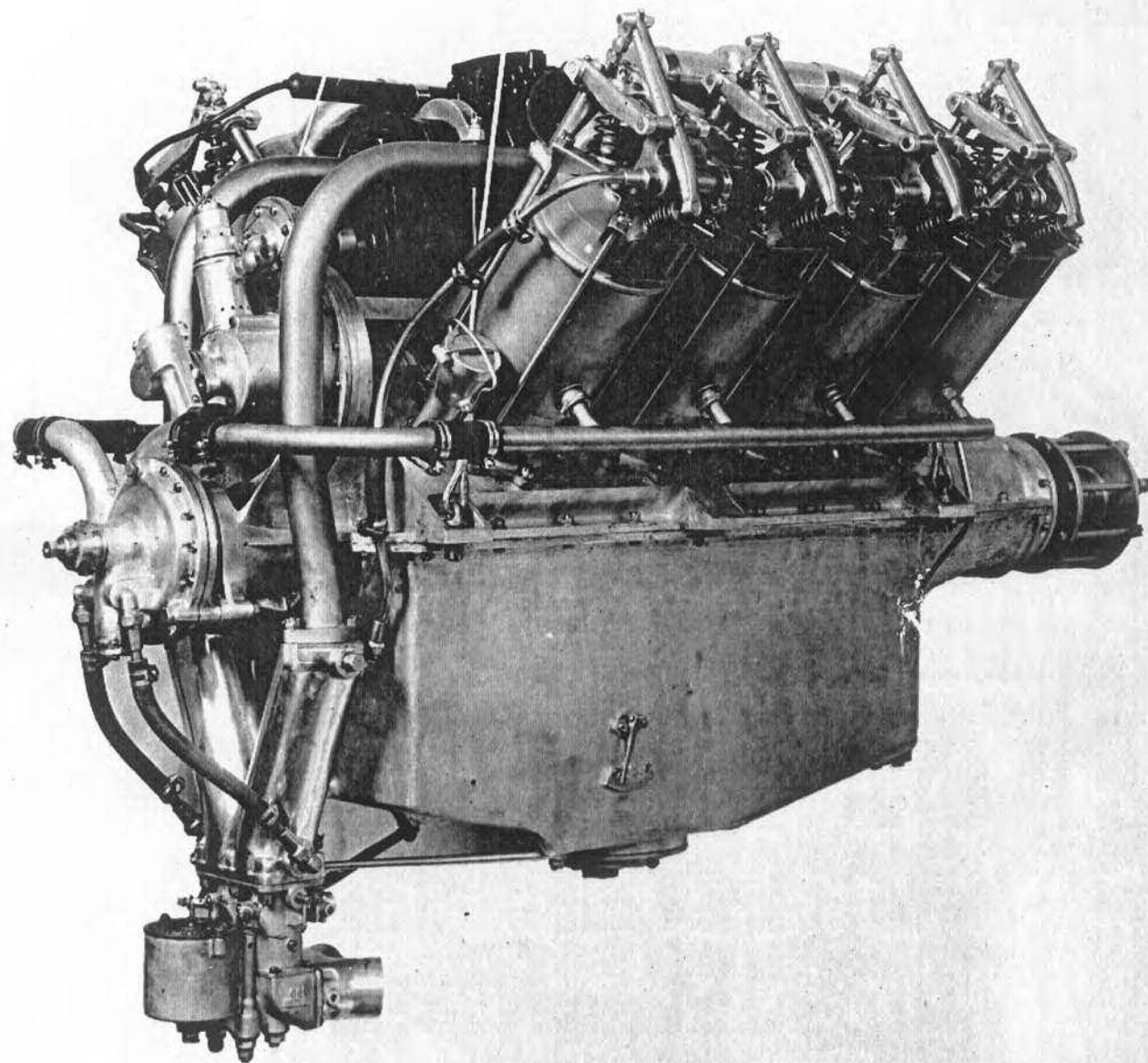
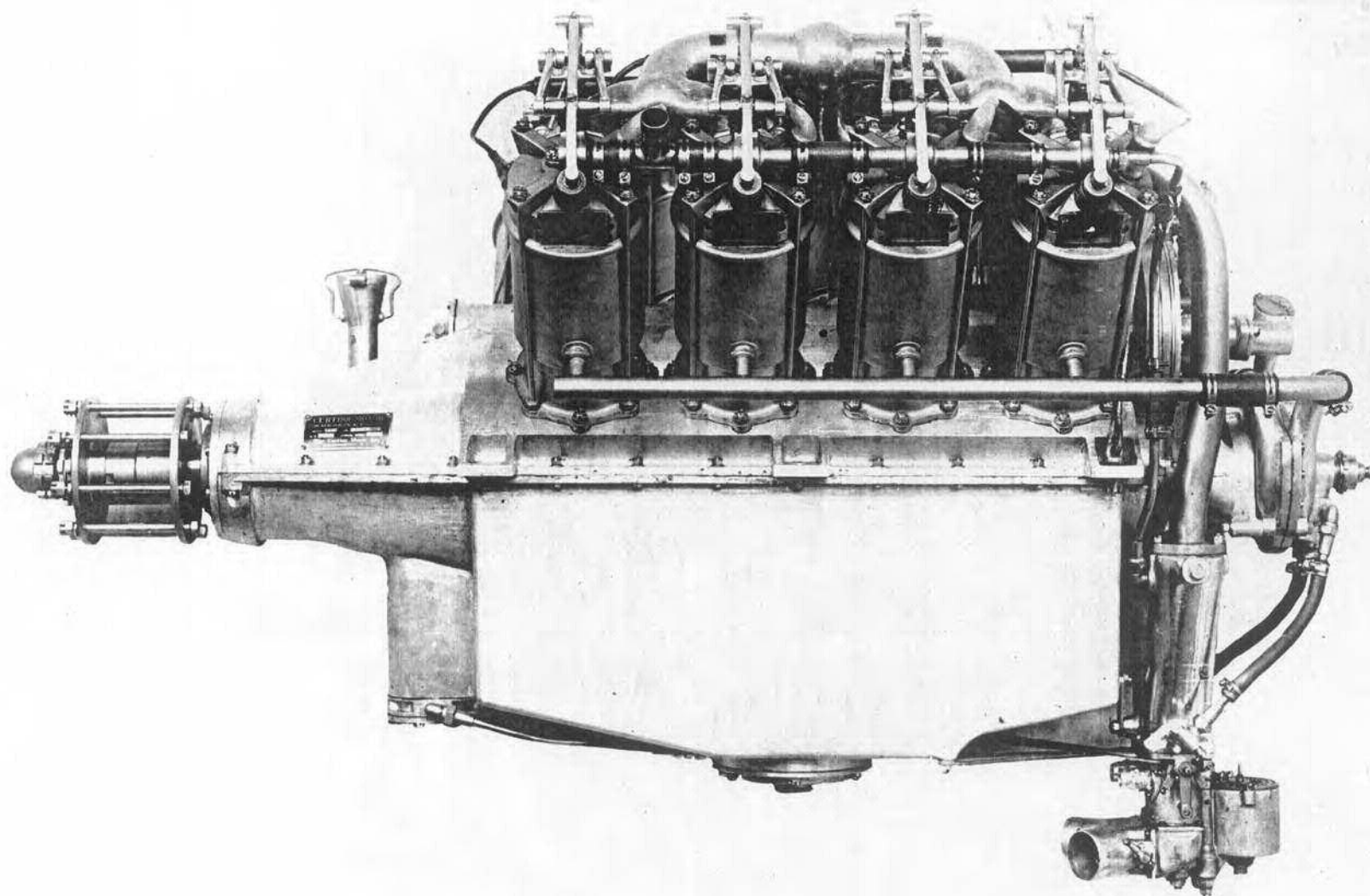


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MODEL OX-5 MOTOR

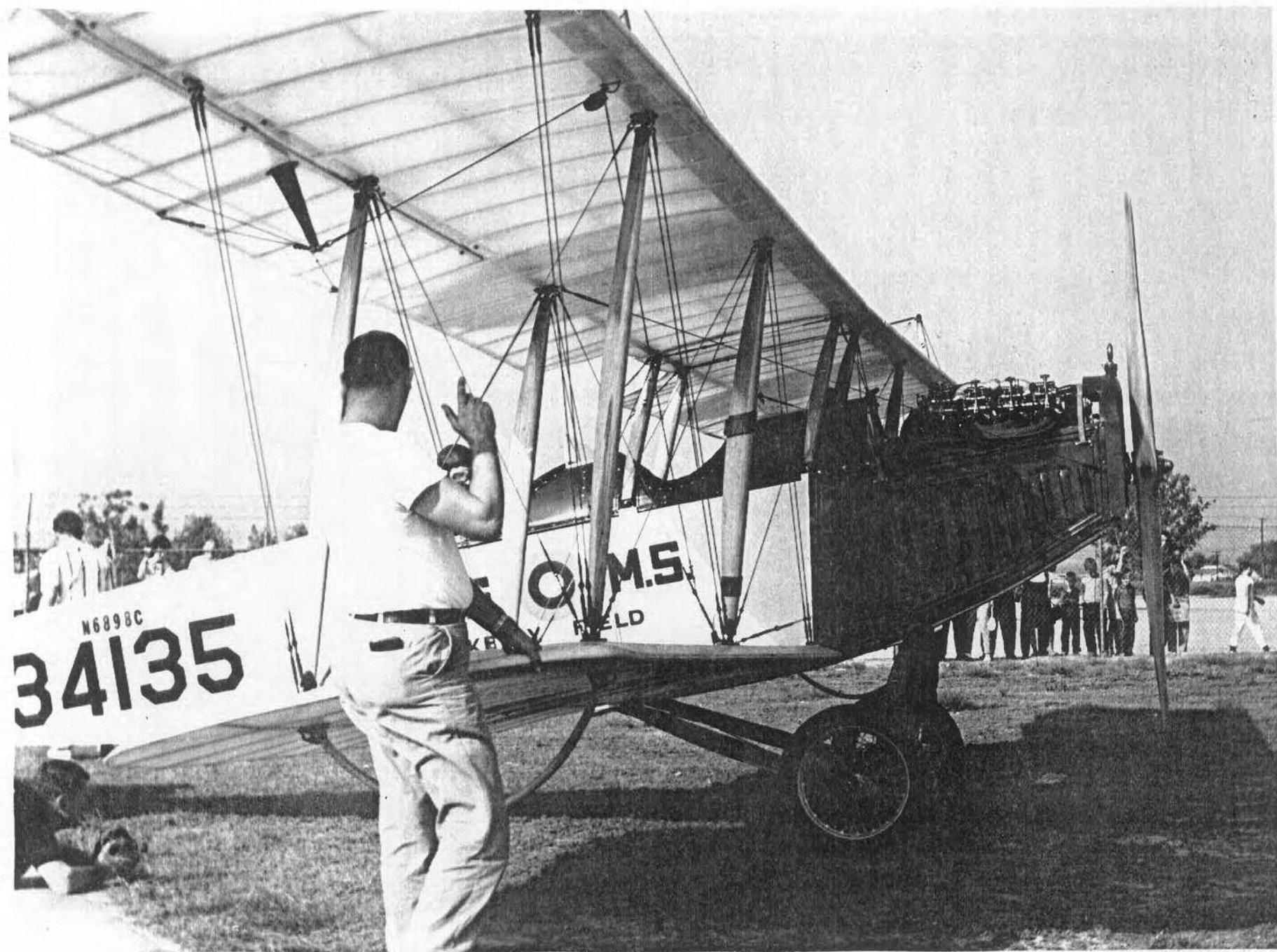


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CURTISS AIRPLANE CO.-PHOTO  
MODEL D-12S H-120P



DATE 4-16-17 NO. 562  
CURTISS AEROPLANE CO.-PHOTO  
MODEL OX-5 MOTOR

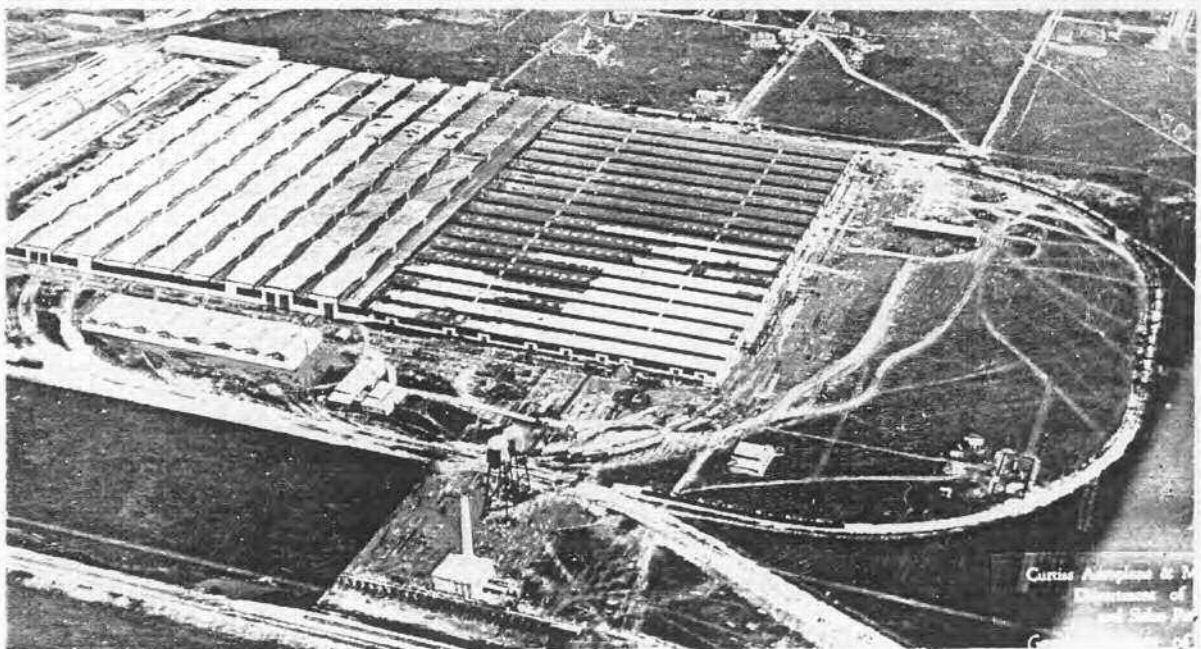
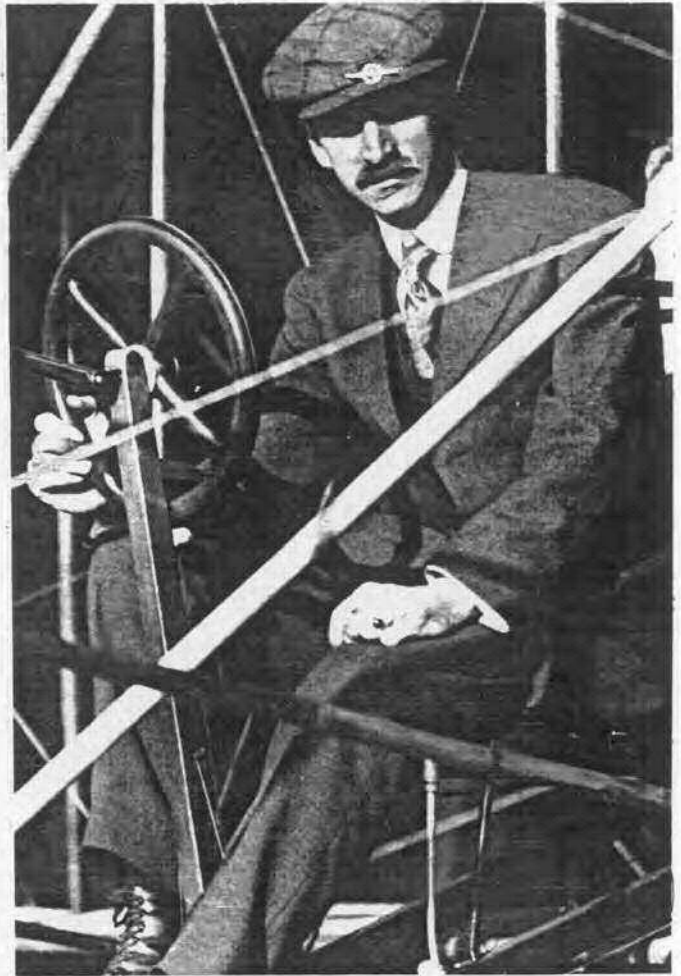




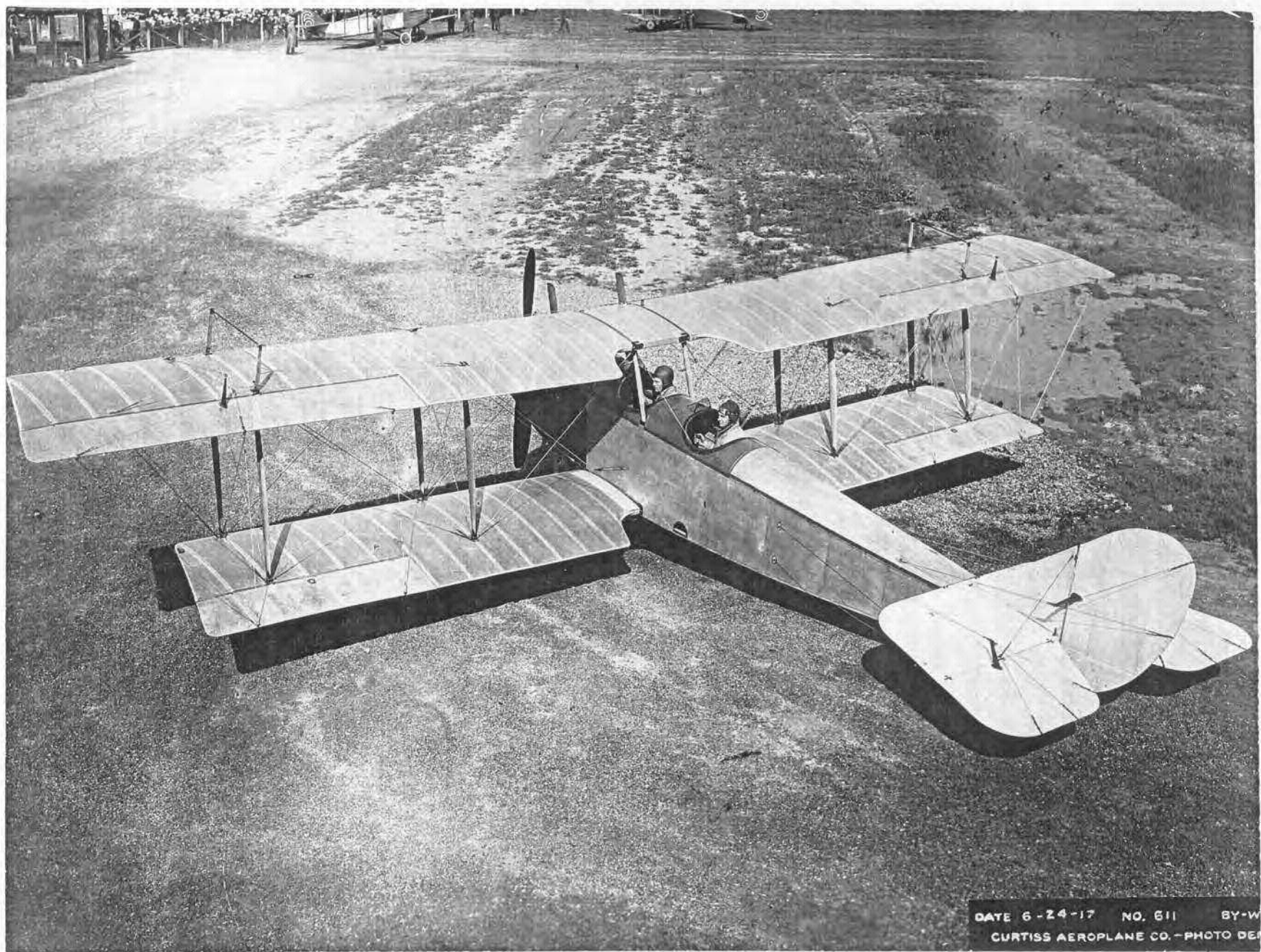


## GLENN CURTISS

A successful motorbike racer and builder of trophy winning racing engines, Curtiss became interested in the exploits of Wilbur and Orville Wright and their Flying Machine at Kill Devil Hill in North Carolina. By 1909 he had built a racing airplane fast enough to win the International Air Race at Reims, France. The engine which powered the winning racer was an eight cylinder water cooled V-8 which developed 50 horsepower. Many historians believe that this engine led to the design and manufacturing of the world famous OX-5. By 1914, Curtiss was president of the huge corporation which bore his name.



*The Curtiss Factory 1918*



DATE 6-24-17 NO. 611 BY-W  
CURTISS AEROPLANE CO. - PHOTO DE



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34135

A.S. O M.S.  
KELLY FIELD







## **Preface**

Whenever old time airmen or old time airwomen get together these days at formal aviation affairs , or just plain air show bull sessions, or perhaps any affair connected with aviation , the subjects sooner or later get around to the days of World War One , the Spads, Nieuports and Camels and Fokkers. Without any doubt , the discussions will continue to the Standards and the Curtiss OX-5 , that cantankerous old water cooled bucket of bolts that was spawned of wartime and survived to become a legend.

This very nostalgic handbook will do much to separate the fact from the fiction surrounding the development and production of the OX-5. This engine is possibly the most discussed - and cussed - aeroplane engine ever built - anywhere.

Curtiss wartime production figures and those of all sub - contractors are , to say the least , lopsided. Curtiss figures do indicate that a total of 15,000 JN-4 airframes were built. The U.S.Army Signal Corps bought and paid for 8500 of these. The rest went to the U.S.Navy , the United Kingdom , Italy and Spain. Curtiss received orders for 2000 spare OX-5 engines as a part of the spares support program but delivery dates do not appear anywhere. It is believed that these engines were built but probably ended up being disposed of as surplus in 1919.

During the post war years , the OX-5 engine underwent a number of modifications by barnstormer pilots and others. A man named Miller introduced roller bearing tappets , improved exhaust valve guides , improved intake valve tension , and Zerk fittings to replace the lubricating holes on the overhead system. To top this off , the Scintilla magneto people came along with a custom magneto. A man named Charles in Richmond, Virginia came up with an ingenious spring loaded flap to help keep water pump drippings out of the carburetor. The old OX-5 was coming up in the world of aviation. And if all this were not enough, a guy named Tank wanted to make a big change , he wanted to turn the old relic into an air cooled job !

Memories of the Curtiss OX-5 engine continue to be kept alive by members of the OX-5 Aviation Pioneers, an organization created by the men and women who flew behind the OX-5 or maintained the OX-5 back in the golden age of aviation.

Membership information can be obtained from :  
OX-5 Aviation Pioneers  
207 Dormont Village  
2961 W.Liberty Ave.  
Pittsburgh , Pa. 15216

# **CURTISS OX - 5**

## **HISTORICAL REFERENCE HANDBOOK**

Compiled and edited by William B. Bullock

- HISTORICAL
- OPERATIONAL
- MAINTENANCE
- NOSTALGIA
- PHOTOGRAPHY

1st printing	1980
2nd printing	1991
Revised	2001

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2001 130927

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Phoenix , Arizona

**ALEXANDER EAGLEROCK OX-5 powered 1928 - 1929 vintage**  
This Ormand - Brouse restoration now hangs in the Albuquerque,  
New Mexico airport passenger terminal.

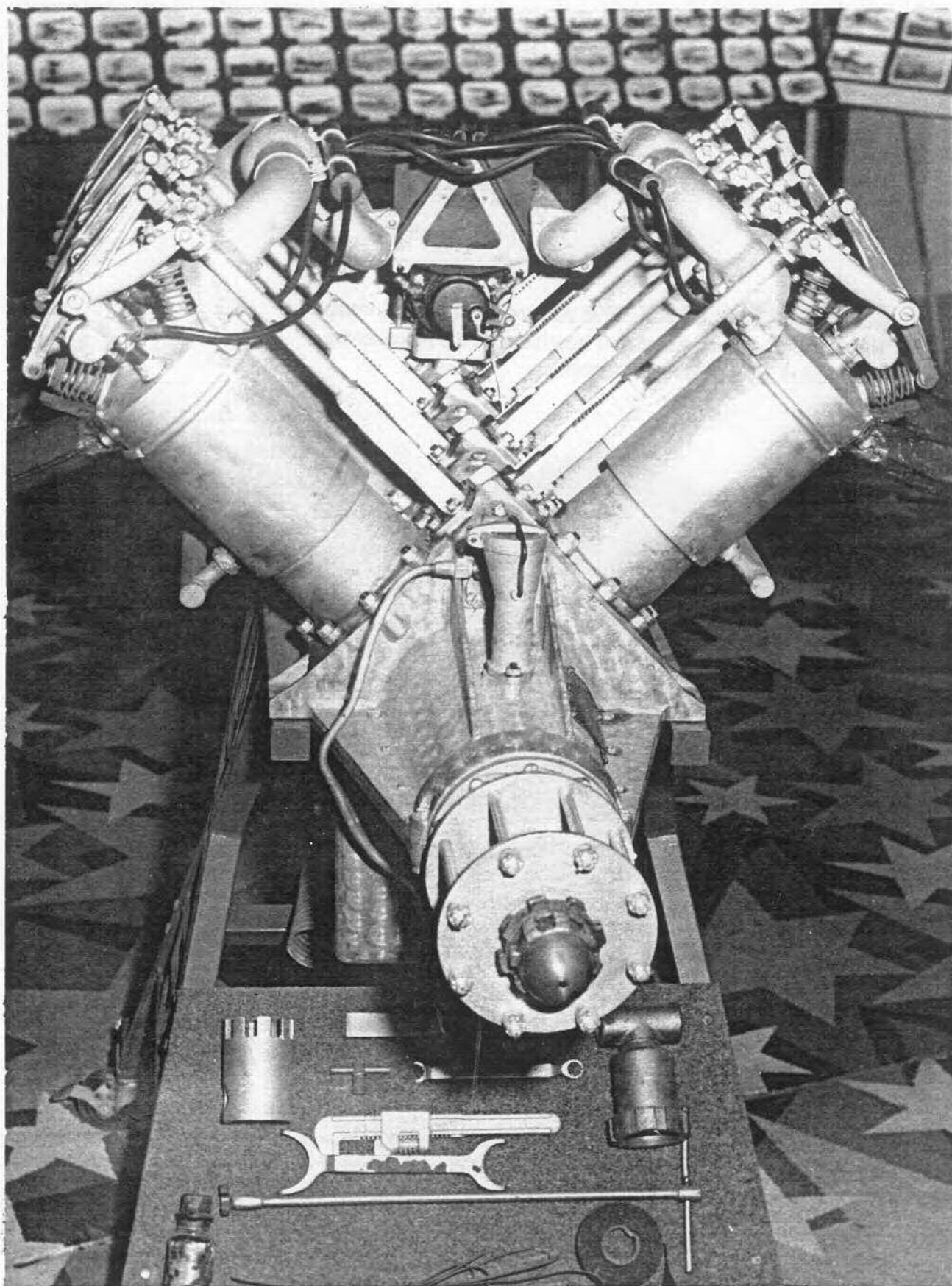


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## ACKNOWLEDGMENTS

I am indebted to a number of well informed individuals and organizations. First let me list the organizations: The OX-5 Pioneer Airmen Newsletter ; Paul Garber Aircraft Storage Facility of the National Air and Space Museum , The National Archives , and the Glenn Curtiss Museum in Hammondsport , NY. I am especially indebted to the late Joe Wischler of Phoenix , Arizona for his wide knowledge of aviation history and the old OX-5 engine. I am also indebted to Henry "Hank" Pfizenmayer for his helping an old time writer with a major vision problem put this book together.





Front View , Curtiss OX - 5 Engine

# OX-5 Series Historicals

The famous OX5 engine, the immortal "Forked Eight" which powered thousands of Curtiss "Jennies" and other World War One trainers, and became the life blood of aviation in America and half way around the globe from 1918 to 1925, was born in 1912 as an obscure Curtiss Model "O" experimental V-8 engine which had been expeditiously designed and built to replace an enormous Curtiss "boo-boo" engine, an eight cylinder "V" model equipped with air cooled cylinders! The air cooled theory didn't work out in many ways, to include overheating and failure to meet many design specifications. The "boo-boo" was subsequently scrapped - but was a turning point for Glenn Curtiss! He never built another air cooled engine!

History records the fact that the Model "O" engine was not a great technical success - not by any stretch of the imagination! In the "O" engine, designer Henry Kickler was looking for about a hundred horsepower, smooth operation, reliability, and low fuel and oil consumption. Unfortunately the "O" model displayed none of these qualities! But rather suffered from overheating, burnt exhaust valves, and severe detonation problems! The Model "O" was a disappointment.

But history also records the fact that Kickler had faith in the design and persuaded Glenn Curtiss to authorize a block of experimental hours for himself and a small staff to study the problems and determine if the Model "O" could be salvaged!

Kickler and his staff went to work with a vengeance. The Model "O" had now been assigned an "X" designation. In Curtiss' records it became the Model OX! In and around the Curtiss plant it picked up a nickname. Everyone but Henry Kickler called it, "Old man Kickler's Ox!"

But old man Kickler was to have the last laugh! Nearly two years, and five design changes later, the "OX" engine became the OX5! By mid 1914 it had been fully accepted by the Army Signal Corps and was being produced in quantity!

The OX5 engine was not exactly what Kickler wanted in a production engine, but the Army needed engines badly and he reluctantly watched his engine hit the assembly lines - still beset with problems!

The OX5 engine as produced in 1914 and throughout the war years, was a water cooled V-8 featuring individual jacketed cylinders interconnected with a maze of pipes and rubber hose, a water pump that leaked directly onto a single carburetor float chamber, and a single ignition system fed by a monstrosity of a magneto called Berling! The engine weighed nearly 400 pounds, developed an honest 90 horsepower at 1400 revolutions per minute, and was a gas and oil hog! Improperly maintained the OX5 would quit running for no good "on the spot" reason, would overheat, burn exhaust valves, and blow cylinders completely off the crankcase! In its "hey-day" the only good thing that could be said about the OX5 was the 50 hour period between overhauls! But if that strikes you as being funny, remember that prior to the coming of the OX5 most aviation engines were being overhauled at anywhere from 10 to 20 hour periods!

But despite its shortcoming, Curtiss received a go ahead for mass production, and more than 15000 units were built between 1914 and the end of the war in 1918! The OX5 was built primarily to power the Curtiss "Jennie" trainers, but was also used to power Standard "J" model trainers and was used to power a number of experimental military aircraft being developed in the United States for the war effort!

Engine models that appeared between the "O" engine and the final OX5 engine are interesting. Discount the OX1. It was a "runout OX model" that had been jury rigged for various tests and was eventually scrapped. The OX2 was the engine that convinced Kickler his original "O" design wasn't as bad as everyone had thought. This second experimental type developed 90 horsepower at 1400 revolutions per minute and was fairly smooth in operation. To get this kind of performance Kickler had to redesign the original "O" engine intake valve mechanism to allow the valves to stay open longer during the intake stroke, thus taking in a bigger charge of fuel. Add to this major





change, improved pistons, improved magneto points, and a major ignition timing change, plus new and improved exhaust valves! Glenn Curtiss himself was by now convinced that Kickler was indeed on the right track and gave the OX2 engine development top priority.

The success of the OX2 engine did not stop Kickler. He was still the extrovert, still looking for perfection in aircraft engines! And while he labored to incorporate other important engine design concepts, Curtiss ordered the OX2 into limited production! The Army needed engines!

When the third experimental engine, the OX3 came along, it was an improvement over the OX2! It featured new production, rugged, Lynite pistons, new and improved spark plugs, much improved exhaust valves, and a Zenith single float carburetor. The OX3 still developed only 90 horsepower but was looked upon by Army Inspection personnel as a "bit more reliable" than the OX2! Just prior to production status, the new OX3 was fitted with new type exhaust valve guides, and both Curtiss and Kickler were recommending the use of a collector type exhaust system in lieu of short stacks in an attempt to cure exhaust valve warping - and to extend the service life of the engine!

Just what happened to the OX4 is a matter of considerable conjecture. Old Army and Curtiss records show the OXX2 and the OXX3 as prototype engines for the OXX6, a dual ignition version of the OX5, but mentions of the OX4 as having been fitted with experimental "Dixie" magnetos for test purposes. Therefore, one may assume that the OX4 was a part of the OXX6 development program. Both the OXX2 and the OXX3 were dual ignition models and developed 100 horsepower, the same as the OXX6. The production OXX6 was fitted with improved exhaust valves, new exhaust valve guides, and Dixie magnetos. It must be noted here that the OXX2 and the OXX3 were built in limited quantities. Even so there are still a few around, having been salvaged by loyal vintage airplane owners who dote on authenticity in the restoration of their ancient craft. Also, there are still a few OXX6 models still flying, and their owners are constantly on the lookout for spare engines and parts!

Today the ancient and beloved OX5 is remembered by a loyal group of pilots, mechanics, and owners who lived through the turbulent OX5 era. They call themselves "The OX5 Club of America." Meetings are held at least once a year to swap lies and trade experiences - and to help perpetuate the memories of a cantankerous old wartime engine that was built for the "Jenny" and lived to become a legend.

When World War One ended in 1918, thousands of surplus OX5 engines - many in original shipping crates - were dumped on the civilian markets and were sold at ridiculous prices, often as low as \$50.00 each! And this price included a Tool Kit, Operating Handbook, Overhaul Manual, and propeller hub!

The OX5 became the backbone of commercial aviation in America and in many foreign lands until the coming of the Wright "J" series engines, the Kinners, Axelsons, Comets, Challengers, etc., and the more modern Wright "J6" series engines. The OX5 powered just about every airplane built in America between 1918 and 1925. There were other surplus engines, of course, like the famed "Hisso" Liberty, Hall-Scott and the LeRhône and Gnome rotaries, that figured in American and world aviation history, but none of these engines reached the popularity of the OX5 or its sister engines! The OX5 was still chugging along when the Japanese hit Pearl Harbor in World War Two, and even after World War Two ended there were still several hundred of them in operating condition! In the late 40's a good OX5 could be picked up for about \$300.00. Try and buy one now for under \$5000.00 - if you can find one!

From the very first day the OX5 became a surplus item, pilots and mechanics alike sought to improve its reliability - and performance. A man named Leslie Miller came up with a completely new valve overhead mechanism, replacing the weird original - and troublesome units. The ridiculous Berling magneto gave way to a new Swiss engineered product called Scintilla. A metal or canvas hood was rigged over the carburetor float chamber to keep the leaking water pump from "wetting up" the fuel. Newly manufactured magneto points for the old Berling helped keep the engine going for those who chose to stick with the Berling! A few enterprising souls moved the updraft carburetor from beneath the water pump to a position between the cylinder banks! In most cases this also meant a new engine driven fuel pump - or pressurizing the fuel tank, since the carburetor was designed for gravity feed! There were others who thought nothing of milling down the cylinder hold down flanges in order to get more power, thus coining the term "Flying Cylinders!"

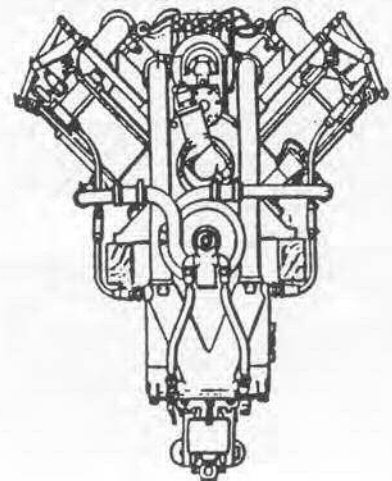
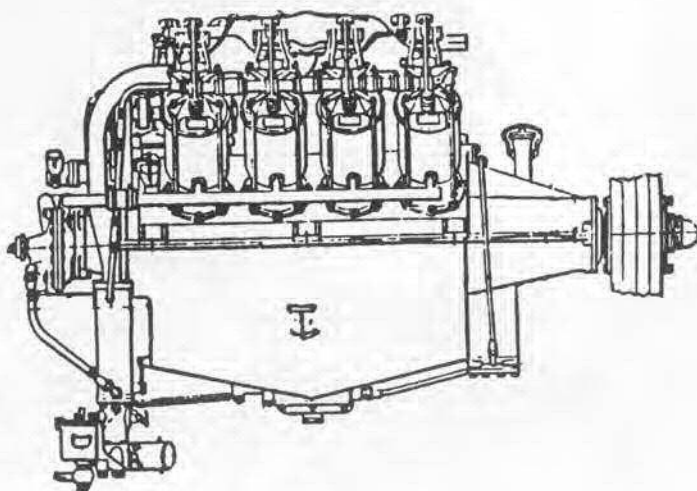


# General Specifications OX5

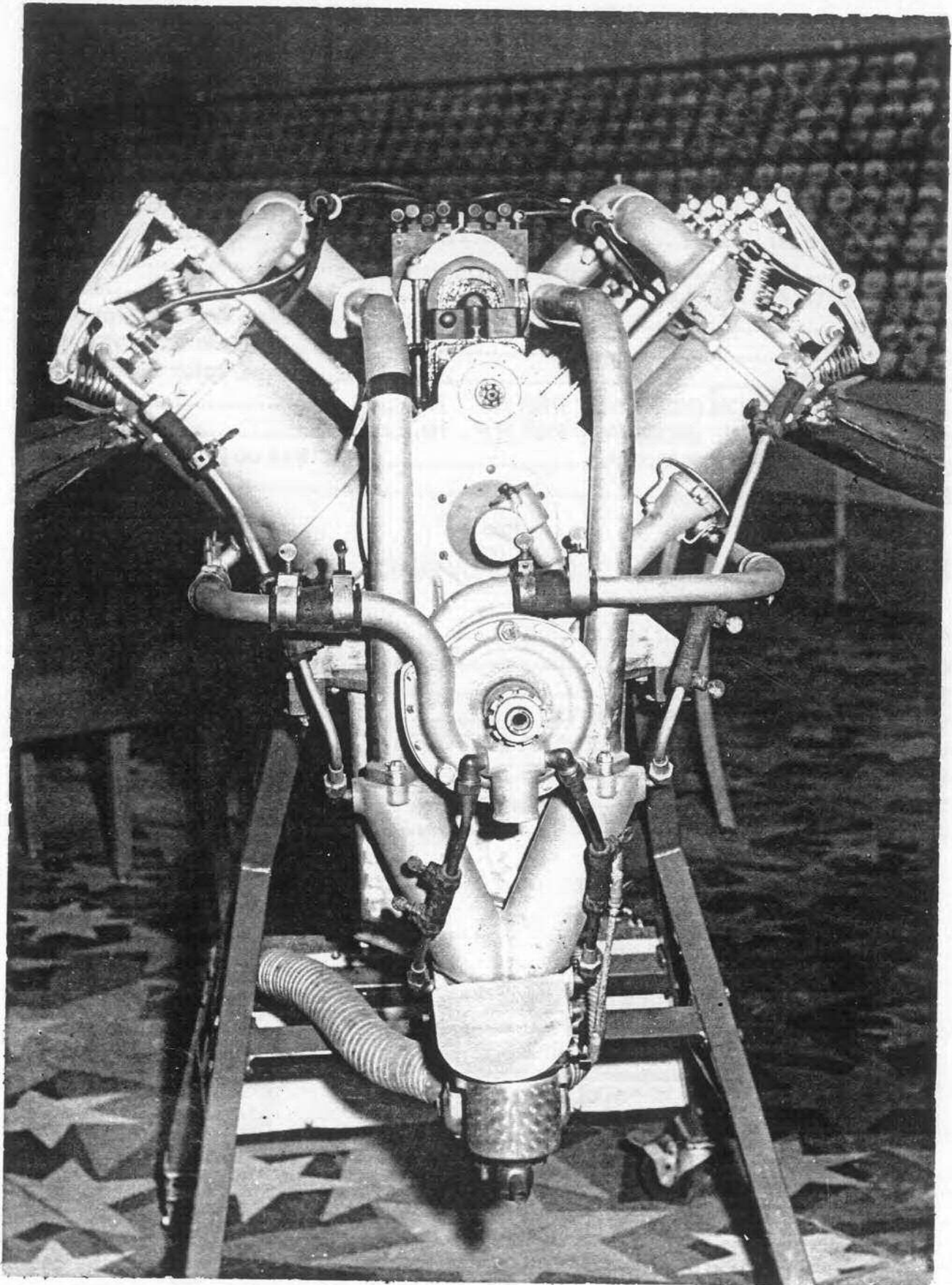
TYPE .....	8 cylinder ( V ) 4 cycle
BORE by STROKE .....	4 by 5 inches
DISPLACEMENT .....	502 cu in
HORSEPOWER .....	RPM 1400 (Rated) 90
HORSEPOWER .....	RPM 1400 (Brake) 93
NORMAL SPEED .....	1400 Rpm
COOLING .....	Water
WEIGHT WITH PROPELLER HUB .....	390 lb
IGNITION .....	High Tension Magneto
LUBRICATION .....	Force and Spray Feed
CARBURETION .....	One Duplex Carburetor
FUEL CONSUMPTION (NORMAL) PER H.P. Hr.....	0.60 lb
OIL CONSUMPTION (NORMAL) PER H.P. Hr.....	0.03 lb
CAPACITY OF OIL RESERVOIR .....	924 cu in .... ( 4 gallons )
FIRING ORDER .....	1- 2- 3- 4- 7- 8- 5- 6

## Dimensions (OXX6 Similar)

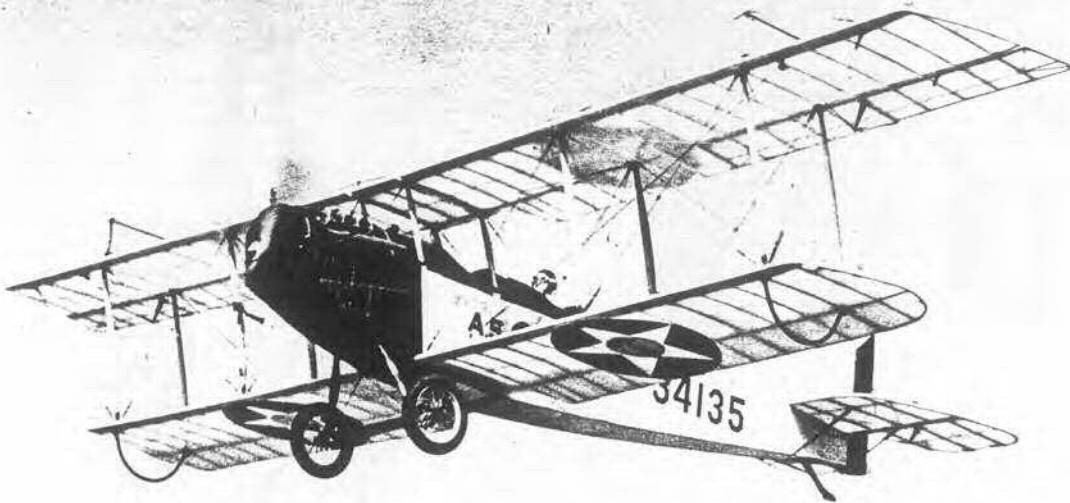
OVERALL LENGTH .....	55 3/8 in
OVERALL WIDTH .....	29 3/4 in
OVERALL DEPTH .....	31 1/2 in
WIDTH AT BED (INSIDE SUPPORTS) .....	10 7/8 in
WIDTH AT BED (CENTER TO CENTER OF BOLTS) .....	12 7/8 in
HEIGHT ( BED TO TOP ) .....	17 3/4 in
DEPTH ( BED TO BOTTOM ) .....	13 3/4 in
BED BOLTS (CENTER TO CENTER) .....	12 5/32 in



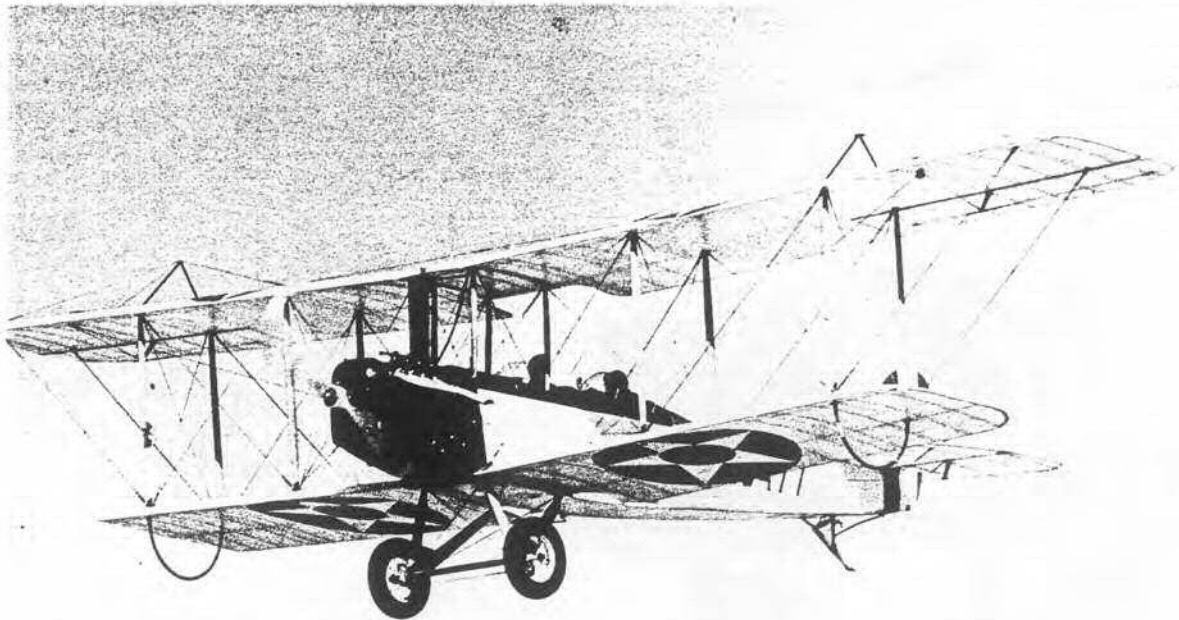




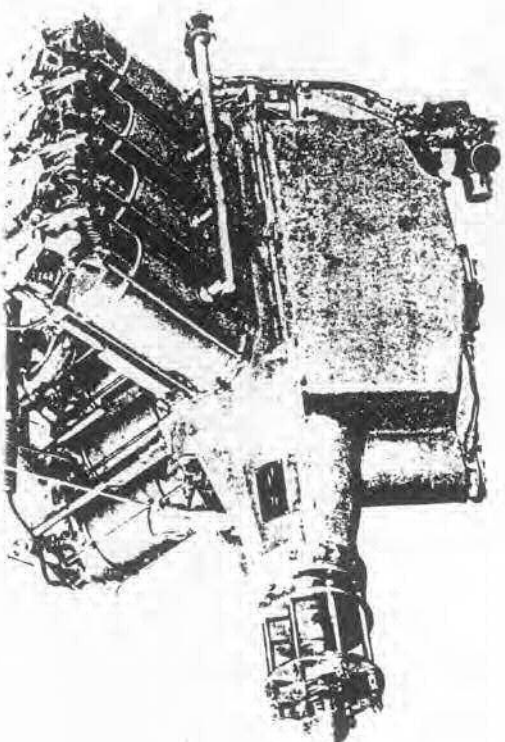
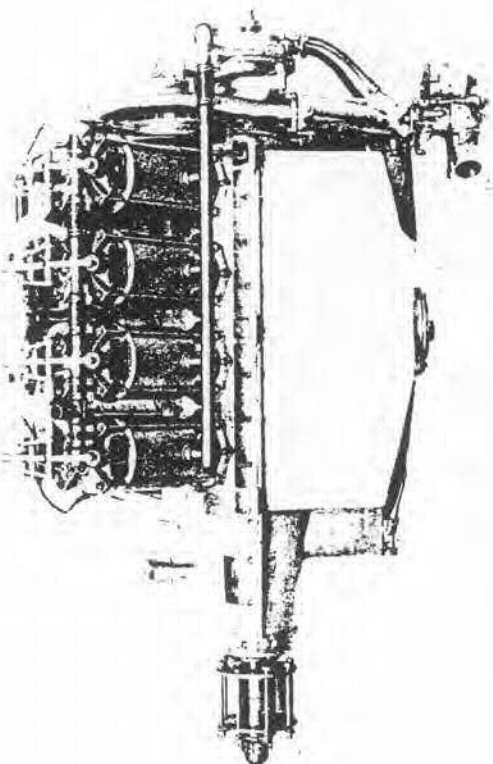
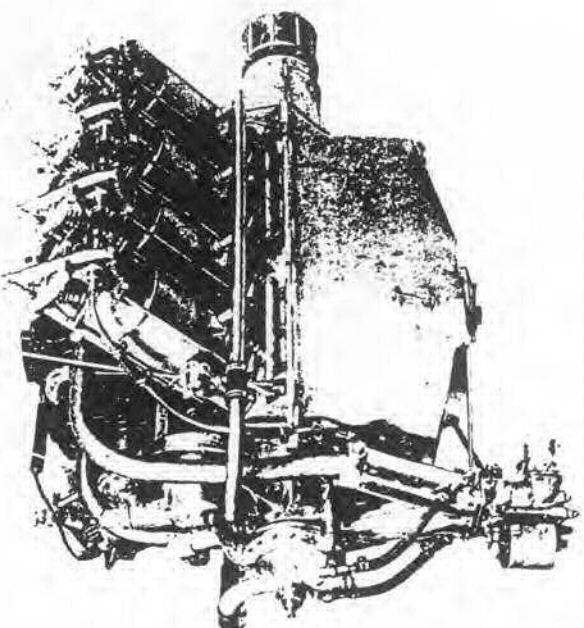
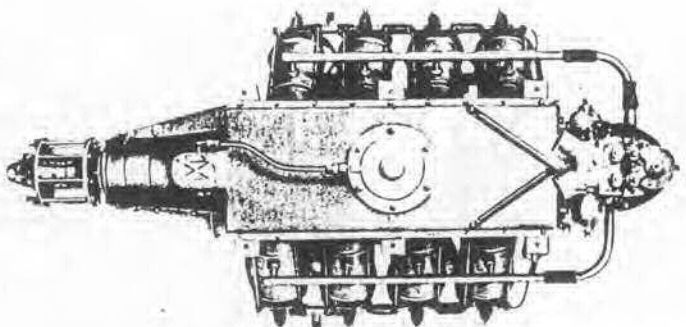
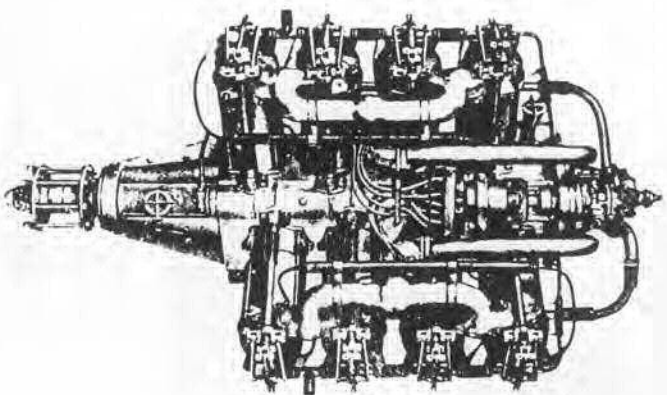
Rear View , Curtiss OX - 5 Engine



*CURTISS JN-4D OX-5*



*Standard J-1 OX-5*



# Description and Operation

## GASOLINE SYSTEM

A duplex Zenith carburetor is used on the OX-5 engine. It is adjusted for normal low test gasoline and no adjustments other than idling screw settings should ordinarily be made. For unusual fuels the main jets may be changed, but it is advisable to first consult the Zenith Carburetor Company for further details.

The four cap plugs under base of carburetor which are immediately below main and compensating jets, should be removed occasionally and freed of any water or dirt. This type of carburetor is unusually sensitive to water and foreign matter and must be protected to give the best results. For this purpose a gasoline strainer is provided in line between carburetor and tank, and drain on bottom of strainer should be flushed approximately every hour of operation to drain off any water or dirt collected.

The main jets foul most easily. A plugged jet will completely cut out one bank of cylinders except at idling speeds and is readily recognized in this manner. If jets are fouled they may be cleaned in place with a fine wire after removing cap plugs or they may be removed with a jet wrench for cleaning and inspection.

## COOLING SYSTEM

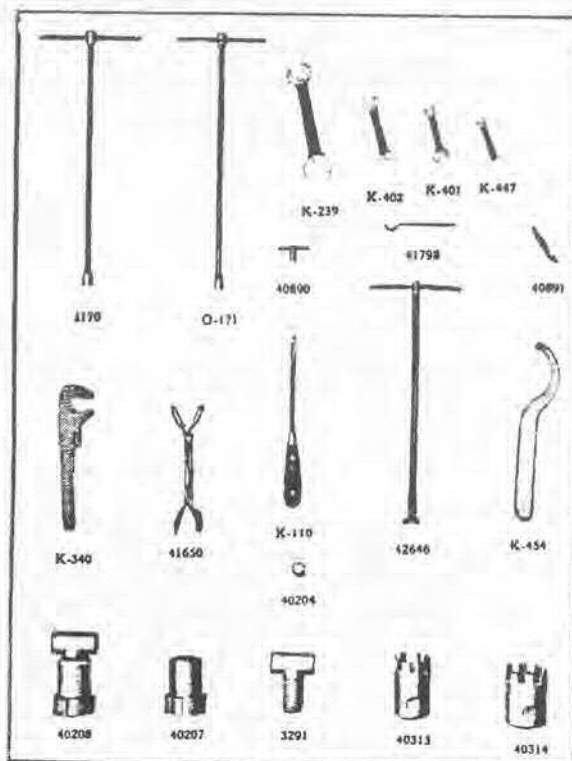
Engine cooling is by fresh water circulated through radiators, in motor car fashion. The water circulating pump is located on the front end of the engine and can be adjusted by packing nuts at either end. See that system is filled with clean fresh water and that small vent hole in top of radiator cap is not plugged.

## IGNITION SYSTEM

Oil the magneto every 25 hours running time with a few drops of light machine oil. See that distributor is clean. Wipe with dry rag if necessary. See that breaker points meet squarely and are free from pits. Adjust to gap of .018" when fully opened. See that high tension wires are not being chafed by valve action. See that spark plugs are screwed in tight against their gaskets and are not cracked or fouled. Adjust to gap of .023".

See that spark advance functions properly and occasionally check full advance position by examining quadrant lever on propeller end of magneto. Viewed in this way from the rear, the lever should be rotated clock-wise as far as possible for full advance. It is very important to have spark fully advanced when engine is running full throttle.

## TOOLS / for maintenance and repair



Complete Set of Tools, \$12.00.

NICHOLAS-BEAZLEY AIRPLANE CO., INC.

Part No.	Part Name	Quantity
K-110	11 1/2" Screw Driver	1
K-239	1/2" x 5/8" Double End Wrench	1
K-340	9" Adjustable Wrench	1
K-401	1 1/2" x 3/4" Double End Wrench	1
K-402	1 1/2" x 3/4" Double End Wrench	1
K-447	1 1/2" Open End Wrench	1
K-454	Thrust Bearing Lock Nut Wrench	1
K-455	Double End Spark Plug Wrench	1
N. B. 3	Piston Pin Clamp Screw Socket Wrench	1
O-171A	1/2" Socket Wrench, Swedish Tool Steel	1
O-171B	3/4" Socket Wrench, Regular Stock	1
3170A	1/2" Socket Wrench, Swedish Tool Steel	1
3170B	3/4" Socket Wrench, Regular Stock	1
3291	Screw, Propeller Hub Puller	1
40204	Seat, Swivel	1
40207	Body, Propeller Hub Puller	1
40208	Propeller Hub Puller Assembly	1
40313	Socket Wrench Crank Shaft Nut	1
40314	Socket Wrench Propeller Hub Nut	1
42640	1/2" Crowfoot Wrench, Swedish Tool Steel	1
41650	Water Pump Packing Nut Wrench	1
40890	Carburetor Jet Socket Wrench	1
40891	Magneto Wrench	1
41798	Intake Push Rod Wrench	1



In normal practice, the breakers on the magneto should open 28 degrees before top dead center on the firing stroke with the magneto in full advance position. This setting is usually checked in the following manner:

1. Turn the motor over in the correct direction of rotation until the inlet valve has closed on number one cylinder.

2. Remove spark plug on this cylinder and with a steel gauge follow the piston in its upward travel as the propeller is turned further in the correct direction of rotation and establish the top dead center position on this cylinder which from the valve setting has been established to be on the firing stroke.

3. Back up the propeller until the piston has dropped  $3/8$  inch below top dead center and check the breakers in full advanced position. This setting should approximate 28 degrees.

For racing purposes and under some conditions, it is permissible to advance the timing to  $1/2$  and in some cases  $5/8$  of an inch before top dead center, although it is not recommended for normal practice.

## OIL PRESSURE

After engine is thoroughly warmed up the oil pressure gauge on the instrument board should register between 45 and 60 pounds at 1400 r.p.m. If the oil pressure falls off gradually for no apparent reason, it is a probable indication that there is considerable wear, particularly end play, in the bearings. If this is the case, rather than adjust the pressure regulator valve, the bearings should be tightened. If the pressure is increased with worn bearings, an excess of oil will be forced through the bearings, and result in too much oil to the cylinder walls. Over-oiling, fouled spark plugs and excessive carbon formation, may be caused by the practice of indiscriminately increasing the oil pressure.

After starting the engine, if the oil pressure gauge fails to show any pressure, stop the engine immediately and ascertain the cause. The failure of the gauge to show the required pressure may be due to the following causes:

1. Use of an oil too light in body. (Follow the instructions in this book.)

2. Loose bearings, due to wear or improper adjustment. (Refit bearings.)

3. A leaky or broken oil tube. (Tighten connections, inspect oil tubes and replace if necessary.)

4. Clogged oil screen. (Follow instructions for cleaning.)

5. Pressure regulator valve improperly adjusted. (Follow instructions for adjusting.)

thickness of the fibre washer under the head of the screw which bears against the pressure regulating valve spring. To increase the oil pressure remove the fibre washer and to decrease the pressure insert one or more washers until the required pressure has been obtained. Adjust pressure only when engine is warm and has been running fast.

### **DRAINING CRANKCASE OIL**

Periodic draining of the oil reservoir is one of the most important factors in reducing wear and in obtaining maximum efficiency of the engine.

Oil becomes contaminated with continued service. Its lubricating value is not actually destroyed but it does become thinned with the fuel absorbed by the oil film on the cylinder walls, which is scraped back or blown by the piston rings and mixed with the crankcase oil. This dilution is greatly increased when the carburetor is set for an over-rich mixture. The crankcase oil also becomes further contaminated with particles of worn metal and by carbon flaking off the under side of the piston heads.

The crankcase should be drained after the first ten hours of service on a new engine and thereafter every twenty hours of service. To do this remove the plug in the bottom of the crankcase.

The best time to drain the oil is immediately after a run when the oil is hot and thoroughly agitated. This oil is more fluid at the high temperatures and if thoroughly agitated will carry off any sediment that may be in the oil.

### **TO CLEAN THE OIL SCREEN**

After every twenty hours of service the oil screen should be removed and thoroughly cleaned so as to prevent the possibility of stoppage of the oil flow. This is readily accomplished by removing the nuts which hold the screen assembly in place in the bottom of the crankcase.

Wash the screen assembly with kerosene or gasoline and dry with a lintless cloth. Do not use waste.

## LUBRICATING SYSTEM

The Curtiss OX-5, eight cylinder, water-cooled engine used in the WACO employs a force feed system of lubrication.

The lower half of the crankcase or sump serves as the oil reservoir. Oil is drawn first through a strainer in bottom of sump and then through an exposed oil line, below the crankcase, to the gear type oil pump on propeller end of engine.

The oil now under pressure is forced to the front end of the hollow camshaft, through an external delivery pipe, from which it reaches the camshaft bearings through radial holes drilled in the journals.

After lubricating the camshaft bearings, the oil enters annular grooves in the camshaft bearings which register with the radial drillings in the camshaft journals, thence into drillings, to the crankshaft core and journals lead the oil, which is still under pressure to the connecting rod bearings.

Excess oil, forced out of the connecting rod bearings, is converted into a fine mist or fog by the whirling action of the crankshaft. This mist permeates the interior of the crankcase and lubricates the cylinder walls, pistons, piston pin bearings, cams and valve tappet guides.

The lower half of the crankcase is so designed that its center is always at the lowest point. This construction insures the oil remaining in the oil sump at any angle of the plane, and prevents the oil supply from flooding the cylinders.

Inside the crankcase there is also an oil pan partition which slopes down toward the center of each side. At the center of the oil pan a hole about one-half inch in diameter allows the returning oil to enter the oil reservoir or sump from which it is recirculated by the pump.

An adjustable, spring controlled, oil pressure regulator (Relief Valve) is incorporated in the oil line. It is located on top of crankcase at propeller end of camshaft housing. Its principal function is to control oil pumping by regulating the amount of oil projected by the bearings on the cylinder walls.

When the discharge of the pump becomes greater than that required to lubricate the bearings and cylinder walls, the excess pressure automatically raises

the valve against the adjusted resistance of the spring, discharging the surplus oil through a suitable opening back to the sump. It also serves as a safety valve to keep the pressure within bounds should excessive resistance develop in the discharge line.

The discharge from the relief valve lubricates the timing gears.

We recommend an oil of the body and character of Mobiloil Aero "H" for use during the warm months of the year and an oil of the body and character of Mobiloil Aero "W" at atmospheric temperatures below 32 degree F.

Oil all rocker arms and the whole push rod action before starting motor unless they are already sufficiently lubricated. Oil the engine controls occasionally to keep them operating properly. Use engine oil. Mobiloil Aero "H" summer and Mobiloil Aero "W" winter.

### VALVE ACTION

Both inlet and exhaust valves should have a clearance of 10/1000 of an inch when the engine is cold. Adjustment is made by backing off lock nuts and turning the push rod for the exhaust valves, or the pull tube for the intake valves. See that all set screws on the rocker arms and all lock nuts are tight and that sufficient valve clearance is allowed. It is better to have them too loose than too tight as a valve which has not sufficient clearance to close will cause severe damage.

See that all valves close properly and that valve spring tension is O.K. A weak spring means slow closing action at high speed and will cause loss of power and burning of valves. Leaky exhaust manifold gaskets may cause gasses to impinge on exhaust valve springs and reduce their tension, and this should be watched. Never run engine with badly leaking or poorly seated valves. It will cause serious burning of valves and valve seats in cylinders.

NOTE: In checking the timing of valves the clearances of both inlets and exhaust should be set as specified above. The engine should then be turned over in the correct direction of rotation and the exhaust valve should just close as the piston reaches top dead center on number ONE cylinder.

Actual values for the opening and closing of all valves is given as follows:



Inlet valve opens 15 degrees after top dead center.

Inlet valve closes 40 degrees after bottom dead center.

Exhaust valve opens 48 degrees before bottom dead center.

Exhaust valve closes 3 degrees after top dead center.

NOTE: A variation of 3 degrees from this setting is permissible.

### SLUDGE

"Sludge" is an emulsion of oil, impurities and water which accumulates most frequently in cool running engines. Water vapor constitutes a large percentage of the exhaust gases in normal combustion. Unless the piston sealing is absolutely perfect, a small portion of this burned gas passes into the crankcase. If the crankcase is kept normally hot, the water vapor will pass off through the breather without condensing. In a cold crankcase it will condense. The water may settle to the bottom of the case or may be continually circulated and mixed with the oil. In either case, sludge is apt to form from the agitation of the oil and water, together with the impurities which are always found in the crankcase.

In winter this difficulty is aggravated from the fact that crankcase temperatures are lower and condensation more rapid. The danger is increased from the fact that the condensed water vapor may freeze and completely stop the oil circulation.

If the water has not been thoroughly mixed with the oil, this freezing may be localized at the low point in the crankcase. If there is a sufficient quantity, the oil circulation may be blocked with ice. If the water is kept in constant agitation it may freeze in crystalline form throughout the whole body of the oil, with the apparent result of thickening the oil so that it will not circulate.

Sludge formation can be controlled by careful attention to the following details:

1. Drain the oil at specified intervals, or oftener if the service consists of short intermittent runs in which the engine does not reach its normal temperatures. This will prevent the accumulation of too much water.

2. Use a suitable radiator cover or shield in winter. By keeping the engine normally warm the condensation of water vapor in the crankcase will be avoided.

### **HOW TO AVOID OIL PUMPING AND OBJECTIONABLE CARBON DEPOSITS**

"Oil pumping" in the common use of the term refers to the accumulation of oil in the combustion chambers rather than to the quantity which actually passes the pistons. With adequate cylinder lubrication there is normally a certain quantity of oil passing into the combustion chamber. If it is burned, its presence is not objectionable — but if it accumulates, fouled spark plugs, sticky valves and excessive carbon deposits are likely to result.

A hot running engine, operating under a full load, will burn a heavier grade of oil than a cool running engine working at quarter load or less. Too heavy an oil in low temperature service frequently fails to burn cleanly. The result is "oil pumping". It is obviously useless to try to correct an oil pumping condition by the use of a heavier oil than has been recommended with reference to engine design and working temperatures.

Wear of cylinders and pistons which has increased the normal clearance or wear of the piston rings may be responsible for an excess of oil in the combustion chamber. Wear of the rings in their grooves will cause a definite pumping action, lifting the oil mechanically into the combustion chamber. When wear occurs it must be remedied by renewing or re-fitting the parts affected. With correct lubrication, wear of this nature will be greatly reduced.

Carbon accumulation in the engine is also the result of incomplete combustion — either of the oil or of the fuel. This failure to burn the fuel and oil completely may be due to the lack of sufficient air for complete combustion or to the lack of sufficient heat for proper vaporization.

Oil pumping and excessive carbon deposits may be controlled by careful observance of the following suggestions:

1. Fill the crankcase to its proper level daily. Do not over-fill. Over-filling may cause over-oiling with consequent oil pumping and carbon formation.

2. Use a high quality oil of the body and character recommended in this book. Either the incorrect grade or a poor quality may make trouble.

3. Do not try to compensate for wear by using a heavier bodied oil than has been recommended. The heavy oil, when heated will pass the pistons almost as readily and will be harder to burn. The trouble will, therefore, be aggravated instead of corrected.

4. If the oil pressure falls off gradually — a probable cause is worn bearings, which allow too much oil to be sprayed from the bearing clearances to the cylinder walls. If this is the case, it is obviously wrong to try to correct the condition by increasing the pressure and feeding still more oil, or by changing to oil of a heavier grade. If the oil pressure is not what it should be, an investigation should be made by a competent service man.

5. Be sure that the carburetor is not feeding too rich a mixture. If there is not enough air to consume all the fuel, there certainly will not be enough to consume any excess of oil which passes into the combustion chamber. Incomplete combustion means carbon.

6. "Missing" promotes oil pumping and carbon formation because the oil normally passing into the combustion chamber is not burned. Keep the ignition system in good order.

7. Compression losses affect the efficiency of the engine and the complete combustion of oil and fuel. Keep the valves properly ground in — the tappets properly adjusted and the cylinder head gaskets tight.

## IMPORTANT

See that radiator is filled with clean fresh water and that there is sufficient oil and gasoline. See that gasoline tank filler cap is screwed on tight. See that propeller is not fouled by anything.

Open throttle very slightly. Pull out choke as in motor car practice, varying amount of choke with the temperature of motor when start is made. With ignition switch in "Off" position, turn motor over until choked sufficiently. Turn ignition switch to "On" position. Motor should immediately start.

Push off choke as quickly as possible, handling it as per usual motor car practice. Never speed

engine over 800 r.p.m. until motor is warm enough to run without use of choke, and until water temperature gauge shows at least 120 degrees F. Watch oil pressure gauge to see that it is registering at least 20 pounds even at slow speed. If motor does not start it may be that motor has become loaded. To correct this turn off ignition switch, open throttle and turn motor several times in reverse direction. Motor should now start when cranked again.

**CAUTION:** Aircraft engines have aluminum pistons which expand greatly when heated and therefore, require large clearances when cold. It is, therefore, very important not to speed up engine until same has been run at slow speed long enough to thoroughly warm it up.

Engine should always be idled for several minutes before shutting off, to allow valves to cool slowly. If attempt is made to shut it off suddenly after running at full speed, pre-ignition may cause it to run after switch is turned off, and this condition must be studiously avoided.

## MODIFICATIONS

Lets clear up one important detail ! The Curtiss OXX-6 was not a modified OX-5 ! Although the OXX-6 incorporated many of the distasteful features of the OX-5 design , it was built to Navy specifications which included provisions for two magnetos , two spark plugs per cylinder , improved pistons , improved valves and exhaust valve guides. Navy specifications called for the engines to be delivered with Dixie magnetos rather than the troublesome Berling models.

Millerized modifications to the basic OX-5 engine - created by an automotive engineer named Miller - consisted of changing the exhaust valve rocker arm from a flat tappet type to a roller type , improved valve guides , improved valve springs , and the addition of a helper yoke for the weird intake push rod system. Zerk fittings were also incorporated to replace the multitude of oil holes in the valve overhead system. And the good Mr. Miller strongly advised that if you did all this to your engine , you would be smart to include a new Scintilla magneto to that thing referred to as a Berling !



# A Few Good Words

1. Don't forget to inspect the motor thoroughly before starting.
2. Don't try to start without oil , water or gasoline.
3. Don't forget to see that the radiator is full of water.
4. Don't get dirt or water into the gasoline.
5. Don't get dirt or water into the oil.
6. Don't forget to oil all exposed working parts.
7. Don't try to start without turning on the switch.
8. Don't start the motor with throttle wide open.
9. Don't run the motor at idle too long ( it is not only wasteful but harmful ).
10. Don't forget to watch the lubrication , it is most essential.
11. Don't forget that the propeller is the business end of the motor , treat it with profound respect , especially when it is in motion.
12. Don't cut off the ignition suddenly when the motor is hot , allow it to idle a few minutes at low speed before turning off the switch.
13. Don't forget to drain the Jet Wells.
14. Don't forget to drain the Gascolator.
15. Don't develop that destructive disease known as "tinkeritus" , when the motor is working all right , leave it alone.
16. Don't forget a daily inspection of all bolts and nuts , keep them well tightened.
17. Don't forget to study this instruction book thoroughly.

# GLEANINGS

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Questions about fuel for the OX-5 are always interesting. The OX-5 does quite well on just about any top grade high test fuel, automotive or aviation type. Anything above 80 octane. And be sure to "Double Chamois" it! Standard Premium and Amoco White were old favorites.

Lubrication is important. Use only top grade aviation recommended oil. Standard, Stanovo, Kendall, SAE 100 year round. But drain and re-heat in winter. You know, the pot bellied stove!

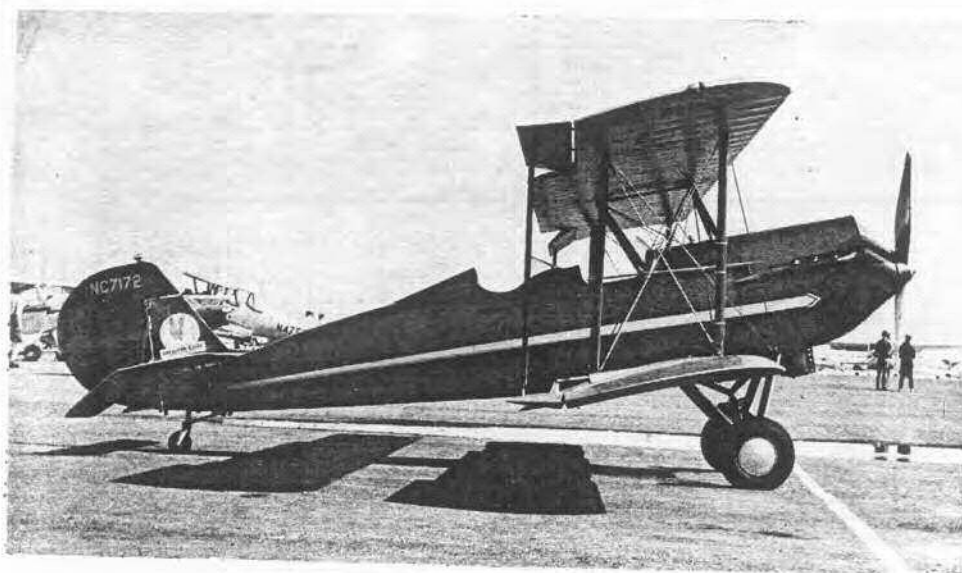
Clean water is a must. Strain if necessary. Sand and twigs will eat the heart out of a water pump - and hot water spots will ruin your goggles!

A word about the rocker arm system. Go Zerk ASAP!

Cover that Berling before washing down the OX-5. Most any cleaning solvent will soften that rotating coil and it will get hot and separate very fast. This means you will soon be looking at a cornfield or cow pasture you have not seen before.

Keep plenty of good wax on that propeller. Sleeve cover at night or whenever not in use can save you dollars.

Increase your OX-5 engine life by flushing during an oil change. Flushing oil is available but if not, make your own. One part filtered kerosene, one part 20W auto oil or any this weight oil. Clean engines, inside and outside run cooler.



### AMERICAN EAGLE

The OX-5 was the stock engine. Optional engines were the OXX-6, 150 "Hisso" or 165 J6-5. A very popular three seater.

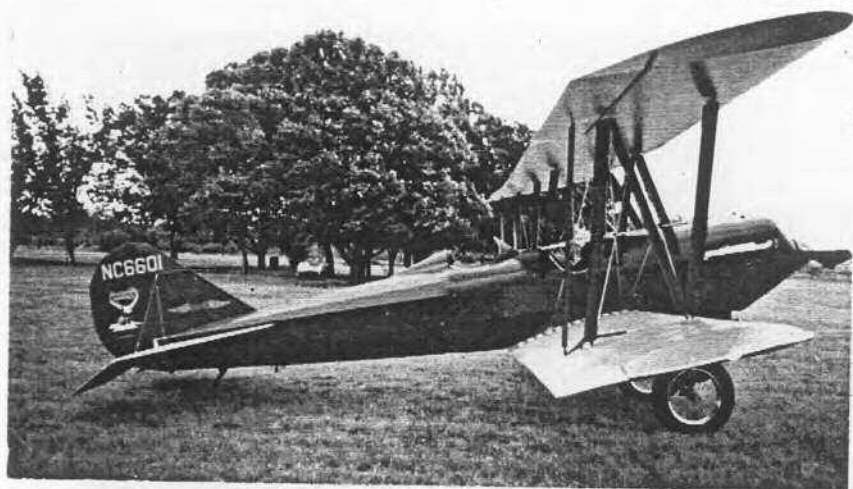
### CURTISS ROBIN

OX-5 was stock in early models. Later models featured the 165/185 Challenger by Curtiss or the 165 J6-5 by Wright.



### TRAVEL AIR

The 2000 model and the 3000 model were available with the OX-5, but the OX-5 was stock on the 2000 model. The 150 "Hisso" was stock on the 3000 model.

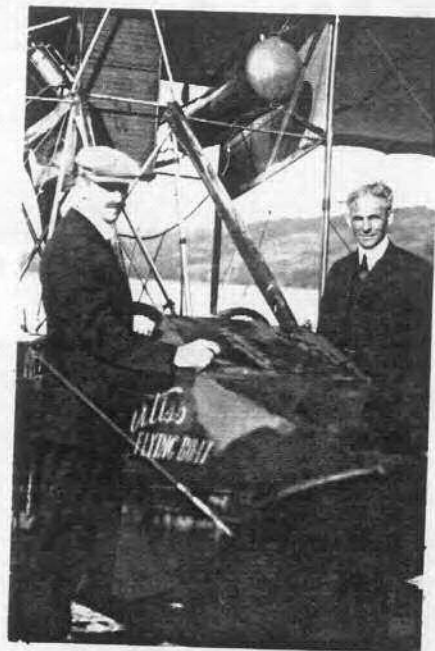


Top Photo

ALEXANDER EAGLEROCK , A-2 Model. The OX-5 was the stock engine.

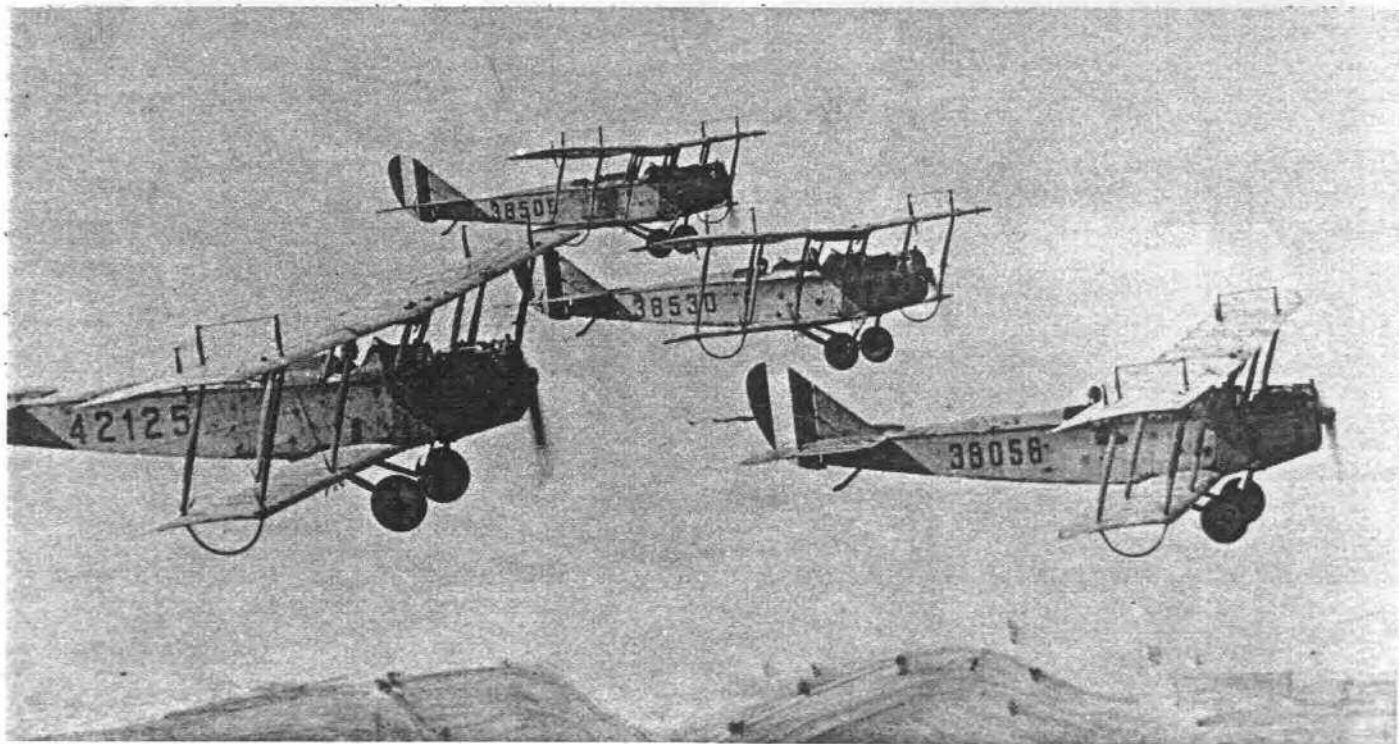
Right Photo

Glenn Curtiss and Henry Ford inspect late model Curtiss flying boat. Engine is Curtiss OX-2.

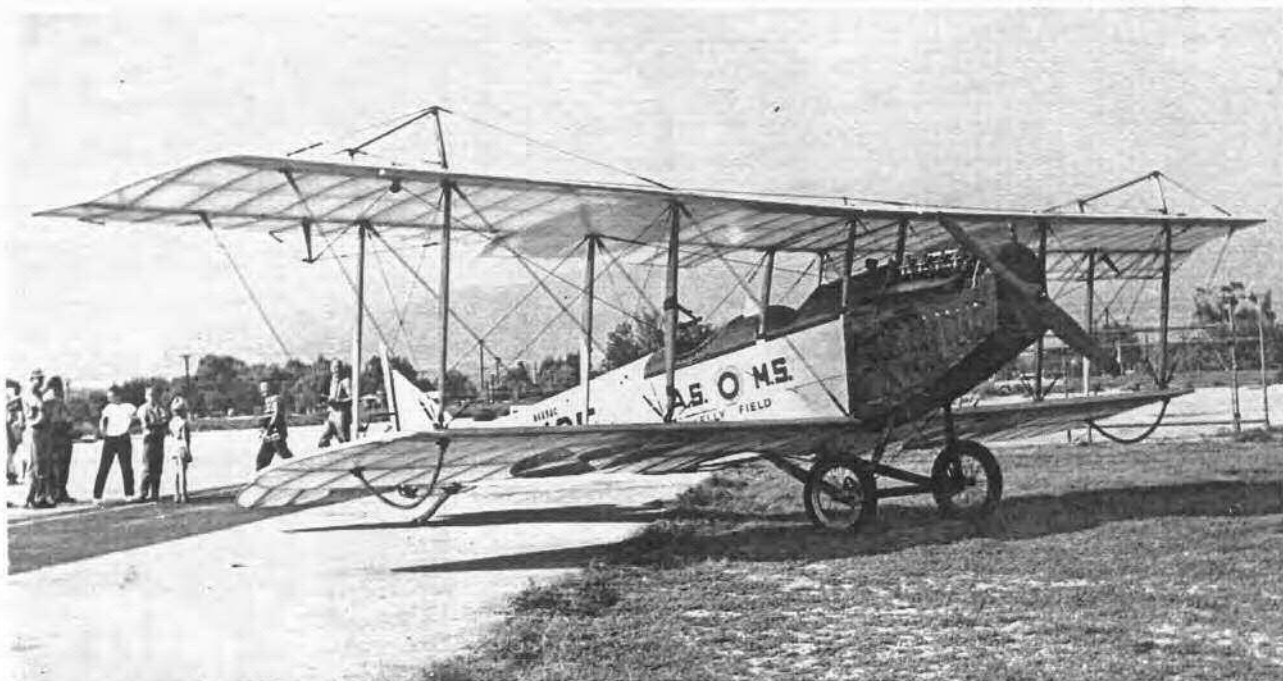


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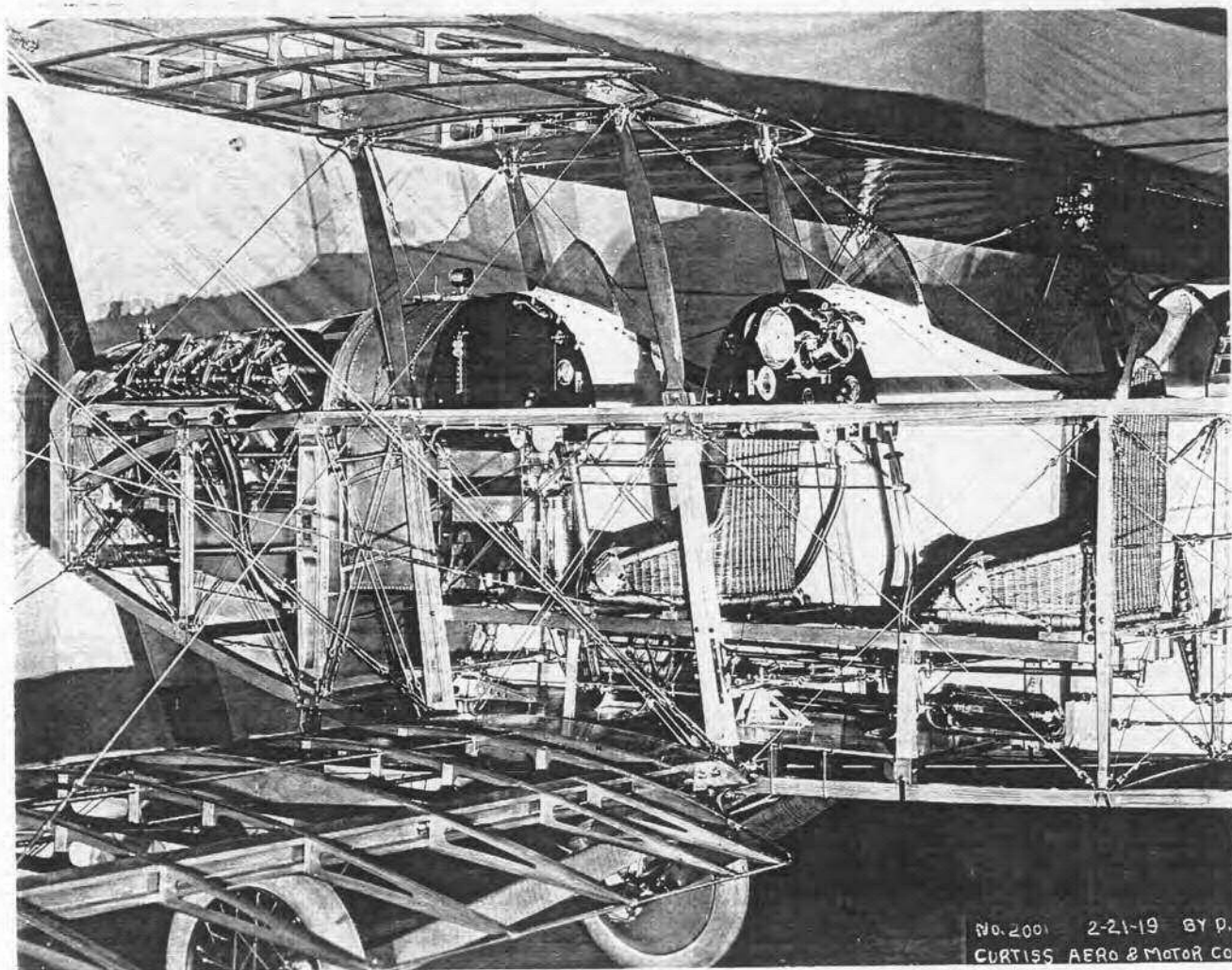
Four Curtiss JN-4 aeroplanes practice formation exercise near Kelly Field , Texas . Circa 1918.







Curtiss JN - 4D Restoration. Stock Engine Curtiss OX - 5

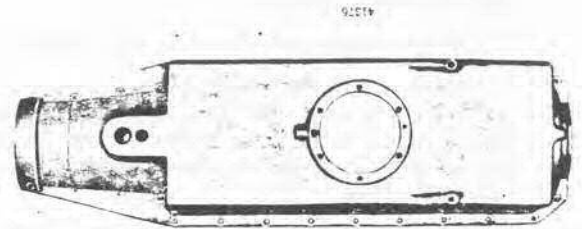
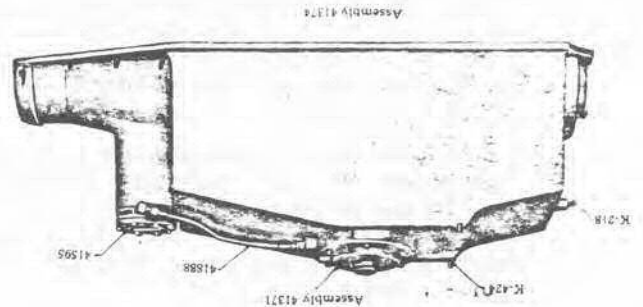
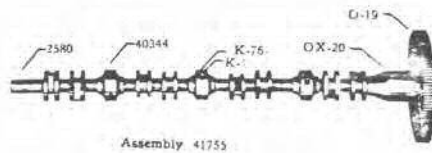
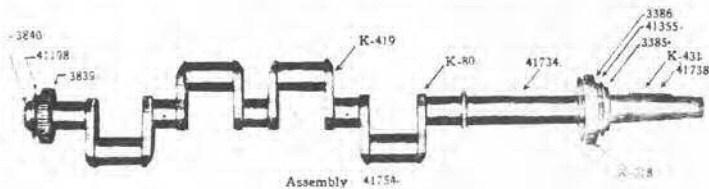
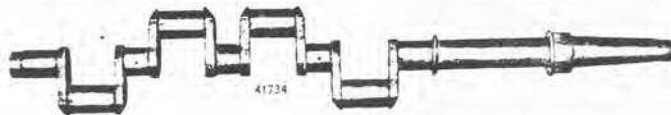
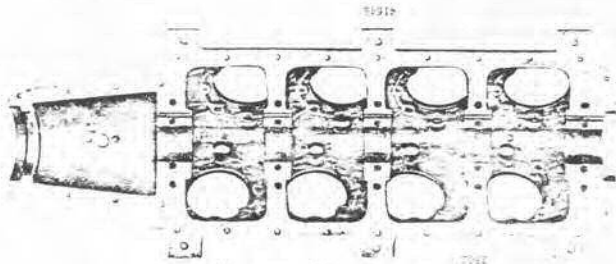
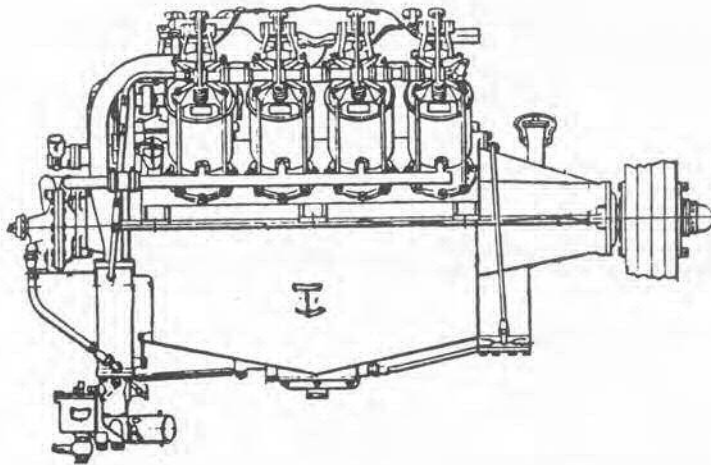


Fuselage and Engine Mount Construction Details

No. 2001 2-21-19 BY P.  
CURTISS AERO & MOTOR CO.

# MAINTENANCE AND OVERHAUL

## Curtiss OX - 5



## THE DISASSEMBLY OF THE CURTISS MOTOR

What should be done before disassembly.—Inspect engine as a whole to determine general layout and consider best order of removal of parts. Notice any fractures or signs of trouble or heating.

Determine direction of rotation of motor. This is done by turning the engine over and carefully watching the operation of the valves of any cylinder, remembering the fact that in the proper operation of a four-cycle motor the inlet valve will open at the same time or immediately after the exhaust valve closes. If the motor were being revolved in the wrong direction, this order of operations would be reversed.

Check valve clearances after making sure that they are at neutral point. All valve clearances should be roughly checked in taking the motor down, at this affords an opportunity to detect a bent or sprung rocker arm. (In taking clearance measurements, the tappets must be held away from the valve stem with one hand to get the full measurement.)

Check timing of valves by piston distance. (Exact method will be described later.)

Check timing of motor as hereinafter described.

**Removing minor assemblies.**—Remove high-tension ignition wires and spark plugs. Be sure to immediately fill spark-plug holes with plugs of soft wood or some other material that will not chip, to prevent cotter pins or other foreign bodies from dropping inside of the cylinders.

Remove carburetor and duplex manifold as one unit after disconnecting water tubes.

Remove inlet water manifolds, breaking the hose joint which is next to the water pump.

**Removing rocker-arm assemblies, manifolds, and pump.**—Next remove rocker-arm assemblies complete by removing two nuts on top of each cylinder, and two at the base of the tie-down straps. In releasing the tie-down straps, tension may very conveniently be taken off the nuts while unscrewing by placing the jaws of a monkey wrench above the tie-down straps and around the hollow push rods. Very slight pressure downward on the wrench handle will make it bind and hold down the spring without doing any injury to the push rod. The inlet manifold assemblies complete may be removed next, care being taken to save and not injure the gaskets.

Next the pump and timing gear end plate should be removed.

**Removing magneto.**—The magneto and base plate may now be taken off and the magneto sent to the electrical repair room for overhauling.

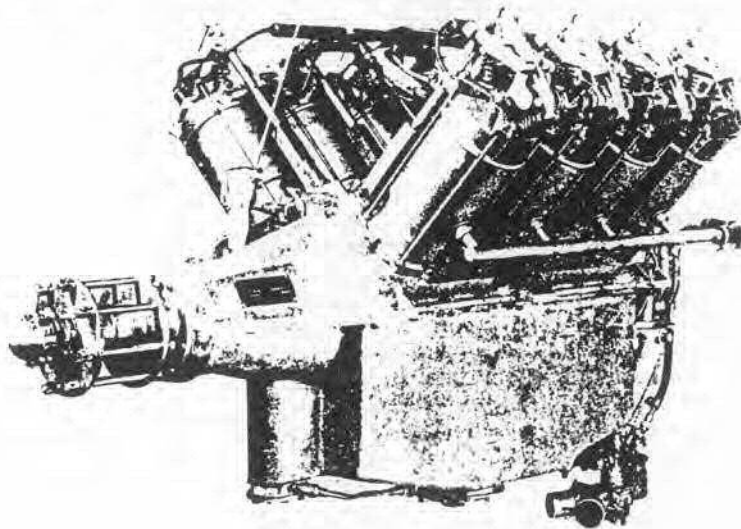
**Removing cylinders.**—Nothing remains on the top of the crank case now but the cylinders. If, after all nuts have been removed, the cylinders stick, a slight tap of the hand will release them from

the case. They should then be raised carefully, first making sure that the gaskets are coming up complete with the cylinders. When the cylinders are being raised clear of the pistons make sure that someone is holding the piston so that in case the wrist pin bearing is free the piston will not fall over and hit its skirt against the connecting rod. Pistons falling over in this way may be very easily broken, but if not actually broken, the skirt will become at least dented outward or cracked.

Care must also be taken not to bend outward the cylinder tie-down rods. In order not to do this, the cylinder must be raised to the top of the stud and held there while the four nuts are unscrewed over the thread at the top of the studs.

**Revolving crank case; removing sump and connecting rods.—**Now the motor may be turned upside down. (Warning—Make sure that the motor is tightly bolted to the revolving stand by all four legs, and that oil has been drained.) First remove the oil pump and connecting pipe, then the face plate on the hub end of the crank case, then after removing all bolts the entire sump may be lifted off. Here again care should be taken not to destroy the paper gasket that runs under the sump. The strainer may now be removed from the sump and washed with gasoline or kerosene, and the whole sump carefully examined for cracks.

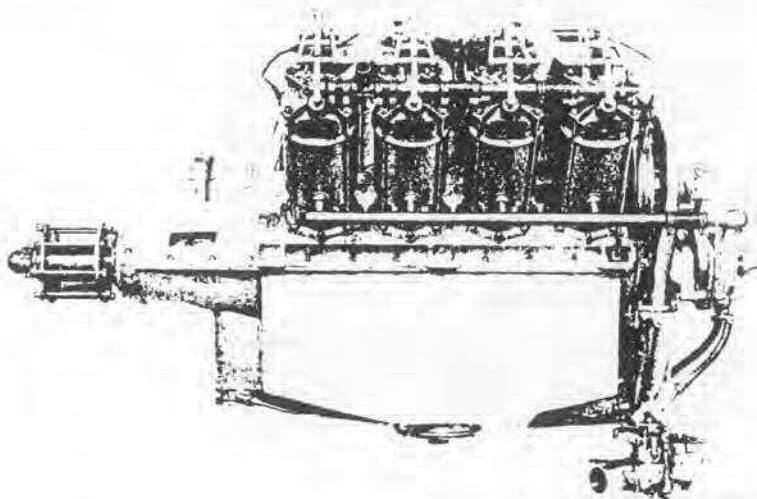
The connecting-rod bearings and main bearings are now exposed. Remove all cotter keys. The caps of the connecting-rod bearings may now be removed, care being taken to hold each rod so that it will fall through when the nuts are released. Each cap should be





replaced on its own connecting rod, and all nuts must be released with a proper fitting socket wrench.

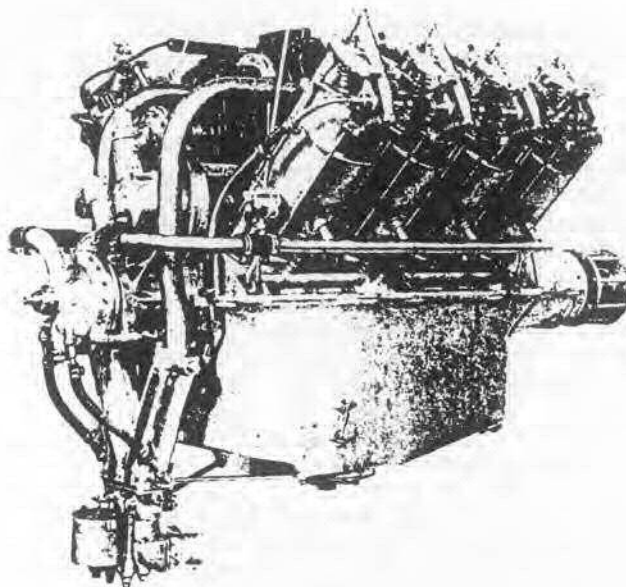
**Removing, examining, and handling of crank shaft.**—Before removing crank shaft examine clearance between cam gear and crankshaft gear in order to determine whether or not the bearings will have to be raised. Then the crank shaft may be taken out. In removing the bearing cap nuts a socket wrench should always be used and should be carefully fitted so that it will never slip. When nuts are removed, the caps can best be lifted with the use of a special tool in the form of a lever with a fulcrum attached. Caps



### **OX5 Engine Side View**

should not be pounded with any kind of hammer to free them. Before raising the crank shaft out of its bed, pieces of rubber tubing should be placed over the bearing studs, in order to prevent the shaft from scraping against the threads when it is being lifted out. This is very important, because the threads are much harder than the shaft, and the least touch will cause a nick in the journal. If the bearing has shims between the halves, it is well to prepare a board with nails for the nuts and shims. In laying the shaft down on the bench, care should be taken to rest the shaft on its side on a flat board so that it will get bearing surface at more than two points, giving an equal distribution of the weight of the shaft.

If the shaft is laid down resting on the gear and thrust bearing only, it will almost always bend a few thousandths out of true. The crank shaft should now be thoroughly washed with kerosene, special care being taken to blow out all oil passages. This may well be done by squirting kerosene into the different holes with a grease



#### **OX5 Engine 3/4 Rear**

gun. Shaft should now be very carefully examined for signs of wear and crystallization, which is noted by a peculiar flaky appearance of the steel. If there is any sign of crystallization, the shaft should be discarded. Early crystallization is due to the incessant hammer-like blows delivered to the shaft by the connecting rods, as the engine runs at full speed all the time.

**Removing the cam shaft.**—All of the motor has now been taken down except the cam shaft. First, all of the bearing set screws should be removed. Then a special Curtiss cam gear puller should be fitted to the gear, and the whole shaft and bearings may be easily drawn out. Very light tapping on the sides of the bearings with a piece of fiber and a hammer will ease out the bearings if they bind at all. Before removing the bearings from the shaft, it should be noted whether they are numbered, so that they may be put back in the same order. The cam shaft should now be carefully cleaned, both inside and out, in the same manner as the crank shaft. Then the crank case may be thoroughly washed out and examined for cracks.

#### **ASSEMBLY OF THE MOTOR**

**Preparatory inspection.**—In building up the motor, the greatest care must be used in the inspection of the parts. The least crack of any kind should be sufficient to condemn the part. Before assembling, all parts must be very carefully cleaned with kerosene or gasoline, and after becoming dry all bearing surfaces must be

covered with a coating of oil. This because, if the motor be assembled dry, it may be forced to run for some time before the pump is able to circulate oil to the remote parts of the engine.

**Fitting cam-shaft bearings.**—As the cam shaft was the last part to be removed from the engine, so it is the first part to be replaced. First, examine the cam gear for wear in the teeth, then examine the shaft. It should be tested in a lathe for straightness if it binds in any way. The split bearings must be screwed together tightly without shims and should not have over 0.0015 to 0.002 of an inch clearance on the shaft. These may be tried before replacing the shaft. The bearings, if all right, should be removed from the shaft and tried in their proper location. The cam-shaft bearings should fit in their casings with an extremely light driving fit. If loose, new bearings should be procured. Remove these bearings, slip shaft into position, then replace bearings around the shaft in a position adjacent to the casing which is to retain them. Great care must be shown in determining that the oil holes in the bearings properly register with the holes in the webs and also with the holes in the shaft. Notice the small shoulder on front bearing and see that this is guided properly into its place. Set up retaining set screws. It should now be possible to rotate cam shaft easily with one finger on the gear.

**Inspecting and checking the crank shaft.**—The first operation in fitting the shaft is to cover the journals with a very thin coating of prussian blue and then lay it in its bed to get a preliminary marking. The thrust bearing should also be blue; and it may be noted here that this bearing should have been carefully inspected, especially to see that all balls have a perfectly smooth surface, scars indicating a future break. After rocking a few times, the shaft is removed and all markings examined carefully. Not much can be said on paper about the proper method of fitting bearings, but the following bits of advice and warning should be heeded: First, do not do any scraping until you have considered the markings on all bearings in conjunction with each other, and have decided the effect that the removal of metal from one spot may have on other bearings farther down the line. When it has been decided to scrape a spot, use a long stroke which will lift the tool off the surface while it is still moving forward; that is, do not stop the stroke of the tool in such a manner that it will leave a nick. Scrape a spot a little larger than that actually covered by the blue spot, as this surrounding area will undoubtedly mark blue on the next trial, and time will be saved by removing this at first. The bearing surface should not be carried entirely up on the sides of the linings, a two-thirds surface being sufficient. When this is procured on the five bearings, attention must be paid to the thrust bearing and gear. Both should be loose and bear no part of the weight. With the end bearing cap screwed down tight it should be just barely possible to rotate the thrust bearing with the fingers. There should always be a clearance between the cam and crank-shaft gears. This can be "felt" by hand as well as seen with a clear eye, and should be between 0.001 inch and 0.003 inch, meas-

ured parallel to the circumference of either gear. On no conditions should a cam gear be filed to give more clearance; and if there is tightness here or at the thrust bearing, the trouble is that the bearings are too low and these should be renewed.

**Placing new bearing shells.**—If it is found necessary to put in new bearing linings, these should be pressed into place with the use of a jig, and held while retaining screws are being inserted. It is well also to allow the edge of the lining to extend about 0.0005 inch above the surface of the casing on both sides, so that when the two halves are clamped together the bearing lining may be further and more completely seated. If no new bearing linings are at hand and the shaft must be raised, 0.002-inch shims may be placed under the bearing linings. This is not good practice, however, and is not to be commended. If shims are used they should be cut to cover the whole surface with the exception of oil holes, and should furthermore extend above the surface about 0.0005 inch in order to be pressed down properly into place. If bearings are shimmed, it will be found necessary to scrape a little off the sides of the linings, as the action of the shims makes the horizontal diameter of the bearing 0.004 inch less, while it decreases the vertical diameter only 0.002 inch.

**Aligning and fitting the main bearing caps and shells.**—Having obtained a proper bed for the shaft, the caps must now be considered. These should first be fitted to the case to insure a true surface, with no tendency to rock. Then all should be set up in place, and motor turned over so that shaft will rest on caps. A marking with bluing should be made in this position, and high sections cut away, as was done in the other half. Then allowance should be made for the clearance of 0.0025 inch in the following manner: A piece of 0.002-inch shim stock should first be laid in the bottom of each bearing under the shaft. These pieces should run the whole length of the journal, but should be only about one-half inch wide. By this method the shaft is raised up a trifle over 0.002 inch and the caps may be fitted until they are a very snug fit. This is done in the same manner as the lower caps, only one at a time. They should be scraped until there is a two-thirds bearing surface, and until the shaft may be turned only with considerable force by hand when the cap is completely screwed down. In screwing down bearing cap nuts, great care must be taken **not to strain** the threads. It is very easy to put too much power into a well-fitting large socket wrench and thus seriously strain the threads. Moreover, only a socket wrench should be used in screwing up these nuts. When each cap has been fitted, shims are removed, and all caps screwed down, after first covering the bearing surfaces with a coat of oil. The shaft should then turn quite freely, and thrust bearings and gears should have proper clearance. In case there is too much clearance, the caps must be filed down. This may be done by drawing the ends of the cap back and forth over a strip of crocus cloth placed on a surface plate. Care must be taken to keep the surface true.



**The "end play" of the crank shaft.**—Nothing yet has been said about the end-play adjustment of the crank shaft. This is determined entirely by the thrust bearing. It will be found that with no thrust bearing there will be allowed about three sixty-fourths inch of end play to the shaft by the webs of the crank case. If the motor is to be used as a tractor, as is usually the case, this end play should be adjusted so that two-thirds of the space is toward the forward end of the motor. This is done so that the forward pull of the shaft will cause the throws to center themselves between the webs as wear appears in the thrust bearing. If it is necessary to set the shaft to the rear, this may be done by introducing a thin shim between the thrust bearing and the shoulder on the shaft. But if the shaft must be set toward the front, it is necessary to put the shaft in the lathe and take a very fine cut from the shoulder on the shaft. No shims can be placed between the thrust bearings and the case.

**Safety locking bearing nuts.**—In regard to the proper placing of cotter pins in the bearing nuts, there is much argument, but the following points stand out preeminent:

**First.**—No nut must be turned backward or loosened to make the cotter-pin holes line up. If it can not be turned forward to the next slot in the castellations without straining the threads, the nut should be removed, and the bottom surface filed a very small amount. This process should be repeated until the nut will turn nicely up to a slot in the castellations.

**Second.**—The cotter keys must completely fill the holes in the stud bolt.

**Third.**—They must be so placed that they do not wiggle or feel loose in any way when touched by the fingers.

**Fourth.**—The cotter keys must not be bent over with a hammer, but should be bent with a pair of round nose pliers. Bend one side of the cotter key up over the nut and the other side downward, unless in particular cases it is found to be distinctly better to bend both sides of the key around the nut.

**Preparing the piston assembly.**—The next operation in assembling the motor is to be assured that the piston assemblies are in proper condition. First, try the wrist-pin bearings. These should be, when cold, quite stiff, so that the pistons will not rock over with their own weight, but will require a fair amount of pressure with the hand. It must be remembered that when the bearings become hot, the aluminum pistons expand considerably more than the steel wrist pins and the bearings become sufficiently loose. If it is necessary to remove a wrist pin, the set screw is loosened and the pin pressed through. Next see that the set screws holding the wrist pins in the connecting rods, are screwed up firmly and properly locked with wire. It is very important that this wire be perfectly tight—can not be moved with the fingers. All carbon should be scraped from the inside of the piston as well as the out-

side, taking care to use no instrument that will scratch the aluminum. Examine connecting rods for possible cracks.

Next, remove the piston rings and carefully clean out the grooves. Do not pry ring out of groove if stuck, but put piston in hot water and ring can be easily removed. The rings may best be removed by inserting under them three or four pieces of hack-saw blades, the teeth ground off, and carefully sliding the rings from the piston. They should not be sprung more than is absolutely necessary. If the rings show signs of wear and do not have perfectly square and true surfaces, they should be renewed. If a new ring is found to be too thick to slip easily into the slot, it may be dressed down slightly by rubbing the top surface on a piece of fine emery placed on a surface plate. The bottom surface of the ring must never be dressed in this manner, as this is the surface that comes in close contact with the slot in the piston, and the true factory-ground finish should be left intact in order to assure a perfect fit between the piston and the ring. It should be noted that the factory trade-mark is always stamped on the bottom or the most perfectly finished surface of the ring. This will be found in very small markings at the point where the two ends of the ring come together. Any roughness on the pistons must be dressed down with a fine stone, and the pistons may finally be polished with Dixon's graphite, but no free flakes must be left on the surface.

**Fitting the connecting-rod bearings.**—Now that piston assemblies have all been completed, attention can be paid to the connecting-rod bearings. These are fitted much in the same way as the main bearings, except that each is done independently of the others. First, the lower halves should be scraped to a proper fit with two-thirds bearing surface. Then the caps are screwed on and the bearings fitted so that there will be a clearance of not over 0.002 inch. It will not be necessary to determine this clearance with the use of shim stock. The clearance may be determined by grasping the connecting rod in the hands and rocking it from side to side, taking care that the rod does not slip on the shaft. A clearance of two-thousandths may be easily determined in this manner after a small amount of practice. Another highly important point in the fitting of connecting rods is their perpendicularity. The best way to check this is by measuring the distance between two ends of mandrels in wrist pin and connecting-rod bearings, but much may be determined with the use of a square laid against first one and then the other side of the piston, and resting on some true part of the case. The bolts and studs should now be firmly cotter keyed, as in the case of the main bearings. In placing the connecting-rods on the shaft, it must be pointed out that there is a difference between the two sides of each bearing—the side of the bearing toward the adjacent connecting rod is finished off squarely, while the outside of each pair of rods has a rounded edge on the babbitt lining. While fitting the connecting-rod bearings, and in all subsequent work until the pistons are on, great care must be taken not to let the pistons fall over from one side to the other, in case the bearings are loose enough to allow them to do so. Also, when the shaft is revolved or the motor turned over the same care

must be taken with each connecting rod. This is very important, as the weight of a falling piston or rod is sufficient to bend or scar the piston. All nuts and cotter keys in the crank case must now be inspected for looseness. The surest way to accomplish this is to place the fingers on each nut, feeling for any looseness or lack of a key.

**Preparing to mount cylinders, grinding valves, and testing springs.**—The next unit to be added to the assembly is the cylinders; but first these must be inspected and the valves ground in. No serious trouble is likely to have happened to the cylinders unless the motor has become dry and they are scored. They should, however, be examined carefully for signs of this, and all carbon should be taken out by the use of a scraper that will not injure the cylinders. The valves should next be removed by pressing the cylinder against a forked piece of iron or the jaws of a vise which will compress the spring so that the key may be removed. All valve springs should be tested for tension. The proper data are as follows:

Exhaust valve spring, 35 pounds at a length of  $1\frac{5}{8}$  inches.

Inlet valve spring, 16 pounds at a length of  $1\frac{5}{8}$  inches.

While testing these, the intake pull-down springs may be tested. This type of spring should test 40 pounds at a length of  $2\frac{3}{4}$  inches. It is very necessary that the springs test very closely to the required amount, otherwise there will be vibration during operation. If a spring tests only slightly below the correct amount, the defect may be eradicated by the introduction of washers under the spring. It is highly important that these washers be placed under the spring and not out on the stem, for if placed at the latter point, they would increase the weight of the valve and change the operation.

**The valve-grinding process.**—After grinding the valves notice must be taken of the valve-stem guides. There should not be any noticeable looseness here, or air will rush in on the intake stroke, ruining the mixture. The valve seats should be inspected next to determine whether there is need of grinding at all. Very small pits may be disregarded, but large ones should be ground out as follows:

(a) Place a small amount of fine grinding compound on the edge of the valve and insert valve into its seat, taking care not to get any of the compound on the inside of the cylinder walls.

(b) Grasp the end of the valve stem with a valve-grinding tool which resembles a tap wrench.

(c) Rotate the valve upon its seat.

(d) Use very short strokes and lift the valve off its seat at the end of every stroke.

(e) Very little pressure must be exerted, but the compound must be renewed after a very small amount of grinding.

(f) The valve must not be pounded down onto its seat. It must be borne in mind that fresh compound continually redistributed on

past top center. All valve clearance should average 0.010 inch. If a timing disk is available, this clearance should be set on No. 1 cylinder and the gears meshed so that the exhaust valve is just closing at this point. This may be determined by placing a 0.001-inch or 0.002-inch thickness gauge under the rocker arm, the moment that this is released being the moment at which the valve is seated. If the gear teeth do not mesh at this point, the cam shaft should be moved so that the timing will be later rather than earlier, but not by an amount that would be in excess of 5°. After No. 1 cylinder is correct, each succeeding cylinder should be placed at 10° past and the timing checked up. Any small variation may then be corrected by changing slightly the valve clearance. If a timing disk is not available, the engine may be timed by piston distance, though this is not so accurate. In this case the piston should be allowed to drop one-sixteenth inch below top center and No. 1 exhaust valve timed at this point. The remaining clearances should be set at ten-thousandths, as this method is not accurate enough to correct by clearance.

**Preparing the magneto for mounting.**—The magneto should now be installed, but first it should be checked up in the following respects: The breaker-box cover should be removed, and small parts examined for wear or burning. The distributor head should be removed and the distributor wiped out carefully with a dry cloth. If the contacts are black, they may be burnished with very fine sandpaper; but if the surface is badly rough, it must be faced off in a lathe. After the surface has been made smooth and clean it should be wiped over with a rag moistened in oil to give it the most polished surface. The magneto should be rotated by hand quickly to see if a spark can be produced across the safety gap. If no spark is obtained, the magneto should be sent to the electrical room for repairs. The magnetos will not be further disassembled than above mentioned without being sent to the repair room. Whenever a magneto is removed from the engine, the distributor must be removed also and not left attached to the wires.

**Timing the magneto with engine.**—If magneto is found to be O. K., it is placed in position on motor. The timing of the magneto on the OX-5 is 32° before top center; of piston distance, about seven-sixteenths of an inch. The motor is accordingly placed in this position with respect to No. 1 cylinder. The magneto is then turned over until the distributor brush is in contact with the segment to be connected to No. 1 cylinder, and then adjusted until the breaker is just on the point of opening. The magneto is then slipped forward into position, great care being taken in meshing the gears not to turn the magneto armature over out of the position in which it has just been set. Very little oil is put on the magneto, just a few drops in the oil holes for each main bearing. The timing should be checked up with two or three other cylinders.

**Finishing up the gear end of the engine.**—After the magneto, the timing-gear cover plate should be put in place, the gasket being shellacked underneath and graphited on top, with due care that it



is not doubled under at any point. The screws holding this should be "safetied" with a wire running through all, and drawn tight. This wire must be so run through the successive screws that, if any one of them were to start to loosen, it would immediately draw the wire tighter. Next, the split plate at rear of magneto gear should be replaced. After this plate is in place, the motor is ready for the water pump. The pump should be taken apart to see that the vanes are in good condition and not rubbing on either side of the housing. If they are, the blades must be shifted on the pump shaft and shimmed. This shaft must be very smooth under the packing and all rust must be carefully removed, otherwise it will wear the packing out rapidly and cause the pump to leak. The packing is a wick packing, and a piece about 8 inches long is required. In taking the pump apart the housing opposite the coupling will slide off after the nut is removed, but it frequently comes very hard, so care must be taken not to bend it or injure the gasket between the two halves. The gasket should be covered with shellac on one side and graphite on the other. The screws holding the pump together may be "safetied" with lock and flat washers. After the pump is in place, the air pump is added, if one is used. This is a simple plunger pump, the bearings of which should be looked over for excessive wear.

**Placing the sump.**—It is now necessary to turn the engine over in the stand and put on the sump. This should be carefully cleaned, including the strainer, and examined throughout for cracks. The gasket must be complete and perfect, shellacked to the sump, but covered with a coat of graphite on the other side. The bolts must be run up from the under side with a flat washer, lock washer, and nut on the top. When this is secured, the end plate at the thrust bearing may be put on and the retaining nuts wired. The oil pump should be opened and examined, although there is little chance of trouble here. It should be perfectly clean, however. In dropping the pump into place it will be necessary to rotate it until the square end drops into place in the square socket in the bevel gear.

**Placing the carburetor and miscellaneous connections.**—The motor is now turned back right side up, and the carburetor, water pipes, and small oil pipes added. The plugs in the bottom of the carburetor should be removed and the carburetor flushed out to make sure that it is clean. The float mechanism should be examined to make sure that it will function properly. A good combination of jets to use for average condition is: Main 120, comp. 110. But this is affected more or less by the quality of the gasoline and the condition of the atmosphere. It is highly important to have good tight-fitting fiber gaskets under the jets. Lock and flat washers may be used in "safetying" the carburetor nuts. In putting the inlet water pipes on, new gaskets should be used unless the old ones are in good condition. All rubber hose connections in

the surface by lifting the valve will accomplish a much quicker and better job than much rubbing under heavy pressure. Moreover, this latter method will cut grooves or rings in the valve seat.

(g) When it is considered that the valve has a tight seat, the cylinder and valve must be thoroughly wiped with gasoline to remove all traces of the compound, and the valve replaced with its spring for testing. Rubbing the valve around in its seat at this point with a little pure oil on it will usually produce a tighter fit.

(h) Test by introducing a small amount of gasoline in the manifold and watching inside of the cylinder to see if any of it seeps through inside.

A perfectly seated valve should hold the gasoline without showing any signs of leaking. If the pit holes are very deep, coarser compound may be used in the beginning, but in this case the valve should be finished off with the finer compound. In placing the cotter keys in the valve stem, care should be taken that the ends are bent around far enough so that they will not interfere with the action of the springs, and at the same time that they are not loose.

**Mounting cylinders.**—The next point before placing the cylinders on the motor is to see that the gaskets at the bottom are in good condition. Shellac should be used to hold the gasket on the cylinder, and it is of the utmost importance that no edge of the gasket is bent over, for if this is the case, the whole cylinder will be forced out of line, oil will leak out at the gasket and the inlet manifold will not fit without straining something. In placing the cylinders, great care must be taken not to break or injure the rings. These should be compressed with the hands and the cylinder should be rocked sideways gently until it slides down easily. Just after passing over the rings, however, the cylinder must be held while the four cylinder nuts are screwed on over the top threads on the long cylinder tie-down studs. If the cylinders are dropped all the way down, the nuts can not be put in place without springing the studs outward, which will tend to crystallize the metal. Again, before bolting the cylinders down in place, a thin coating of graphite should be placed on the under side of the gaskets. This will seal the joint tight, but will not seize it like shellac and tear the gasket when the cylinder is removed again. Just as the cylinder nuts are about to be tightened down, the intake manifold should be placed on the intake ports of the four cylinders and screwed up in order to line up the cylinders with the manifold. Then the cylinder bolts should be tightened down gradually and together. The cylinder nuts may be locked with the use of lock washers with a flat washer under each to prevent the sharp edge of the washer from cutting into the aluminum of the crank case. The tie-down spiders should next be put in place, but the nuts should not be screwed down as yet, and the center nuts should not be put on at this time, as they will have to be removed later in order to put on the water manifolds.

**Placing the valve-operating parts.**—The cam followers should now be placed in position. Each should be examined carefully to make sure that the set screw is not so long that it binds the exhaust

cam follower. Also, if a flat surface has been pounded on the bottom of the followers, they may be very carefully ground off by hand on a fine stone until the surface is round again. At this point the end play of the cam shaft should be checked, if this has not already been done. There should be practically no end play to the cam shaft, just enough so that it will turn free, and it should be so placed that the cams fall exactly under the center of the holes in the case for the cam follower guides. If the cam shaft is out only a little in this respect, there will be danger that the exhaust follower will ride on the intake cam, or rub against and break down the edge of it. The cam follower guide nuts, like the cylinder nuts, should be locked with lock washer and flat washers. Next, the magneto base may be put in place with a lock washer under each screw.

**Mounting the intake manifolds.**—The intake manifolds should next be put in place, after first examining them carefully for cracks and for trueness along the ports. The gaskets must be carefully picked over, and if the life is gone from them new ones should be used. Care must be taken, however, that the gaskets used on one side are of the same thickness as those on the other so that the manifold will screw down tightly without springing. The gaskets in this case are put on dry.

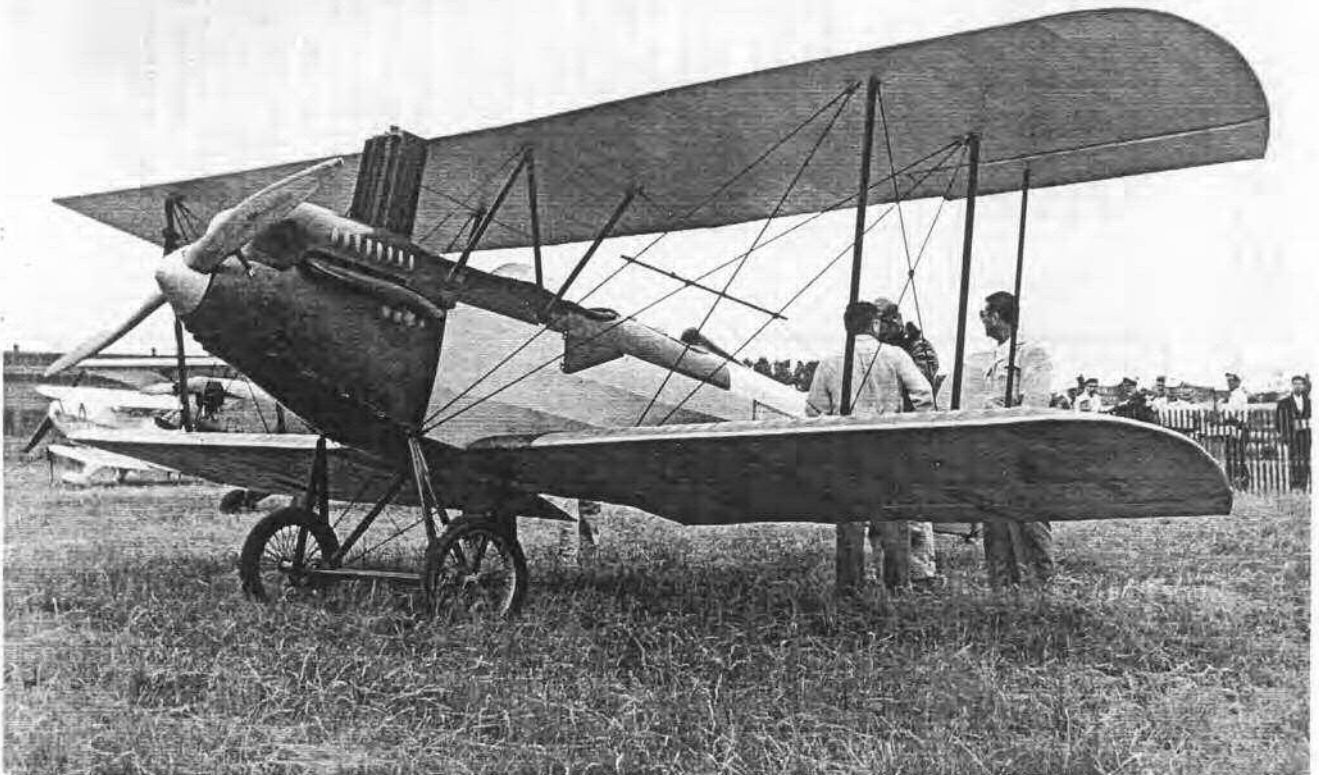
**Mounting the rocker-arm assemblies.**—While some of the men are working on the manifolds others should be inspecting the valve-operating mechanism. Quite frequently exhaust rocker arms are found bent or sprung. In this case they should be renewed and not rebent. The rocker-arm bearings, if improperly oiled, will wear quite badly and become loose. Bearings in this condition should be taken down and rebushed in the machine shop. Possibly it will be necessary to make new pins. Very careful attention should be paid to the small bearings on this part of the motor. The small water gaskets on this assembly should not be overlooked. They must be shellacked to the rocker-arm assembly, but should be coated with graphite grease on the side next to the cylinders. These gaskets must be cut so that they extend out to the sides around the studs. All moving parts must be properly oiled and especial attention paid to the small oil holes in the rocker arms. These become easily clogged with dirt, and this condition is the cause for a great deal of the wear that so often takes place at this point. The two center nuts holding the water leads are now tightened, as these can not be tightened later without throwing out the valve clearance. Then the four outside ones may be set up, and safely locked with cotter keys on account of the excessive vibration on them. The nuts holding the tie-down straps must be safely locked with lock washers. As the nuts located on the tops of the cylinders are fastened down, the cam shaft should be revolved so that there will be no strain on the rocker arms when the nuts are being set up.

**Valve timing.**—Everything is now ready for the timing of the valves. On the Curtiss OX-5 the exhaust valve should close  $10^{\circ}$

the water system should be coated inside with shellac. The clamps should be screwed tight, but not tight enough to cut into or injure the hose. As an additional precaution against leaks, the hose may be taped with friction tape and another coating of shellac placed outside. This shellac will seize or stick to the rubber, but may usually be broken away by grasping the hose in the hand over the joint and twisting it. The few remaining parts are now added and the motor is complete.

**An inspection.**—Undoubtedly the most important part of airplane motor work is the inspection, so that now the motor must be given a very thorough and rigid inspection. It is well to feel of each nut with the fingers, as in the case of the crank-case nuts. Ignition wires should be carefully looked over for possible chafing. They should be checked over again to see that the right lead goes to the proper plug, and that the ends of the leads are not weakened by the breaking of a number of the strands of the wire. This is a point that is quite important and one which is often overlooked by the mechanic in the field.

**Regarding spark plugs.**—The proper cleaning of spark plugs should be demonstrated before these are replaced in the cylinders. Several plugs should be taken apart and the correct method of installing porcelains or gaskets taught. The proper setting for the spark plug points is 0.025". In fastening and tying down the high-tension leads, make sure that they touch no moving part.



KRIEDER REASNER KR-31 OX-5 powered . Owner unknown.



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200-0X5 and 0XX6 motors. New, used and overhauled.

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Brand new original factory jobs, perfect condition, only five left, less engine, each	\$1,000.00
Brand new complete less motor	700.00
Brand new complete with used OX5 motor	750.00
Brand new complete with Government overhauled OX5 motor	850.00
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Brand new complete with overhauled OX5 motor	1,000.00
Brand new complete with brand new OX6 motor	1,100.00
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Brand new complete with 160 H. P. Hispano motor	\$1,500 to 1,800.00
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## ENGINES CURTIS

90 HP OX5, used	\$50.00 to \$	90.00
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90 HP OX2, overhauled		140.00
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220 HP A condition	300.00

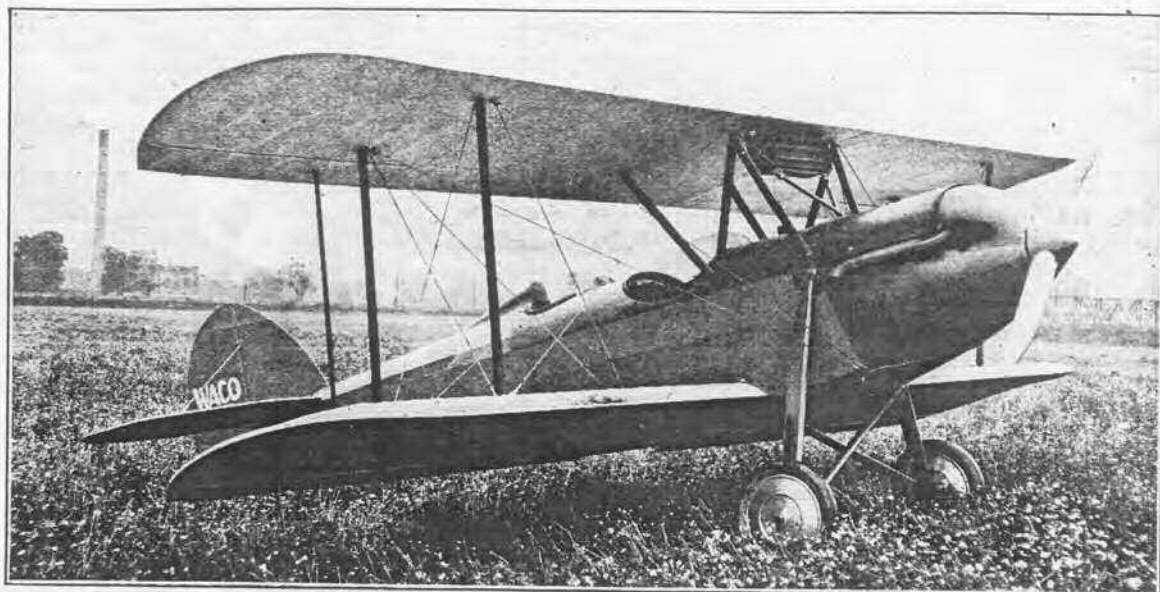
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OX5 Berling Magnetos, new	16.00
OX5 Berling Magnetos, used but in good condition	12.50
OX5 Dixie Magnetos, new	15.00
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Liberty, Hartzel, metal tipped Reborn Toothpick, cooper tipped, OX5 or OXX6	35.00
Genuine OX5 Copper tipped Toothpick, any make, each	10.00
OX5 Hamilton, each	15.00
OX5 Cooper tipped Club, each	70.00
	10.00



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Step into the cockpit of the WACO TEN, take off in almost unbelievable space, climb faster than you have ever thought possible with an OX5 job.

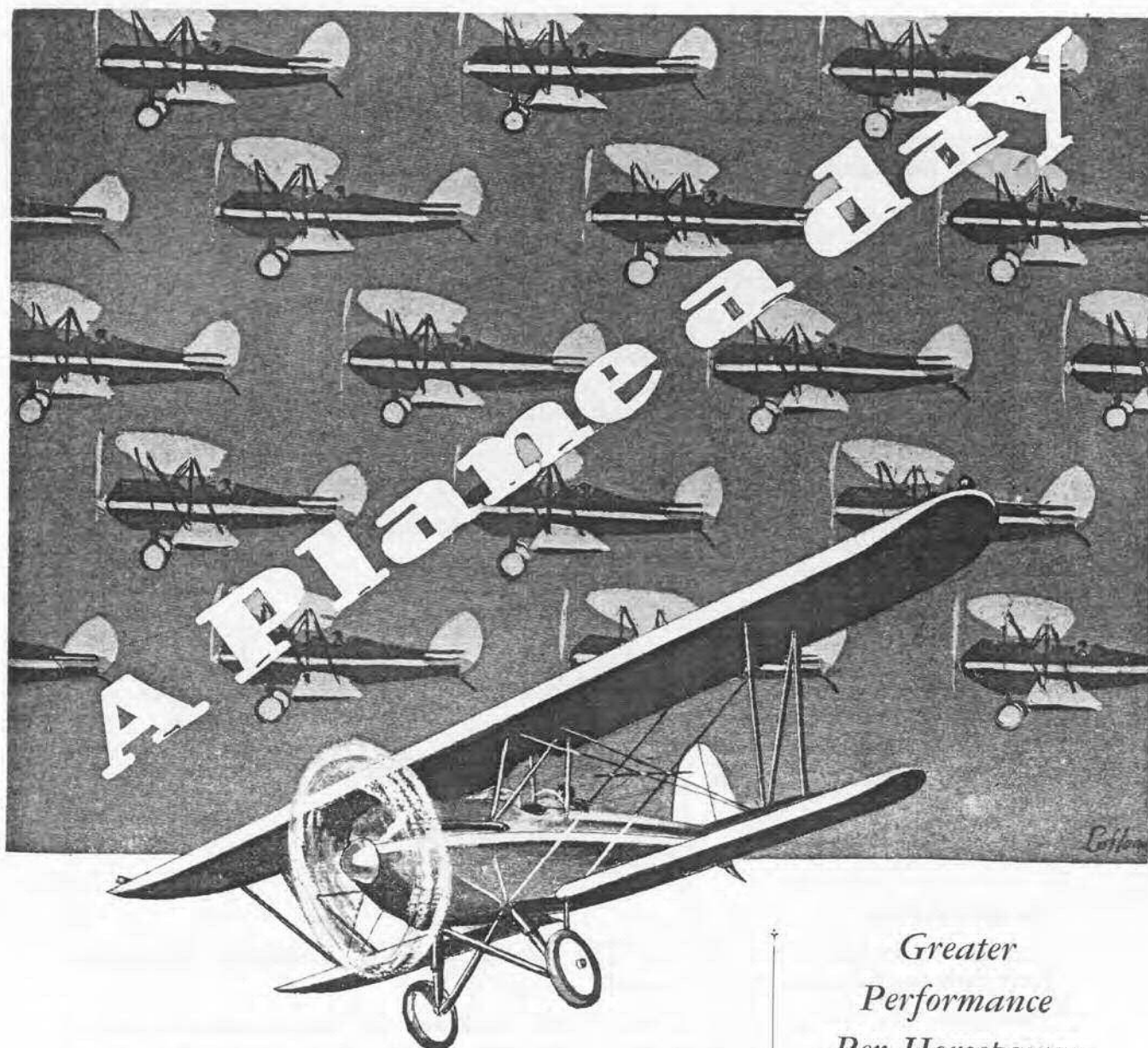
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Performance data  
with Curtiss OX-5

High Speed . . . . . 120 M. P. H.

Landing Speed . . . . 35 M. P. H.

Cruising Speed . . . . 100 M. P. H.

Gas Consumption at  
100 M. P. H. . . . . 5 gal. per Hr.

Take Off Run . . . . . 100 Feet

Rate of Climb . . . . 1,000 F. P. M.

Absolute Ceiling . . . 20,000 Feet

Endurance at  
Cruising Speed . . . . 9 Hours

NO FIELD TOO SMALL . . .  
NO TREE TOO TALL



## The Travel Air Three-place Biplane Type 2000 With OX-5 Engine—90 H. P.

### SPECIFICATIONS

#### CAPACITY—

Pilot and two passengers.

#### PERFORMANCE WITH NORMAL FULL LOAD—

High speed at sea level.....100 M. P. H.  
Landing speed.....42 M. P. H.  
Normal cruising range (with 42 gal. fuel).....400 to 420 miles

#### DIMENSIONS—

Over-all span (tip to tip).....34 ft. 8 in.  
Over-all height.....8 ft. 9 in.  
Over-all length.....24 ft. 7 in.  
Wing chord (upper).....66 in.

Wing chord (lower).....56 in.  
Wing area.....296 sq. ft.  
Wing section.....Travel Air No. 1

#### POWER PLANT—

\*Curtiss OX-5.  
90 H. P. at 1450 R. P. M.  
Fuel consumption at cruising speed.....8 gal. per hr.  
Hamilton or Hartzell wood propeller.

#### WEIGHTS—

Gross weight, fully loaded.....2180 lbs.  
Weight, empty.....1335 lbs.

### EQUIPMENT [and other particulars]

#### COLOR—Fuselage

Tail Surfaces }  
Chassis } Travel Air Blue  
Struts }  
Wings—Aluminum

#### UPHOLSTERING—Fabrikoid.

LETTERING—"Travel Air" on fin. Department of Commerce numbers on wings and rudder.

#### WHEELS—and tires 28x4.

#### INSTRUMENTS—

Tachometer  
Oil pressure gauge  
Water temperature thermometer

Altimeter  
Ignition switch  
Choke

LIGHTS—Wings wired for navigation lights. No lights fitted.

CONTROLS—Single, in rear cockpit. (Dual control, \$75.00 extra.)

GAS CAPACITY—42 gallons.

TANK LOCATION—In fuselage, forward of passenger cockpit.

GAS SUPPLY SYSTEM—Gravity.

OIL CAPACITY—4 gallons in motor.

WATER CAPACITY—Approximately 5 gallons.

RADIATOR LOCATION—Underslung.

PASSENGERS—Two in front cockpit. Pilot in rear cockpit.

CHASSIS—Rubber shock cord in tension.

HEADREST—Standard equipment.

\*NOTE—This ship can also be equipped with OXX6 motor.





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*and*  
*REPAIR MANUAL*

CURTISS  
**OX-5**  
AERONAUTICAL ENGINE  
90 H.P. at 1400 R.P.M.

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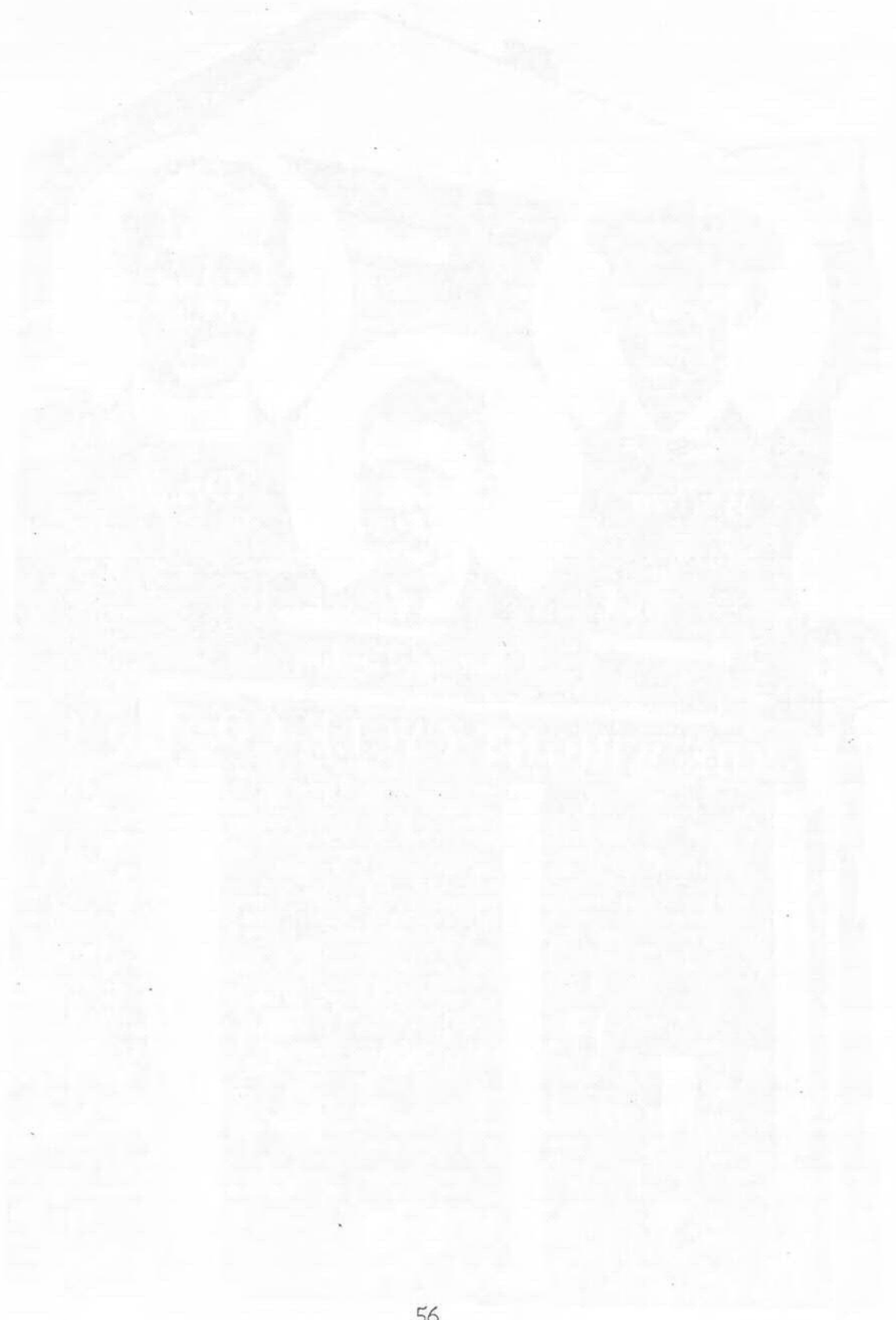
OX-5, 90 H. P. Motor, Brand New .....	\$1,000.00
OX-5, 90 H. P. Motor, Gov. Overhauled .....	600.00
OX-5, 90 H. P. Motor, Used, Serviceable .....	Write for Prices
OXX-6, 100 H. P. Motor, Brand New .....	\$1,250.00
OXX-6, 100 H. P. Motor, Overhauled .....	750.00
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# NOTES AND AUTOGRAPHS

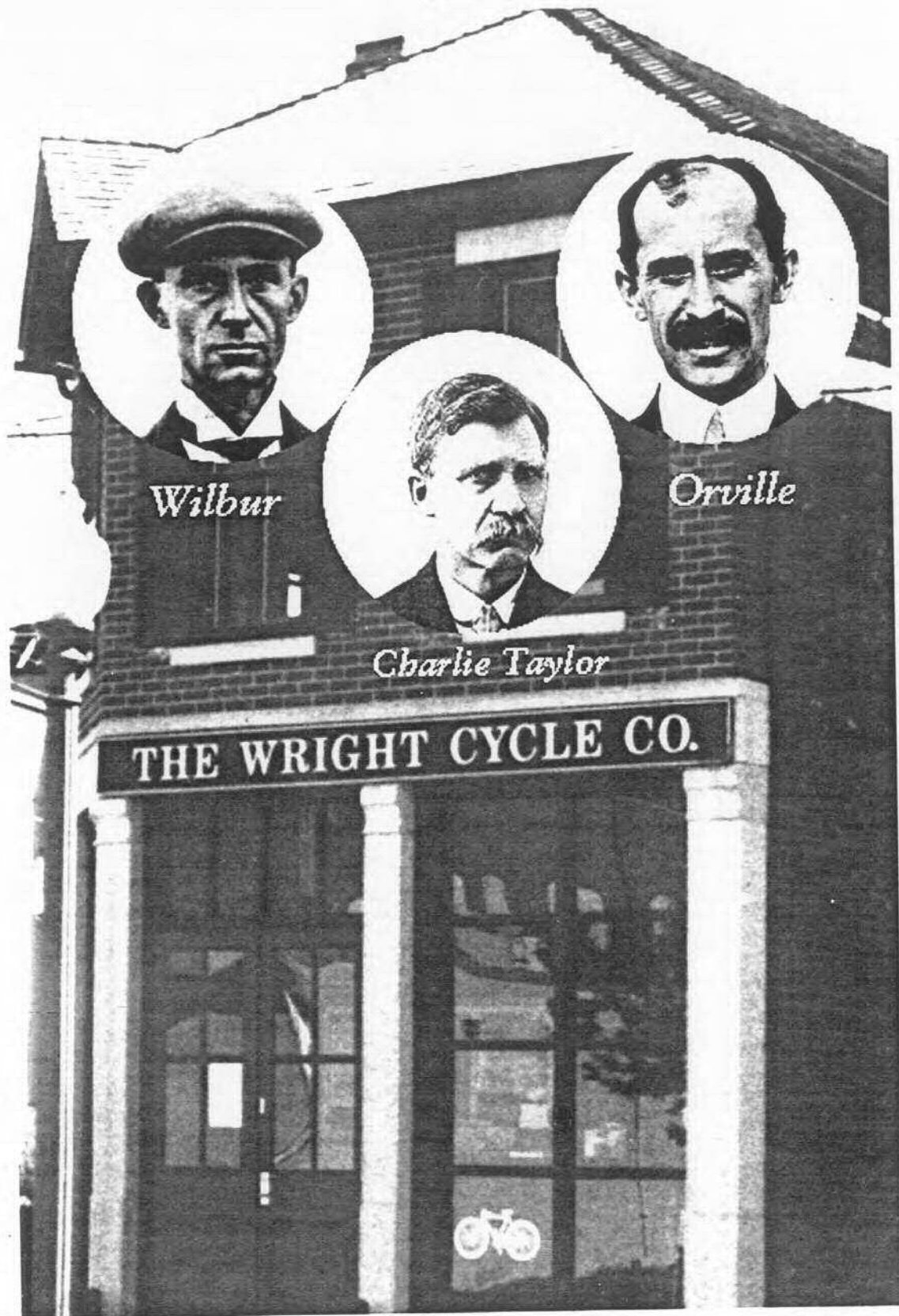
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# NOTES AND AUTOGRAPHS



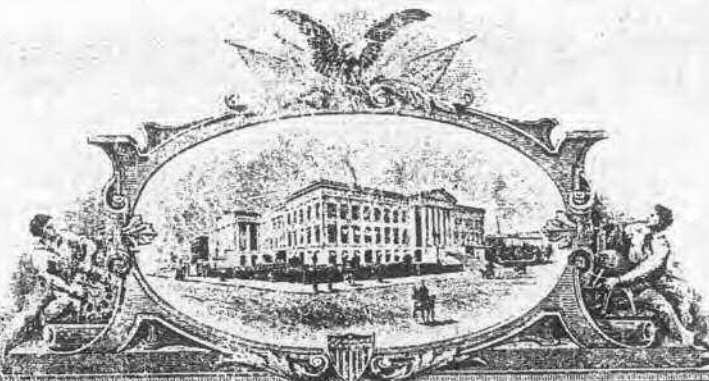


*It all Began Here*



21.

21,393.



# THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas *Orville Wright and Wilbur Wright,*  
*of Dayton, Ohio,*

HAVE PRESENTED TO THE Commissioner of Patents A PETITION PRAYING  
FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

*Flying-Machines,*

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH  
A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND HAVE COMPLIED WITH  
THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT ~~AS~~ ADJUDGED  
TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID

*Orville Wright and Wilbur Wright, their* HEIRS OR ASSIGNS  
FOR THE TERM OF SEVENTEEN YEARS FROM THE *twenty-second* DAY OF  
*May* ONE THOUSAND NINE HUNDRED AND *six*

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE  
UNITED STATES AND THE TERRITORIES THEREOF.

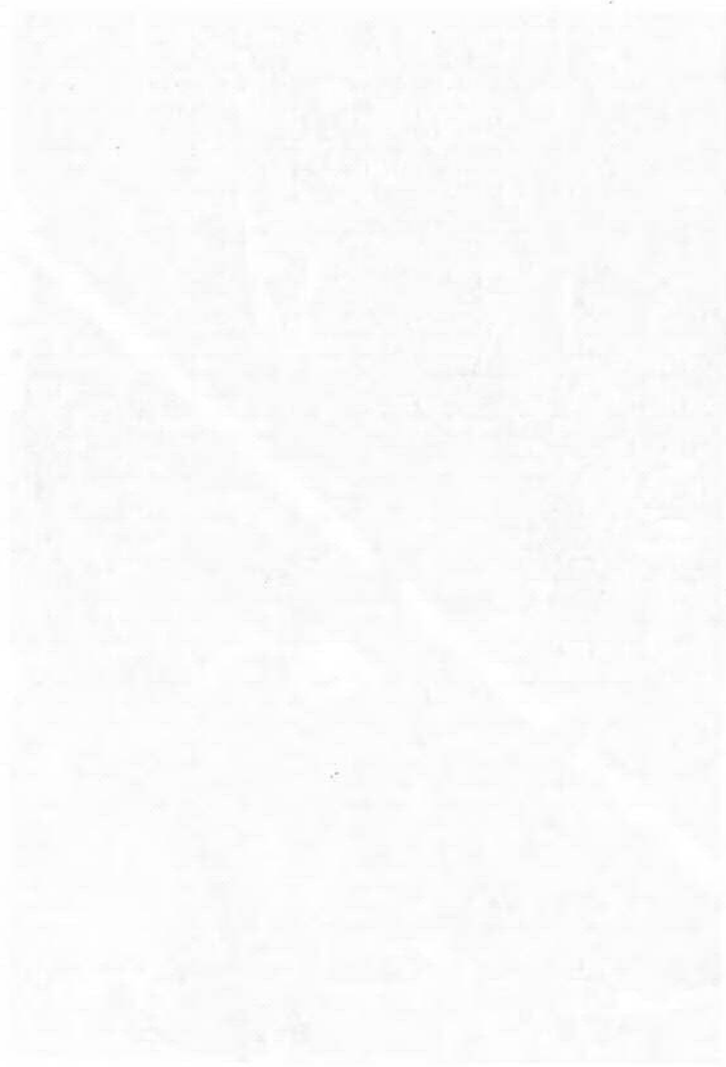
In testimony whereof I have hereunto set my  
hand and caused the seal of the Patent Office  
to be affixed at the City of Washington  
the *twenty-second* day of *May*  
year of our Lord one thousand nine  
and *six* and of the  
Independence of the United States of America  
the one hundred and *thirtieth*

*R. S. Allen*

# NOTES AND AUTOGRAPHS

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*James H. Fowler*  
*June 12, 1892*

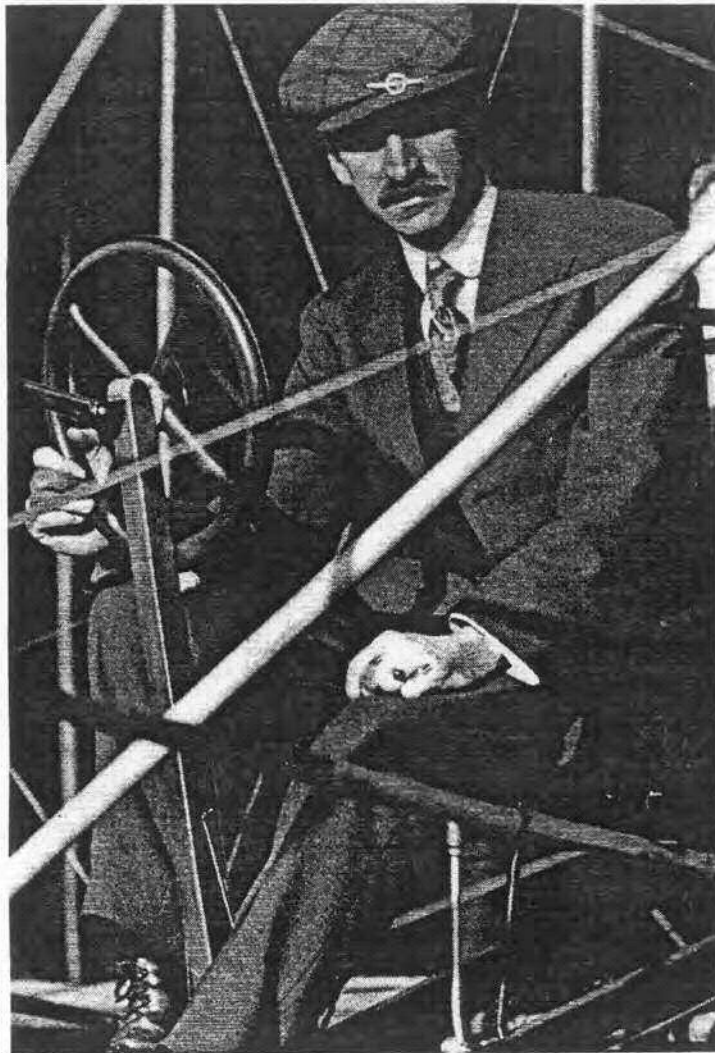




# *Glenn H. Curtis*

*Born 1878*

*Died 1930*



*The Father of the OX-5 Engine*

## ***The Author***

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William (Bill) Bullock learned to fly in 1929 at a cow pasture flying field near Lynchburg , Virginia. He took his flight training in an Eaglerock biplane powered by a Curtiss OX-5 engine. After solo , he graduated to an OX-5 powered Travel Air, an OX-5 powered KR Challenger , a Gypsy Moth, and a Curtiss Robin, Challenger style. After about 200 hours of barnstorming in Virginia and North Carolina , he was advised to get a pilots license but could not pass the physical due to eye problems. He continued to fly and became an exhibition parachute jumper until 1931 when he decided that a military doctor might either pass his eye problems or offer a treatment that would allow him to take the test for the flying cadet program. It did not work. However, they did offer to train him as a navigator , which he declined .

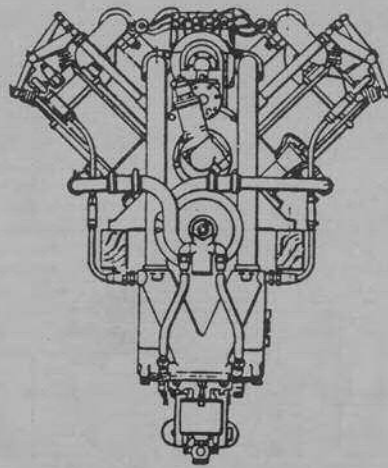
In 1939 , following several years of numerous aviation activities , he went to work for the old Glenn L. Martin Aircraft Company in Baltimore , Maryland. he stayed with Martin for more than a quarter century. During this period he also became active in aviation magazine and book writing and was a free lance contributor to Flying Magazine and numerous foreign aeronautical journals. During a great part of this period he managed to find time to restore several civilian and military aircraft as well as building a sport Biplane of his own design. Today , pushing 90 years , he makes his home in the sprawling Paradise Valley area near Phoenix , Arizona and remains active in many aviation related historical activities such as the OX-5 Aviation Pioneers and the American Aviation Historical Society.



# NOTES AND AUTOGRAPHS

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*Curtiss*      **OX5**

AERONAUTICAL ENGINE

