. 91%

Wires and metals – I – 65%

Air Comerce [sic] Rules – S – 90%

Woods-work; defintions – S – 88%

Definitions; glue; etc. – S – 93%

Propellers – E – 100%

Covering and doping – E – 100%

Aligning fuselages – S – 93%

Riggings – E – 98%

Finals – S – (95%)

Engine Mechanic Course – Av. 97%

Curtiss OX 5 Engine – S – 90%

Hisso, Wright J-5, Kinner – S – 93%

Carburetors; Carburation – E – 100%

Complete Overhaul – E – 100%

Overhaul; trouble shooting – E – 100%

Finals – E – (97%)

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Notes on the Engine Mechanic Course

Arthur Fisher

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47.

Engines – Curtiss Ox5

An internal combustion engine; is an engine that creates its power within itself; an engine or mechanical device designed to convert the latent heat energy contained in fuel into mechanical work.

Stroke – The total distance a piston travels from top to bottom dead center.

Two stroke cycle principle is when a power impulse is imparted to the piston on every stroke away from the combustion chamber, or when there is a power stroke for every revolution of the crankshaft. 360º.

Four stroke cycle principle embodies four strokes or two complete revolutions of the crankshaft for each power impulse. Crankshaft turns 720º.

In order to being about strokes, consider action of the valve strokes.

Ox5 – Intake valve opens 10º before T.D.C.

” ” closes 60º after B.D.C.

10º + 180º + 60º = length of intake stroke.

Exhaust valve opens after 60º after B.D.C.

” ” closes after 10º after T.D.C.

60º + 180º + 10º = length of intake stroke.

Compression stroke (length) = 180º – 60º ; B.D.C

Power stroke (length) = 180º – 60º ; T.D.C

Power gap or power lap is the space between power impulses or an overlap of power impulses.

The types of engines are the X, V, W, vertical, radial (static and rotating). A cam is a surface, the contour points of which are an unequal distance from the center of rotation. Cams are used to operate the valves on internal combustion engines. A lobe operates each valve, at ½ the speed of the crankshaft. The crankshaft travels twice as fast as the camshaft. On a radial engine a cam-plate is used and one lobe operates all the valves. The firing order of an Ox5 is – 1, 2, 3, 4, 7, 8, 5, 6. A crankshaft is so designed so that exertion on it is distributed as evenly as possible.

Construction of Ox5

Ignition: One high tension, single spark, 8 cylinder mag. located at the top of crankcase and driven off timing gears at front. Spark plugs are located in the integral head of the cylinder on the upper side.

Carburetor: One duplex zenith, modle “OCDS.” Each intake supplies one bank of four cylinders through separate manifolds. Lower end of manifolds water jacketed. Auxiliary air intake in manifolds with hand control for altitude adjustment.

Lubrication: Pressure feed.

Water Circulation: Centrifugal pumped bolted to propeller end of crankcase and driven off end of crankshaft through coupling.

48.

Const. of Ox5 – continued.

Cylinders: Grey iron casting, each casting embodying one cylinder with valve chambers and valve stem guides cast intergal. Steel metal jackets brazed on. Outside of cylinder heavy nickle [sic]-plated to prevent rust.

Valves: Poppet type in head. Intake, nickel [sic] steel. Exhaust, tungsten steel.

Valve springs: Coil type; valve cages: valve seat direct in cylinder head casting.

Rocker arms: Exhaust, drop forgings, nickle [sic]-plated. Intake, cast aluminum; cam followers: plunger type, cast-hardened steel; guides: manganese bronze, bolted to case.

Camshaft: Steel, case-hardened. Hollow for oil system.

Camshaft bearings: Aluminum alloy castings.

Pistons: Al. alloy castings with deep ribs for cooling.

Piston pins: Chrome nickle [sic] steel, heat treated.

Connecting rods: Chrome vanadium steel forgings, “H” section machined all over and heat treated.

Connecting rod bearings: Bronze, backed, babbitt [sic] lined. Reamed for crankshaft. Secured by brass rivets.

Crankshaft: Heat-treated chrome nickle [sic] steel forging, finished all over and drilled hollow.

Four throw, five main bearings. All bearings ground. End of shaft, tapered and threaded for propeller hub.

Crankshaft bearings: Bronze backed, babbitt lined. Reaming of the bearings instead of hand-scraping the crankshaft and connecting-rod bearings eliminates the variations that are unavoidable when this is done by hand.

Thrust bearing: Large annular and thrust ball bearing mounted in extended rear end of crankcase.

Crankcase: Aluminum alloy casting with heavy deep ribbed decks. Six engine support arms. Lower half bolted on.

Timing gears: Spur type.

Magneto drive: Steel gear driven from camshaft gear at each end. Ball bearing mounted.

Flexible coupling to magneto shaft.

Water pump: Centrifugal type. Cast Al. housing.

Tachometer drive: Shaft gearing in aluminum housing bolted on face of timing gear housing. Dag drive off camshaft gearing.

Exhaust pipe: Steel tubes bolted to exhaust ports.

Water piping: Steel tubing, nickle [sic] plated.

Reinforced rubber hose connection with clamps.

Bolts, nuts, etc. and cotter pinned or lock-wired in series.

Lubrication System

Pressure feed: The oil is forced from lowest point of sump by gear pump to rear end of hollow crankshaft, through pressure adjusting valve, through camshaft to timing gears and all camshaft bearings, then through tubes to crankshaft bearings and through crankshaft throws to connecting-rod bearings. Gravity return to splash pan and oil reservoir. Oil pump is located at bottom of propeller end of crankcase, and is driven off crankshaft through bevel gear. Removable oil screen at lowest point of sump. Oil pressure from forty to sixty pounds at 1,400 r.p.m.

49.

Hispano – Suiza; Valve Timing.

First set all the tappets .078 at low point of cam. Use a timing disc. Find T.D.C. on #1 left piston, then set pointer to indicate T.D.C. Then demesh camshaft. Next rotate crankshaft until 10º past T.D.C. Rotate camshaft to a position to just close the exhaust valve and at the same time the intake starts to open. At this point mesh the camshaft gear and the left bank is timed. Check timing; place a thin sheet of paper under the intake and exhaust lobes. Turn the crankshaft slightly in direction of rotation and if the valves are timed correctly the paper under the intake will tighten and the paper under the exhaust will release at exactly 10º T.D.C. If the paper fails to do this until 20º late, change the mesh to one tooth. If out 10º change ½ turn in the vertical shaft. If out 4º change one key way; and 2º, two key ways. Then turn the crankshaft through 90º of rotation and no. 4 cylinder on the right bank should be 10º past T.D.C. Time the right bank the same as the left bank only use no. 4 cylinder instead of no. 1. Firing order; 1L; 4R; 2L; 3R; 4L; 1R; 3L; and 2R.

Ignition Timing: Set the breaker pts on the mag. .020” clearance with spark ball advanced. Check the bench timing of the magneto. Then place no. 1 left piston 20º 20’ before T.D.C. compression stroke. Then rotate the mag. until the breaker pts. are just open, firing no. 1 segiment [sic]. Check by placing at thin sheet

of paper between the breaker points. Install on the engine and mesh the gears. Then rotate the crankshaft in the direction of rotation and if the paper releases from the points at 20º 20’ before T.D.C. the ignition timing is correct. Repeat operation on no. 2 magneto.

Wiring for Ignition Timing.

Wiring order of mag. Firing order of cylinders.

1 ———————— 1L

2 ———————— 4R

3 ———————— 2L

4 ———————— 3R

5 ———————— 4L

6 ———————— 1R

7 ———————— 3L

8 ———————— 2R

Lubrication System of the Hisso.

The oil is pumped from the sump by a gear pump. It goes through a pipe running parallel with and below the crankshaft. It is forced up to the main bearings and enters the hollow crankshaft and from there to the connecting rod bearings. It is thrown up to the pistons as a spray. The oil gets to the hollow camshafts through verticle [sic] pipes in the front of the engine. It goes through the camshafts and down through the verticle [sic] shafts and back to the sump.

50.

Wright J-5 Valve Timing

Set the valve tappets on #1 cylinder at 60 thousandths at low point of cam, and all the other valves at 40 thousandths. Then find T.D.C. of #1 cylinder and set the pointer to point zero on the timing disc. Each mark is 5 thousandths so back off eight marks. Rotate the crankshaft in direction of rotation until the intake valve on #1 cylinder just starts to open then demesh the camshaft gear. Then rotate crankshaft to 8º before T.D.C. (by pointer on the timing disc). Mesh the gears. Rotate on past T.D.C. and exhaust valve should just close at 8º past T.D.C. If it doesn’t check keep turning crankshaft until exhaust does close. Notice the number of degrees it closes. If at 10º, go back until intake tightens and demesh the gears. Rotate the crankshaft to 9º before T.D.C. Then mesh the gears and check again. The exhaust should now close 9º after T.D.C. Then turn crankshaft through 2 complete revolutions and check as before. Also balance over this lobe.

Ignition: Set the breaker points at .012” (cyntila mag.). Rotate crankshaft in direction of rotation until 30º before T.D.C. compression stroke #1 cylinder. Bench time and test the magneto. Rotate mag. until points are just opening and firing #1 segiment [sic]. Install the magnetos on the engine and check the timing by placing a thing sheet of paper between the breaker points and the paper should release 30º before T.D.C.

Firing order: 1; 3; 5; 7; 9; 2; 4; 6; and 8.

Construction of a Wright J-5

It is a 9 cylinder radial air cooled static 4 cycle engine, with a bore of 4 ½” and a stroke 5 ½,” it develops 220 H.P. at 1800 r.p.m. It consists of the following: 4 crankcases and a nose plate. The main crankcase supports the following: One crankshaft which is of the single throw counter balanced type, supported on the rear general by a large roller bearing. The main crankshaft has internal induction passages cast in the case. This case also has mounting studs for the sumps, rear crankcase, cylinders, intermediate and front crankcases to the crankpin. To the crankpin is assembled the I beam master rod. Eight link rods are attached by means of 8 knuckle pins. The cylinders are two peaced [sic] conventional air-cooled construction, and are sealed by an aluminum piston which is attached to the link rod by a full floating wrist pin. The intermediate crankcase supports the forward end of the hollow crankshaft on a large ball or roller bearing; it also encloses the cam-plate which is a 4 lobe dial plate. The four lobes actuate the intake and exhaust valves through the means of 18 cam followers which are held

51.

Wright J-5

in a fixed position in this case. The front crankcase is bolted directly to the intermediate crankcase and contains the following: Mounting shelves for magnetos, hollow camshaft, cam-gears, timing gears and camshaft bearings, magneto drives and gears. It also supports the thrust bearing which is a large ball bearing. The more nose plate covers the thrust bearing and holding it in place, also oil regulator. The rear crankcase contains the starter gears, crankshaft master gear, tachometer (r.p.m.) drivers, oil pressure pumps, two scavenger pumps, bypass valve, oil filter screens, fuel pumps and their assembly. The engine uses stromberg [sic] 3 series carburation each series controls 3 cylinders. Through a separate set of internal and external induction passages. Fuel vapor from this carburetor is completely vaporized by the hot oil surrounding the inductor line on the oil sumps. The ignition system is dual, consisting of two scintilla hi-tension mags. And two spark plugs to each cylinder. Firing order is: 1; 3; 5; 7; 9; 2; 4; 6; and 8.

Lubrication System: It is a conventional dry sump system. Oil is circulated and regulated by means

of a one pressure pump; two scavenger pumps and a bypass valve. The valves are of the tulip type, salt cooled, and are seated on bronze seats and are held closed by three valve springs and are accuated [sic] by means of a conventional set of rocker arms; push rods; and cam followers which operate from their cam-plate which is driven by the camshaft which in turn is geared to the crankshaft.

Lubrication of the Wright J-5

The oil is drawn from the bottom of the tank by a pressure pump and forced through passage to double oil screen, (bypass valve is located here), on through to the groove around the rear crankshaft bearing at which point it enters the hollow crankshaft. It is then forced to the connecting rod or master rod crankpin bearing, to cam bearing and camshaft, and also to the magneto shaft drive bearings. The spray from the crankshaft throw is utilized by the pistons and the spray from the other parts is used by the gears, valve tappets and crankshaft bearings. Holes through connecting-rods let oil pass to knuckle pins and their bearings. The oil then drops back to the sumps and is pumped from there back to the oil tank.

52.

Principle of Lubrication

The chief principle of lubrication is to reduce friction and wear by the keeping apart of two moving surfaces through use of a good grade of mineral oil. This oil must have a high flash point, and an exceptional viscosity. Flash point is the minimum temperature at which that oil will give off vapor in sufficient quantity to burn continuously. Viscosity is the density or mass of a liquid and is measured by the length of time required for a given amount to pass through a certain sized hole at a given temperature. Sludge is a collection of foreign matter such as water and dust particles in the air and in some cases thin oil due to over-priming of the engine or improper vaporization of the fuel. This mixture is whipped into a sort of foam which tends to clog oil lines, filter screens, and internal passages. The oil in an engine should be drained every 20 hrs. or oftener. The desired temperature of oil is from 140º to 160º. The minimum safe temperature is 120º. The maximum safe temperature is 180º.

A wet sump engine has oil in a crankcase. A dry sump engine has oil contained in an external tank. Oil is pumped to the engines under pressure by a pressure pump and is returned to the tank by a scavenger pump.

53.

Fuel Systems

The three systems used are gravity, pressure, and a combination of each. The gravity system is most used.

Gravity system

Carburetor

Cowling

Carburetor drain

Flexible connection

Filter

Gas Tank

Shut-off valve

Off/On

\*refer to page 53 of handwritten manuscript for diagram.

Always test tank for leakage, see that all connections leading from tank are firm and properly soldered. Thoroughly clean the tank. On making connections metal olives should be slipped over the ends of the line and sweated to this line (shrinking). The coupling should then be drawn up to a uniform tension thus avoiding air leaks. Use heat treatment on copper tubing before and after bending. Never use hand drawn copper tubing. The minimum bend permitted is a 6 to 1 ratio, measured on the inside of the bend. Never use tubing badly scored. Make all bends as neat as possible. All long extensions or connections of fuel lines must be braced by using

a rubber hose around the tubing and clamping in place. All holes through the fire wall must be lined with rubber grommets. A gas filter will be connected as close to the carburetor as possible. A shut off valve controlled from the cockpit shall be connected between the gas tank and the carburetor and placed as near the carburetor as possible. A flexible connection of the following description must be located between the carburetor and the filter and be as close to the carburetor as construction will permit. This connection shall consist of a gas resisting hose which must be slipped evenly over the ends of the copper fuel pipe with a metal hose liner. Connect the two ends of the copper line.

All gas systems must have a carburetor drain leading from the lowest part of the carburetor to the outside of the cowling. There must also be an extension leading from the main air intake to the outside of the cowling.

54.

Engine Instruments

They are the tachometer, oil pressure gauge, oil temperature gauge and the ignition switch. The tachometer is an instrument for registering the r.p.m. It works on the following principle. A small governor is held apart by a spring, this governor is driven by a tachometer drive connected to the engine; as the engine speed increases this governor tends to shorten up and a lever connected to this governor and working through a system of gears, and a small clock spring causes a needle to swing over a card graduated in hundredths, thus registering the r.p.m. of the motor. The purpose of the oil temperature gauge is to register the temp. of the oil. The oil pressure gauge registers the pressure (in lbs.) exerted by the oil pump, (system throughout). They are safety instruments.

The ignition switch controls the right and left magnetos. When the switch is in the off position the primary circuit in the magnetos is grounded and when it is in on position the circuit is broken thereby permitting the magnetos to function.

Kinner Airplane Engine

Description: Model K-5 is a 5 cylinder static radial air cooled four-cycle engine. Rated at 100 H.P. by the U.S. Dept. of Commerce, and manufactured under approved Type Certificate No. 3. Less prop. hub and accessories, and dry, the engine weighs 275 lbs., minus and plus 5 lbs. The bore is 4 ½” and the stroke 5 ¼” making the total piston displacement 372 cu. in. The compression ratio = 5.0 to 1. The front of the engine is clear of all obstructions. All accessories and push rods have been placed at the rear of the engine. The front crankcase cover is streamlined. In consequence, the engine can be very effectively cowled [sic].

Lubrication: the conventional pressure lubrication with dry sump is used. The pump is of the two unit type. The pressure pump forces oil through the crankshaft from the front main bearing to the rear and out by an oil pressure relief valve located on the rear cover. The scavenger pump is entirely separate, eliminating the possibility of air destroying the pump capacity. This pump drains the sumps and returns the oil to the supply tank. The two main bearings and the master rod bearing are pressure fed, while the remainder of the mechanism is lubricated by splash thrown from the crankshaft.

Pressure gauge

Temp. gauge

Bypass valve.

Sump

Oil

Scavenger pump

Gear pump from tank

\*refer to the flipside of page 54 of handwritten manuscript for diagram.

55.

Carburetors and Carburetion

A carburetor is a mechanical device designed for mixing air and fuel in the proper proportion to from a combustional [sic] mixture at all engine speeds. The combustitional [sic] mixtures are the following: Extreme rich – 8 parts air to 1 of gas; rich – 11 to 1; running mixture – 14 to 1; lean – 16 to 1; and extremely lean 18 to 1. A rich mixture is indicated by the engine belching black smoke at the exhaust ports and long yellow flame with red tips. This mixture causes uneven running and overheating of the engine. When cut down to a running mixture a steady blue flame issues from the exhaust ports and no smoke. A lean mixture is indicated by a short irregular blue flame and also causes over-heating of the engine. The gas level in a Zenith carburetor should be 1 9/64” from the top of the float chamber or 5/64” from the top of the main jet. The venturi tube is placed in the throat of the carburetor surrounding the tip of the main jet. It causes a restriction of the passage thereby compressing the air about the tip of the main jet, creating

a greater suction. The purpose of the compensator is to give a correct mixture at all engine speeds, through the cooperation of a compensator jet, and the main jet. Example: At low speeds the main jet tends to give a lean mixture and the compensator a rich mixture at high speeds; this condition is reversed; therefore one growing richer and the other leaner compensate the mixture at all engine speeds. There are three types of altitude controls: Air-port, needle value, and back suction types.

Air at sea level is about 15 lbs. per square inch; and at 20,000 feet altitude it is reduced to about one half. Therefore the gas mixture becomes rich. The purpose of the altitude control is to permit more air to be mixed with the gas or to reduce the flow of the gas, then the mixture will remain the same at all engine speeds.

56.

Carburetors (continued)

A plain jet at low speeds tends to give a lean mixture which will cause uneven running, overheating and hard starting due to suction not being sufficient to raise gas in the proper proportions for a correct mixture; as engine speeds increase the suction increases until at full throttle results in a very rich mixture which would result in a sluggish motor, overheating, and the engine belching black smoke at the exhaust ports; at low speeds a slightly richer mixture is desired which at high speeds a leaner mixture can be used. These results are brought about by the compensator. This jet in some cases is the idling jet and uses a constant flow device and works under atmospheric pressure.

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57.

Cross – section of Zenith Carburetor

1. Butterfly valve
2. Venturi tube
3. Choke valve
4. Cap jet
5. Main jet
6. Air intake
7. Screws to clean channels
8. Jet drain cups
9. Secondary well
10. Primary well
11. Idle adjusting screw
12. Idle tube
13. Air hole
14. Compensator
15. Hollow float
16. Float chamber
17. Counter weights
18. Needle valve
19. Needle valve seat
20. Gasoline line
21. Fuel level
22. Strainer
23. Altitude control valve

\*refer to the flipside of page 57 of handwritten manuscript for diagram.

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58.

Cross – Section of Stromberg Carburetor

1. Butterfly valve
2. Venturi tube
3. Main air bleed
4. Butterfly valve shaft
5. Main discharge nozzle or jet.
6. Air intake
7. Screws to clean channel
8. Jet drain cup
9. Main metering jet
10. Idling tube
11. Idle adjusting screw
12. Idling discharge jet
13. Idling air bleed
14. Idling metering jet
15. Hollow float
16. Float chamber
17. Float fulcrum pin
18. Needle valve
19. Needle valve seat
20. Gasoline line
21. Fuel level
22. Strainer
23. Altitude control valve

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59.

Trouble Shooting:

Trouble in an engine is either local or general. When local, one cylinder or one particular part of the engine isn’t operating right. When general, something affects the entire engine such as magneto not functioning, lack of fuel, or stoppage of fuel lines.

Ignition system: Meaning of ignition in the igniting of compressed fuel vapor in the combustion chamber. Two types of ignition systems used are: Make and break system and jump spark system. The make and break system is seldom used. It consists of a taper shaped block or screw extending in the cylinder walls into the combustion chamber. Through this block extended one movable electrode and one immovable which was insulated from the block by mica washers. The moving of this electrode caused the separating of the electrodes within the combustion chamber thus creating a spark. Then the jump spark system came into use. The principle of this

system is the arcing of a high tension current across the electrodes, held in a fixed position in the combustion chamber, known as the spark plug.

Magnetos: There are two types of high tension magnetos; the induction type of which the scintilla an example, and the armature type of which the Berling and Bosch are examples. The operation of the induction type makes use of a rotating bell magnet, that rotates between laminated poll shoes. The rotating bell magnet causes the current to flow through the laminated poll shoes of the primary circuit. This current starts to flow the instant the polls of the magneto form an angle with poll shoes. This current continues to build up until the polls in the magneto approach a verticle [sic] position. Slightly before this position is reached the current is at its maximum intensity. This results in a large amount of magnetism being stored up in the primary coil. At this point the breaker points are

60.

Trouble Shooting (cont.)

timed to open. This results in a rapid collapse of this low tension alternating current of about nine volts. By induction this current enters the secondary of high tension coil, where it is stepped up to a high tension current of from twenty to twenty-five thousand volts, through a great number of fine wires in the secondary coil. This current continues through the high tension loads, through the distribution block; from there through the high tension leads to the spark plugs, where it is released in the form of a hot spark across the spark plug electrodes thus igniting the fuel vapor in the combustion chamber. A device called a condenser is shunted across the breaker points. This condenser stores up a back pressure from the primary of about 40 volts, thus preventing vilent [sic] sparking of the breaker points which would greatly reduce the voltage delivered by the secondary coil due to considerable

less voltage being induced into that circuit. A device called a safty [sic] gap which has a 20% greater resistance than the spark plug gap is connected to a ground near the high tension lead. The safty [sic] gap prevents the secondary coil from burning out in the event of a short circuit. The alternating current of the primary is produced by the number of times the magnetic polls reverse their position per minute. Every time these polls reverse their position, the direction of flow through the primary changes its direction, thus creating another firing impulse. This current is designated as A.C. An alternating current is electricity whose direction of flow changes. Direct current is an example of dinamic [sic] electricity, whose direction of flow remains constant (storage battery). Dinamic [sic] electricity is that form of electricity that flows through a conductor. Static electricity appears on the surface of a body as a change.

61.

Ignition System

Induction type magneto

Primary Coil

Secondary coil

Distributor

Spark Plugs

Safety gap

Grounds

Bell magnet

Breaker points

Condenser

Switch

\*refer to page 61 of handwritten manuscript for diagram.

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Armature type of magneto.

On the armature type the coils rotate instead of the magnet. The coils are wrapped on a rotating armature, and rotate within the field of the permanent horse shoe magnets. The remaining operations of the magneto is much the same as the induction type magneto, that was explained before.

Armature type magneto – Ignition.

Primary coil

Secondary coil

Distributor

Horse shoe magnet

Switch

Condenser

Grounds

Breaker points

Safety gap

Spark plugs

\*refer to page of 62 handwritten manuscript for diagram.

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63.

Engine General Overhaul

At the end of every 300 or 350 hours of operation, an engine should be disassembled. All parts should be carefully inspected as to a certain working condition, stating repair and general clearances of parts. The first thing to do is to disengage all plumbing and drain the oil. Then disconnect all lines and connections leading to the engine. Put a sling around the engine raise slightly. Remove mounting lugs and place engine on inspection stand. Then thoroughly wash all the outside of the engine, with air pressure gun and gasoline. Then disassemble the engine according to the manufacturer’s specifications. As you a remove a part, thoroughly clean it and place on the inspection stand. First overhaul the crankcase; examine for cracks, scores, and flaws. Check all the stud bolts and see that they are not stripped, if they are replace with oversized studs. Examine the bearing supports.

Next overhaul the crankshaft. Examine for cranks, scores, flat places, and also check for balance and alignment. Check for flat places with a micrometer. Take measurements in four different positions or places. In checking for alignment lay the crankshaft in its bed and note the marking up in the bearings. Check for balance by laying it on knife edges. Check the crankshaft master gear, by examining for cracks, chipped for scored teeth. Check for proper clearences [sic] between the master gear and camshaft gear, with a feeler guage [sic], which should not be less than .005” clearence. Next check the gears for trueness. Check the crankshaft thrust bearing; examine its general condition and end play which should be .012.” Overhaul the link rods; examine their general condition and check the rods for alignment and see if they are worn, bent, or sprung out of line. Then check the bearings, the main and connecting rod bearings, as to their condition,

64.

Engine Overhaul (cont.)

alignment and clearance. The diametrical clearance should be .002.” See that side clearance [sic] is correct. Specifications about .012.” Next overhaul the pistons. Check the general conditions and state of repair of piston. Remove all small scores with an oil stone. If a piston is out of round over .005,” discard it. Check the clearences [sic] between the piston and wrist pin; you should be able to push the pin out when cold. Check the piston for proper clearance in the cylinder, to the manufactors [sic] desired clearances. Usually .015” at the skirt, and .020” at the head. Then replace with new rings with a gap clearance .0025” to .003” per inch of cylinder bore. The side clearance of the ring should be checked; clearences – .0015;” .0025;” 0.003.” Overhaul of cylinders. Check the general condition of the cylinders. Small scores can be removed by honing. Examine the cylinders

close for cracks, especially around the mounting lugs. Examine the cylinder head for cracks and scores. Deep scores result in cracks. See that the cylinder is firmly seated on the crankcase. Cranks and scores are more likely to occur around value guides and spark plug inserts. Overhaul of value guides and spark plug inserts; if loose replace with oversized guides or inserts. If they are worn, and the clearance is over .004,” they should be replaced with new guides. The desired clearance is .0015.” To remove value guides or spark plug inserts from an aluminum head, heat around the guide or insert with a torch to a point where soft solder will melt. When at this temperature, force out the old guide, as the metal will be expanded to its full extent. Keep the metal at this same temperature and put in the new guides.

65.

Engine Overhaul (cont.)

Overhaul of valves and valve seats. Examine the general condition of the valve seats. If badly pitted or worn, they should be replaced. Examine the general condition of the valve; see that it is not warped, scored, cracked, or pitted. Lap the valve end with compound, until a uniform seat of not less than 5/32” wide is obtained. Be careful in grinding valves, that they are not ground to a wire edge. Such a valve should be replaced with an oversized valve, or both a new valve and new valve seat. Overhaul of rocker arm assembly. Examine the condition of the valve springs. Replace all loose or broken springs. Examine the tappet rollers, and if they are out of round over .003,” replace with new ones, or true the old ones up. Rebush [sic] the rocker arms if necessary, and bring the side clearances to the

manufactureror’s [sic] desired clearance. Check the rocker arms for alignment. Examine the condition of the push rods, and see if they are straight or not worn off on the ends. Next, overhaul of the camshaft and cam followers. Check the camshaft bearings. They should have .0015” diametrical clearance. Check the end play. Examine the cam lobes for flat places, if worn over 1/64,” replace with a new camshaft. End play in the camshaft should not be over .015” (desired clearance - .010”). Examine the camshaft for alignment for alignment. The keyway in the camshaft should be examined carefully, because it has a great tendency to ware [sic]. Examine the camshaft gears for cracks, scores, chipped or broken teeth, and also for alignment and track. Check the general condition of the cam followers, and if they

66.

Engine Overhaul (cont.)

are worn they should be replaced. Next is the overhaul of the lubrication system. Thoroughly was and clean the oil pump. Check the condition of the gaskets and all machined parts or surfaces. Examine the gears and shafts for excessive ware [sic], cracks, or scores. If the gears are damaged, replace with new ones. See that the side clearence [sic] is not less than .001” or over .0025.” End play is the same clearence [sic]. The clearence [sic] in the bearings are also the same. Examine the case for cracks, scores, and also the condition of all stud bolts. Next examine the bypass valve. First check the tention [sic] of the spring. Replace if necessary. Examine the condition of the valve. Next check the filter screen and see if it is clean, and that there are no leaks. Inspect especially and closely around the screens.

Overhaul of ignition system. Check the general condition of the magnetos. Examine the condition of the ball bearings and the bearing race. Check the end play of the rotar [sic]. The end play should not exceed .0015.” See that the operation of the rotar [sic] is free. Polish all segiments [sic] with sandpaper. The clearance between the segiments [sic] should be .002.” Remove and clean the distribution pencil and file the ends smoothe [sic]. Thoroughly clean the integral parts of the magneto. Then check the cam for uneven ware [sic]. Next clean and file the breaker points smoothe [sic], and be sure they seat together squarely. Check the breaker box throughout. Then replace with new spark plugs and new ignition cable if necessary. Then bench time and test the magnetos. If the condenser shows any sign of weakness, replace with a new one.

67.

Engine Overhaul (cont.)

Also recharge the magnets if weak. Next overhaul the carburetion system. Check the mechanical condition of the carburetor, and thoroughly clean it. Remove and inspect all jets. Trace all passages and see that they are clean. Examine the economizer jet for ware [sic]. Examine the spring and the condition of the valve and accelerating pumps. Examine the condition of the needle valve and the altitude mixture control. This valve tends to ware [ware] uneven and causes an uncorrect [sic] mixture. Examine the needle valve seat, float, and float chamber. Check the fuel level in the carburetor. Check the air bleede [sic] adjustments. Replace with new gaskets throughout. Clean the filter screens and see that connections are tight.

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68.

Summary of Fits and Clearances

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Min. | Desired. | Max. | Replace |
| 1. | Breaker gap in Sc. Mag. PN 5D | .012 | — | .015 | .016 |
| 2. | Camshaft diam. clearance in boss | .003 | .0035 | .004 | .007 |
| 3. | Camshaft end play | .010 | .015 | .020 | .025 |
| 4. | Camshaft diam. clearance. M. bearings. | .00175 | — | .002 | .003 |
| 5. | Crankshaft end play | .010 | .012 | .014 | .025 |
| 6. | Master rod bearings on crank pin | .0018 | .002 | .0022 | .004 |
| 7. | Master rod end play on crank pin | .008 | .010 | .012 | .020 |
| 8. | Mag. drive shaft diam. clearance | .003 | .0035 | .004 | .007 |
| 9. | Magneto shaft end play | .011 | .015 | .020 | .030 |
| 10. | Oil retaining ring | Light press fit on crankshaft | | | |
| 11. | Oil pump drive shaft diam. clearance in body | .0015 | .002 | .003 | .004 |
| 12. | Oil pump drive shaft diametrical clearance in cover | .0015 | .007 | .003 | .004 |
| 13. | Oil pump drive gears diametrical clearance in body | .001 | .003 | .005 | .006 |
| 14. | Oil pump gears end play | .001 | .002 | .0035 | .005 |
| 15. | Oil pump gears diametrical on idler shaft | .0012 | .0015 | .0027 | .004 |
| 16. | Piston ring gap | .012 | .012 | .015 | .025 |
| 17. | Piston ring in groove NO. 1 top (side play) | .003 | .0035 | .004 | .006 |
| 18. | Piston ring in groove NO. 2 top (side play) | .002 | .0025 | .0025 | .005 |
| 19. | Piston ring in groove NO. 3 top (side play) | .002 | .002 | .0025 | .004 |
| 20. | Piston ring in groove NO. 4 top oil scavenger (side play) | .001 | .0015 | .002 | .004 |
| 21. | Piston pin in piston | Push fit at 68 ºF | | | .002 |
| 22. | Piston in cylinder on skirt | .020 | — | .025 | .030 |
| 23. | Piston in cylinder at top | .0345 | — | .0375 | .043 |
| 24. | Piston in cylinder | Replace if over .005 out of round | | | |
| 25. | Propeller hub diametrical clearance | Bearing 1 ¼” on big end, no bearing on small end. | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Min. | Desired | Max. | Replace |
| 26. | Key fit in hub | Fit | .001 L | .002 L | .003 L |
| 27. | Key fit in shaft | Light press fit. | | | |
| 28. | Link rod on lock pins forced feed | .0008 | .001 | .0012 | .0025 |
| 29. | Link rod side play force feed | .006 | .0075 | .009 | .020 |
| 30. | Link rod on piston pin | .0008 | .001 | .0012 | .003 |
| 31. | Link rod on lock pins splash feed | .0015 | .002 | .0025 | .0035 |
| 32. | Link rod side play splash feed | .012 | .018 | .024 | — |
| 33. | Spark plug B.G. type gap | .014 | .015 | .016 | — |
| 34. | Tappet roller on axles | .0015 | .0017 | .002 | .004 |
| 35. | Tappet roller side play | .005 | .007 | .008 | .012 |
| 36. | Tappet in tappet guide | .0032 | .004 | .0048 | .008 |
| 37. | Rocker arm axle in bushing | .0015 | .0015 | .002 | .006 |
| 38. | Rocker arm side play | .010 | .012 | .014 | .030 |
| 39. | Tappet clearance at valve-cold engine (68 ºF) | .020 | — | — | — |
| 40. | Valve dimensional clearance, exhaust | .0025 | .003 | .004 | .010 |
| 41. | Valve diametrical clearance, intake | .0025 | .003 | .004 | .010 |
| 42. | Lock pins in master rod | .0002 T | .0003 T | .0004 T | — |

These fits and clearances are for the Kinner K-5 engine but they can be safely used on many other engines.

69.

Questions and Answers – Trouble Shooting.

1. Name three causes for loss of oil pressure.
2. Improper installation of plumbing, causing air leaks. Excessive vibrations causes loose connections.
3. Clogged filter screen or internal passages, due to sludge.
4. Bypass valve sticking over due to improper tention [sic] of spring or foreign matter under the seat.
5. If an engine started missing on one cylinder where would you look for the trouble?

Fouled spark plug, short circuited conductor, loose terminal, dirty segiment [sic], or loose spark plug, air leak around valve seat, or a blown intake manifold gasket.

1. What would cause a magneto to cease functioning?

Wire leading from magneto to switch shorted. Breaker points becoming fouled or pitted. Condenser developing a short circuit. Secondary coil shorted. Breaker point main spring breaks, causing

points to fail to open or close. Distributor pencil breaking.

1. How would a leak in the intake manifold affect the running of the engine?

At low speeds it causes the engine to cut out and run irregularly. At high speeds it causes violent overheating due to the extreme lean mixture.

1. Is a magneto grounded when the switch is off or on?

The magneto is grounded when the switch is off, providing all the connections are made correct.

1. What are the advantages of air cooling and what are the advantages of water cooling?

Air cooling is mainly compactness, simplicity of design and lighter weight per horse power. The advantages of water cooling is that it is easier to streamline, a more even cylinder temperature, and better visibility for the pilot. New types of motors being designed are bringing better visibility for the pilot.

]

70.

Questions (cont.)

1. What is the safe temperature for water in a water cooled engine?

A safe temperature is 180 ºF

1. How often should the oil be changed in an aviation engine?

Every 20 hours of running or oftener.

1. Name five reasons for the engine to vibrate.
2. Irregular running of the engine is due to any one of the following.
3. Spark plug trouble.
4. Warped valves, valves holding open causing air leaks and air compression.
5. Air leaks in the induction lines.
6. Breaker points out of adjustment.
7. Fly wheel out of balance or out of track.
8. Loose or tight bearings
9. Uneven compression
10. Engine loose in bed
11. What would result in a defective spark plug in a double ignition engine? (Such as the Kinner, etc.)

A slight loss of revolutions per minute and a small amount of vibration.

1. What would cause an engine to continue to run after the switch had been cut off?

Engine overheating due to too lean a mixture. Improper cooling; running on retarted [sic] spark; or excessive carbon deposits, thus causing the engine to pre-ignite due to blowing carbon, or to extreme heat which is increased on the compression stroke. The ground wire being disconnected.

1. In cold weather what could be done to oil tanks and lines?

They should be thoroughly cleaned and, then padded with asbestos to retain heat and keep the oil at the proper temperature.

1. What inspection would a careful pilot make on his engine prior to flight? Check the compression on all of the cylinders. See that spark plug wires are saftyed [sic]. See that all filter screens are clean. Examine the connections of all the plumbing. Drain the wells of the carburetors, then run the engine thoroughly, and

71.

Questions (cont.)

examine the working condition of all the instruments. Check the oil pressure and temperature. Check the r.p.m. on both magnetoes [sic], and see that all throttle connections are O.K.

1. Why do must radial engines with the cylinders in one place have an odd number of cylinders?

It is thus arranged to have an even number of firing impulses with simplicity of design. Such engines use a single throw crankshaft which tends to give compactness and lighter weight.

1. Give two causes for free ignition.
2. In blowing carbon.
3. Extremely hot running engine.
4. What would happen if the float in the carburetor leaks?

Causes continued flooding of the carburetor. The engine would belch black smoke, lose revolutions, overheat and run irregular.

1. What would happen if the breaker points on the magneto are set too close together?

The engine would run at low

speeds but cut out at high speeds. If extremely close the engine would cut out also at moderate speeds.

1. What would probably result if you “took off” before properly warming an engine?

The engine would tend to load up, cut out and run irregular. It would probably cut out altogether. This condition would be due to improper vaporization of the fuel, and improper combustion of the fuel results in a forced landing or a very dangerous “take off.”

1. How is oil pressure regulated?

By a bypass valve with the assistance of the pressure pump.

1. How are the following indicated: Rich and lean mixture and too much oil?

A rich mixture is indicated by black smoke and a yellow flame coming from the exhaust ports. A lean mixture is indicated by a short irregular blue flame and the engine overheating. If there is excessive oil in the engine, blue smoke issues from the exhaust ports.

72.

Questions (cont.)

1. What precautions would you take in starting an engine in freezing weather?

The oil should be drained and heated, then refill in the engine. The engine should then be turned over several times to thoroughly circulate the oil. Then prime the engine, being careful not over-prime, because this would wash the oil off the cylinder walls, causing loss of compression and would probably score the parts.

1. What are the results of breaker points being set too wide?

Hard or impossible to start, and cutting out at both low and high speeds. More noticable [sic] at low speeds.

1. Name the engine instruments and explain their use.

The tachometer – r.p.m. of the engine. Oil pressure and temperature gauges. Fuel level indicator – amt. of fuel in tank. Ignition switch – to ground and break the magneto circuit.

1. How would you track a prop?

By clamping a straight edge to the airplane, extending out past the tips of the propeller. Pencil both tips of the prop, and move first one blade, then the other, over the straight edge. If the propeller is in track, there will be one narrow line on the straight edge. If it is out of track, tighten the bolts on the high side and shim the lower until it tracks OK. 1/16 of an inch is considered tracked.

1. How would you locate a defective spark plug on an engine? Name the engine.

Kinner – Start the engine. Check first on the right and then on the left magnetoes [sic]. Locate the missing cylinder and replace the old spark plug, with a new one, connected to that magneto. The engine should then run OK, providing everything else is operating properly.

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Questions (Cont.)

1. Name four or more reasons for an air cooled motor to overheat, providing the lubrication system is functioning properly.
2. Spark retarded.
3. Mixture too lean.
4. Mixture too rich.
5. Bearings too right or excessive friction due to improper clearance.
6. Irregular operation of the engine, causing it to labor.
7. Explain the use of the altitude control adjustment and what are its advantages?

It is used to lean off the naturally enriching mixture, and due to the fact that a lesser volume of air is drawn in the carburetor at high altitudes. At 20,000 ft. air weighs about ½ what it does at sea level. The advantage of it, with the control leading from the pilot’s cockpit to the carburetor, the pilot can, at will, lean off a rich mixture by opening this control,

or he can make a lean mixture rich by closing the control. The chief advantage, however, is the maintaining of a proper running engine at high altitudes.

1. Describe the function of the carburetor, and tell what determines the flow of gasoline.

The function of the carburetor is to mix fuel and air in the proper proportions to form a combustional [sic] mixture at all engine speeds. The flow of gas is determined by a float operating a needle valve in the intake opening.

1. Explain how to start and warm up an aircraft engine. Name the engine. –Kinner.

First see that the switch is off. Next throw the propeller through a number of times to clear the engine. Then crank the throttle several times to prime. Then throw the propeller through several revolutions to drain the prime into the cylinders. Be careful

Questions (cont.)

not to over prime. Set the throttle about 1/8 open. See that everything is clear of the prop. and give the signals. When ready the mechanic calls “contact,” steps forward in position and swings the prop. through and steps clear. On starting the operator sets the throttle to about 800-900 r.p.m. until the engine is thoroughly warmed up; as indicated by the temperature gauge. He also sees that the oil pressure is normal. After the temperature reaches 120º he gradually opens the throttle until full throttle is reached. Run the engine for 2 or 3 minutes, checking the r.p.m. on each magneto. He also checks his other instruments. He then checks the idling speed of the engine, if O.K. he is ready to take-off.

1. Explain how to cool off and stop the engine. Never cool off an engine

suddenly. Cut it down to about 900 revs. for a few minutes, then shut off the gas and idle the engine at about 500 revs. and let the gasoline burn out. Just before the engine stops, open the throttle to clear the carburetor, when stopped cut the switch and close the throttle. If the engine is cooled to rapidly it results in warped valves.

1. If on turning up an engine you did not get the required revolutions, where would you look for the trouble?

First see that the spark is not retarded. See that the altitude control is closed. See that the mixture control is properly set. Examine for leaks. See that the breaker points have the right clearance. Check the compression on each cylinder. Examine all valve clearances and check the valve action throughout. The improper operation of the valves is the chief cause for the loss

75.

Questions (cont.)

of revolutions, and loss of compression ranking second. If the loss of the revs. is due to mechanical trouble, the engine may be improperly timmed [sic].

1. What is the purpose of the condenser in the ignition system? Mainly to store up the back pressure from the primary coil and prevent burning of the breaker points.
2. Draw a diagram and explain two fuel systems used aircraft engines. (Explained previous notes.)
3. Why are dual ignition systems used in most airplane engines?

Because of greater safty [sic] factor and a slight increase in r.p.m. It also causes a more complete combustion of the fuel vapor, and makes the engine more efficient and cleaner.

1. What is the purpose of the thrust bearing and where is it used?

It consists of a ball or taper roller bearing, mounted on the forward end of the

crankshaft. Its purpose is to take the thrust and radial loads of the crankshaft and propeller and transfer these loads to the crankcase of the engine.

1. What effect does a retarded spark have on an engine?

Late firing of the fuel vapor. They are ignited after T.D.C. and results in considerable loss of power and over-heating.

1. In mounting a magneto, is it necessary to ground it?

Yes! It is grounded through the ignition switch. If it wasn’t grounded this way, the magneto would be on contact all the time. Spark is retarded with rotation, and advanced against rotation.

1. What results when the spark plug gaps are too wide?

Hard or impossible to start. Cuts out and runs irregular at low speeds, and if extremely wide the current will arc

76.

Questions (cont.)

across the safty [sic] gaps, and the engine will cut out altogether.

1. What is a wobble pump?

It is a small pump located between the main tank and gravity tank. It is used to pump gasoline from the main tank to the gravity tank, and at the same it serves to prevent a back flow of gas from the gravity tank, when it is not working.

1. What causes valves to warp?

The too rapid cooling of a hot motor. Example: Making a long glide or side slipping steeply with short exhaust stacks or improper cooling of the engine.

1. Are aircraft magnetos of the high or low tention [sic] type?

They are high tention [sic] magnetos, and consist of a conventional low tention [sic] magneto with a high tension coil incorporated with it. The circuit in the low tention [sic] coil is induced into the

secondary or high tention [sic] coil, where it is stepped up to a high tension current.

1. What circuit of a magneto does the switch ground?

The primary or low tension circuit.

1. Why wont the average motor operate normally in inverted flight?

Such engines are not properly designed to return the oil and thus prevent overloading of the cylinders, therefore such an engine would load up with oil, follow the spark plugs, overheat, cause vibration, and in due time cut out altogether. Also the majority of these engines are connected up to a straight gravity feed, therefore in inverted flight the gasoline flow will be reversed and the engine would fail as soon as the gas supply worked out of a carburetor. Inverted flight is not only hard on the engine but it tends to overstrain the whole plane.

77.

Questions (cont.)

1. How does high altitudes effect the carburetion of an engine?

First the atmospheric pressure at sea level is 14.7 lbs. per sq. in., and this pressure is created by the weight of a column of air over a given surface. Therefore at high altitudes this column would be less in weight, due to several reasons: Air at high altitudes is less humid, there are less dust particles, is colder and more rarefied. At an altitude of 20,000 ft. it is about ½ that at sea level, and as high altitudes are reached, the mixture constantly gets richer, due to a lesser volume of air to the proportions of the gasoline being supplied. It is controlled by an altitude control and a supercharger.

1. Name five reasons for the most frequent engine failures while in flight?
2. Restricted gas flow due to

stoppage in the lines, jets, carburetor passages, and filter screens.

1. Air lock in gas line.
2. Breaker points stripped off the cam, or being burnt, fouled, or pitted.
3. Blown gasket or loose connections on the intake manifold or induction lines.
4. Oil pressure stops functioning due to restricted lines, broken lines, air leaks, or sticking bypass valve.
5. How may a dead cylinder be quickly located in an air cooled engine?

By feeling the barrels, if hot they are OK, but if one is cold, it is dead. You can also tell by noting the exhaust.

1. How would a sticking exhaust valve effect the operation of an engine?

The fuel vapor, after burnt will fail to be exhausted, and upon the opening of the intake valve, the burnt fuel vapor would work its way

78.

Questions (Cont.)

out through the intake to the carburetor, thereby preventing the intake of a new charge of fuel vapor. This is only when the valve sticks shut. If open you wouldn’t be able to compress the fuel vapor, thus the cylinder would miss.

1. How would a sticking intake valve effect the operation of an engine?

It would cause an improper amount of fuel vapor to be drawn into the cylinder. If the valve remained open at the start of power stroke, the ignited charge would blow back through the intake, and probably go back to the carburetor.

1. What is detonation?

It is a dull thud developed in the motor. It is caused by compressing fuel vapor beyond its limit, thus causing it to break down and explode with much or

great force. It may be caused by leaving out the head gasket, or grinding off the base of the cylinder.

1. Is it best to completly [sic] fill the oil tank on an air cooled engine?

Not it is not. You should leave room for expansion. When the oil is heated in the engine it expands and if the tank was filled while cold the oil would overflow from the tank when it expanded. You should only fill the tank within three inches from the top.

Things Causing Improper Operation.

1. Causes for a magneto to fail entirely: primary grounded; secondary grounded; switch grounded; condenser grounded, or magneto crossed, (magneto of the armature type).
2. Causes for pre-ignition: carbon deposits; over heating; rich mixture; ignition out of time; or spark plug wires crossed up.
3. Excessive carbon deposits: Engine fouled with oil, caused by high oil level or excessive oil pressure. Poor piston rings: inferior oil; running on a rich mixture of fuel vapor; engine operated a long time without cleaning; or the cylinders pumping oil, due to a number of causes.
4. Engine spitting back in the carburetor: Cold engine; cold mixture; lean mixture; air leaks in the manifold; air leaks around the intake valve stems; weak springs; sticking valves; ignition out of time

or retarded. Camshaft out of time; over heating; carbon; low test gasoline; water in the gasoline; or a worn throttle shaft.

1. Back firing in exhaust manifolds: Pre-ignition; camshaft out of time; rich mixture; retarded spark; faulty or weak spark; sticking valves; missing or weak cylinders.
2. Single cylinder missing at low speeds: Shorted spark plug; shorted spark plug wire; short distribution block; spark plug gap too close; weak compression; air leak around the intake valve stem, or weak exhaust spring.
3. Scattering misfire: Lean mixture; rich mixture; water in the gasoline; air leak in the manifolds; intake valve holding open; sticking valve guides; weak springs; excessive breaker point clearance; Weak breaker arm

Improper Operation (Cont.)

spring; excessive rotar [sic] contact gap clearance; moisture on the distributor block, or faulty spark.

1. Reasons an engine won’t turn up if it doesn’t miss fire: Mixture too lean or too rich; valve timing late; ignition timing late; inferior oil; tight engine; carburetor venturi tubes too small; throttle not opening fully; excessive carbon deposits; valves not opening far enough, due to the seats too deep; or if the engine uses a super charger it may be defective.
2. Engine fails to start: Lack of gas; gasoline not reaching the carburetor, or a poor grade of gas. Lack of priming or too much priming. Water in the gasoline; moisture in the magneto or wiring; weak spark; dirty spark plugs; lack of compression; engine out of time; cold

engine and cold oil; broken or defective camshaft or magneto drive gears.

Every Flying Day Inspection

Every flying day the following inspection should be made: Are the spark plugs tight; grease rocker arm shaft; are ignition terminals secure to wires and plugs, and is the insulation good on the wires; is the compression normal on all of the cylinders; are the carburetor and carburetor manifolds tight; are the fuel and oil tanks filled; are the magneto ground wires secure; are the throttle, mixture, and magneto controls free throughout their range; what is the r.p.m. at full throttle, is the operation good on both magnetoes [sic]; and check the oil pressure and oil temperature.

81.

Inspection – 20 hr. of Flight

After every twenty hours of flight you should take the valve gear apart and check it thoroughly. If you find excessive tappet clearance, determine the cause and remedy it. Then check the spark plugs and see that the points are clean and set at their proper clearance. See that the intake manifolds are tight. Check the cylinder hold down nuts. Clean all the fuel and oil strainers. Are all of the connections in the fuel and oil lines tight and secure? See that they aren’t cracked. Drain the oil from the tank and lines then flush them with gas. Next refill with new oil, and see that the engine mounting bolts are tight. Are the magneto breaker points in good condition, and set their proper

clearance, and are the magneto couplings in good condition. Oil the magnetoes [sic] and all throttle connections, and all other controls. Check the propeller hub nuts and see if they are tight and saftyed [sic]. Be sure that the spark plug wires are saftyed [sic] to the spark plugs.

A top overhaul should be given an engine about twice to every general overhaul. When the engine starts to loose [sic] revolutions it needs a top overhaul. You remove the cylinders, magnetoes [sic], carburetor, etc. It has to do with the top of the engine. The engine may not be removed from its bed in the plane.

82.

Value Timing and Ignition Timing of the Kinner K5 Engine

When you assemble the engine you will find that in the rear there are five separate camshafts for the push rods that operate the valves on each cylinder. The gear fitted on the rear of the crankshaft operates the gears on the camshafts, and the number of the cylinder each camshaft operates is stamped on each camshaft gear (along edge of teeth). The numbers are also stamped on the gear, on the crankshaft. So, when you assemble the engine, mesh the gears so that the numbers are just opposite each other, and correspond, on both gears. The numbers on all five camshaft gears should be opposite and correspond to the number on the crankshaft gear.

Secure the the [sic] back plate on the engine and the valves are properly timed, but for the tappet clearances. Adjust all the tappets at .020”. When the engine is warmed up the value clearance will be .025”.

Ignition timing: Before timing the magnetoes [sic] to the engine, first bench time them, to see that they are functioning properly. Set the breaker points at .020” when open. Then turn the magneto in direction of rotation until it is firing number one segiment [sic], the breaker points just opening. Then turn the crankshaft on the engine in the direction of rotation until number one cylinder is on the compression stroke. Then insert a ruler in the

83.

Valve Timing of the Kinner.

spark plug hole and keep turning the crankshaft (the piston is coming up on the compression stroke) until the piston is two inches from the rime of the spark plug hole. In this position mount the magnetoes [sic] on the engine. Then wire them up to the spark plugs, the right magneto feeding all of the front spark plugs and the left magneto feeding all of the rear plugs. Be sure to connect up the ground wires.

Wiring order of the magnetoes [sic] Firing order of the cylinders

1 —————————————————————— 1

2 —————————————————————— 3

3 —————————————————————— 5

4 —————————————————————— 2

5 —————————————————————— 4

A good definition of power gaps:

Power gap is the distance the crankshaft travels on its own momentum, from the time one cylinder develops a power impulse until the next cylinder develops its power impulse.

Some Answers to Questions in the Exams of the Engine Mech. Course.

Power gap is the number of degrees a piston travels, between power impulses, on its own momentum.

Power overlap is the number of degrees one piston begins to deliver its power impulse before the other piston is finished.

Illustration – 4 cylinder engine.

120º 120º 120º 120º

60º 60º 60º 60º

Power stroke = 120º

120º x 4 cy. = 480º of power strokes

720º = two revolutions of the crankshaft (a four cycle engine)

720º – 480º = 240º of power gap.

240º ÷ 4 cy. = 60º power gap for each cy.

Nine cylinder engine.

125º

45º

45º

45º

45º

etc.

Power stroke = 125º in length

125º x 9 cy = 1125º power

1225º – 720º = 405º “lap”

405º ÷ 9 cy = 45º

The power overlap for each cy. = 45º

Two types of oiling systems used on internal combustion engines are pressure and splash systems.

Oiling system of the Packard.

The engine is lubricated by a wet sump type. The oil is pumped from the sump and enters the crankshaft. The line runs to the main bearings. From these bearing it enters the crankshaft, and then goes to the connecting rod bearings. There it is whipped into a spray and thrown to the pistons. It then drops back to the sump. Oil not entering the crankshaft is forced on through the pipe under the crankshaft, and out through external pipes to the camshafts, and then back to the sump.

85.

Engine Fails to Start.

If an engine fails to start, go about looking for the trouble in a systematic manner. First check the ignition system. See that the magnetoes [sic] are timed to the engine properly, and that the breaker points were operating correctly and the gap between the points is correct. Then check over the wiring from the magneto to the spark plugs. If the ignition is working properly next check the carburetion. See that the gas is entering the carburetor, and that no fuel lines are clogged. Check the jets and all passages to be sure they are not clogged. If the carburetor is also OK, there must be something wrong with the mechanical workings of the engine. Then check all of the valve clearences [sic] and see that they are correct, both

the intake and exhaust valves. Also see that the valves are timed correctly. Also check the intake manifolds or inductions lines and see that no air leaks into them. After you have made all of the necessary adjustments and corrections, and everything is functioning properly, the engine should then start. Length of the four strokes of the valves in an engine having the following specifications.

Intake opens 10º B.T.D.C. – 10º + 180º + 35º = Int.

” closes 35º A.B.D.C. – 35º + 180º +10º = Ex.

Exhaust opens 35º B.B.D.C. – 180º – 35º = Power

” closes 10º A.T.D.C – 180º – 35º = Comp.

The compression and power strokes are each figured from T.D.C. to the point of closing of the intake and opening of the exhaust, respectfully.

86.

Questions Given on the Engine Mechanic Course – Weekly exams.

1. (a) What is power gap; (b) power overlap? Illustrate
2. What would the power gap be in a four cylinder engine having a power 120º long?
3. What would be the power overlap in a nine cylinder engine with a power stroke 125º in length?
4. Explain the oiling system of an Ox5 engine; in detail.
5. Explain the process of timing the valves on an Ox5 engine.
6. What is the purpose of a cam shaft in an engine, and what is a cam?
7. Name four types of engines.
8. What is the purpose of the thrust bearing, and where is it located?
9. How would you replace a worn or broken connecting rod bearing in Ox5 engine?

10. Name three kinds of connecting rods used in aviation engines.

11. (a) What is the chief principle of lubrication? (b) What requirements must the oil for use in an aviation engine have?

12. (a) Draw a diagram of a pressure lubrication system and give complete nomenclature of parts.

(b) What other type of lubrication system is sometimes used?

13. (a) Name two types of fuel systems.

(b) Draw a gravity system and name all the parts.

(c) Give the rules governing the instalation [sic] of a gravity fuel system.

14. Names the engine instruments, explain their purpose and their operation.

15. Explain in detail the valve timing of the Wright J-5 engine.

16. Explain in detail the valve timing of the Hisso engine.

17. What are the following: Bypass valve; Flash point; Viscosity; Wobble pump; Flexible connection.

18. Explain in detail the valve and ignition timing of the Kinner K-5 engine.

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19. (a) What is power gap; (b) power overlap? Illustrate.

20. What are the following: Sludge; Scavenger pump; Dry sump engine; Wet sump engine.

21. (a) What is carburization?

(b) What is a carburetor?

22. (a) What is meant by fuel level in a carburetor?

(b) How high should the fuel level be?

23. What is a venturi tube and what is the purpose of it?

24. Draw a diagram of a Zenith Carburetor and give the complete nomenclature of the parts.

25. What is the use of a compensating jet in a carburetor?

26. Explain the operation of the idling system in carburetor.

27. Name three types of altitude controls and explain each.

28. (a) Why is an altitude control necessary?

(b) What is the purpose of a superchanger?

29. (a) What proportions of gas and air from the best mixture?

(b) How are rich, lean, and a correct mixture indicated?

30. (a) Explain the use of an economizer jet.

(b) Explain the operation and use of an accelerating well and an accelerating pump.

31. Give the construction of the Packard engine.

32. Trace the oiling system of the Packard engine.

33. How are troubles classed in trouble shooting?

34. If an engine failed to start, how would you go about locating the trouble? Explain in detail.

35. (a) What is meant by ignition?

(b) Name two types of ignition systems used in the internal combustion engines.

36. Explain in detail the operation of an induction type, high tension magneto.

37. Draw an induction type magneto and give complete nomenclature of parts.

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Engine Questions (Cont.)

38. What is the purpose of a condenser, and where is it located in the circuit of the magneto?

39. What is a safty [sic] gap and what is its purpose?

40. Explain the valve and ignition timing of one of the following engines: Curtiss Ox5; Hisso; Wright J-5; Kinnder K-5, Packard.

41. Explain the ignition timing of one of the above engines.

42. What precautions should you always make before turning a propeller through by hand.

43. Explain the operation of an armature type of magneto.

44. Draw a diagram of the armature magneto and name all the parts.

45. When should an engine be given a complete overhaul?

46. If a plane came in for a complete motor overhaul, describe how you would proceed up until the parts were on the inspection bench.

47. Describe the overhaul of the crankcase.

48. Describe the overhaul of the crankshaft.

49. How would you check a crankshaft for out of round, alignment and balance?

50. Describe the overhaul of the pistons and piston rings.

51. Describe the overhaul and alignment of the link rods and master rod.

52. (a) Describe the overhaul of the cylinder.

(b) Where are cracks most likely to occur in a cylinder?

53. Explain the overhaul of valve guides and spark plug inserts.

54. How would you replace worn valve guides and spark plug inserts in an aluminum head [sic].

55. Explain the overhaul of the camshaft and cam followers.

56. Exp. overhaul of lubrication system.

57. Exp. overhaul of ignition system.

58. Explain the overhaul of the carburation system.

59. What are the most common causes for magneto failure in flight?

60. Explain the various causes for an engine to start missing on one cylinder.

61. How does a leak in the intake manifold effect the running of the engine?

62. What effect does the breaker points set too close, have on the operation of a magneto?

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Final Examination Questions Given on the Engine mechanic course.

1. What is an internal combustion engine?
2. Explain the principle and operation of a two stroke cycle engine.
3. Explain the four stroke cycle principle of an int. comb. engine.

Draw diagrams to illustrate.

1. (a) What determines the length of the piston stroke? (b) What is a stroke? (c) What is a cycle?
2. Explain the length of the four strokes of the valves in an engine having the following specifications:

Intake opens 10º B.T.D.C.

” closes 35º A.B.D.C.

Exhaust opens 35º B.B.D.C.

” closes 10º A.T.D.C.

Draw a diagram to illustrate.

1. (a) What is power gap and power overlap?

(b) What power overlap would a nine cylinder engine have, with a 130º power stroke, per cylinder?

1. Name three types of fuel systems used in airplanes.
2. Draw a diagram of a gravity fuel system and give complete nomenclature of parts.
3. Give the rules governing the instalation [sic] of a fuel system in an aircraft. Exp. carefully.
4. (a) What is the chief principle of lubrication?

(b) What requirements should the oil for use in an aviation engine have?

1. Draw a diagram of a pressure lubrication system used in radial air cooled engine, giving nomenclature and tracing oil to all moving parts of the engine.
2. What are the following: Sludge, Bypass valve; Wobble pump; Flash point; Viscosity; Crank pin; Thrust bearing.
3. Name the engine instruments and describe their use.
4. How would you determine the firing order of an engine with which you were not familiar?
5. (a) What is a major overhaul?

(b) When should a major overhaul be given an engine?

(c) Describe the complete overhaul of a Kinner K 5 engine.

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Engine Final Questions (Cont)

1. (a) What is a carburetor?

(b) What is carburetion?

1. (a) What is venturi tube and what is its purpose?

(b) What is the purpose of the metering jet?

1. Draw a diagram of a Zenith Carburetor and give complete nomenclature of parts.
2. Explain the operation of the compensator in a carburetor.
3. Name three types of altitude controls and explain each.
4. Draw a diagram of an induction type magneto and explain the operation.
5. (a) Why is the ignition timmed [sic] to occur several degrees before T.D.C?

(b) Why is the intake timed to open before T.D.C?

1. Name six causes for an air cooled motor overheat, if the lubrication system is functioning properly.
2. What are the most common causes for magneto failure in flight?
3. Name six causes for an engine to vibrate too excessively.
4. What is detonation? How does affect the running of an engine?
5. Name six reasons for an engine to be hard to impossible to start.
6. If upon turning up an engine it failed to give the required number of revolutions, where would you look for the most probably cause for the trouble?
7. What would cause a V type motor to run OK on one blank, where the other would cut out entirely? Explain two different causes.
8. What is pre-ignition and what causes it?

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