HUGHES H-1

SPECIAL

FLIGHT MANUAL

aerosoft GmbH

HUGHES AIRCRAFT COMPANY

HUGHES H-1B ‘SPECIAL’

-LONG AND SHORT WING VARIANT-

REMANUFACTURED FOR MICROSOFT FSX FLIGHT SIMULATOR
IN 2008 BY AEROSOFT GMBH, GERMANY
AND S. HOFFMANN

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Additional thanks to Finn Jacobsen.

SYSTEM REQUIREMENTS

- **Pentium 2 GHz (Duo2Core Intel advised)**
- **1 Gb RAM (2 Gb advised)**
- **256 Mb DirectX 9 graphics card (512 Mb advised)**
- **350 Mb of free available SPACE on the hard disk**
- **Sound card**
- **Microsoft Flight Simulator X SP1/SP2 (NOT compatible with older versions)**
- **Windows 2000, Windows XP, Windows 2003, Windows Vista (NOT compatible with older versions)**
- **Adobe Acrobat® Reader 6 minimal to read and print the manual ([1])**

([1]) Available for free, download at: http://www.adobe.com/prodindex/acrobat/readstep.html

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FOREWORD

The aircraft this is all about was built only for one purpose: To fly faster than any other landplane at the moment of its creation. The job required revolutionary new thinking of aerodynamics and advanced manufacturing techniques. Only a single team, that of Howard Hughes Jr., should have enough financial power, visionary ideas and aircraft design experience, to create one of the most remarkable aircraft of the so-called Golden Era of Aviation: The H-1.

The core team consisted of three men: The aero-dynamical designer Robert 'Dick' Palmer, the financer/master-brain/test-pilot Howard R. Hughes Jr. and Glenn 'Ode' Odekirk, who co-designed and physically built the plane with his mechanics.

Additionally to the superior speed of the H-1B Special (short winged version) of approximately 370 MPH at maximum engine performance, the H-1B Special (long winged version) can take off and land on every grass and dirt strip with a length of 1,500 feet and had a range of almost 3,500 statue miles. That covers a huge number of airfields and guarantees almost endless flying adventures around the world.

I hope this product will add great and enduring joy to your FSX Flight Simulator experience and give you some feeling about what it felt like to fly an on-the-edge aircraft almost seventy years ago.

Stefan Hoffmann, April 2008

AIRCRAFT VARIANTS AND TECHNICAL DATA

The H-1 was built in two different versions, which aimed for two different achievements:
The first one was the H-1B Special with short wingspan (25 ft). Its task was to topple the old FIA world speed record, which was held by French pilot Raymond Delmotte with 314.32 MPH until Hughes' new record flight. On the morning of September 13th, 1935 Hughes Jr. took off from Martin airfield near Santa Ana, California. He did seven high speed runs within a closed three kilometer course. The results were measured and authenticated by the FIA (Federation Aeronautique International): 355, 339, 351, 340, 350,354 and 351 miles per hour. Hughes heard on his radio that he had already beaten Delmotte's record with now 352 MPH (four fastest runs average), but now his passion ordered him to open the throttle lever fullest. He did an eighth run where he achieved 370 MPH. While forgetting to check his fuel capacity he ran the tanks dry. He pulled the H-1B away from the record course to prepare for a belly landing, which took place on the now legendary red beet field, where the underneath of the crash-landed (but very intact) aircraft was covered in reddish juice from the vegetables. Hughes' friends thought he was badly injured, but he suffered only a light flesh cut on his feet from the rudder pedal mechanics.

After finishing this adventure, the lightly damaged aircraft was brought back to Hughes' Aircraft Company hangars for inspection and overhaul. After no further problems emerged, the short wing set and its fairings were completely removed from the aircraft's fuselage. The new longer wing set was built for more lift, so the aircraft could travel longer distances. The wingspan was increased from 25 to 32 feet and the angle of incidence was changed to optimize takeoff runs. But the increase of lift also led to an increase of air-drag. This brought down the top speed of the H-1 to now 330 MPH at sea level. The flight altitudes that the long-winged version of the H-1 called its home lay between 14,000 and 20,000 feet. Testing the aircraft at those altitudes Hughes experienced low oxygen exhaustion. Almost dying in one test flight incident without an additional oxygen supply, Hughes Jr. ordered the implementation of one of the first oxygen support systems inside an aircraft. Prepared like this and further supported by extended fuel capacity the H-1B lifted off to break the existing United States Transcontinental Record. This meant to fly nonstop from Los Angeles to New York without refueling. Hughes arrived in New York right at dinner time after he travelled the 2,490 statue miles within 7 hours 28 minutes and 25 seconds. That was an average speed of 332 MPH, flown with the help of good west winds and at altitudes between 14,000 and 19,000 feet.

Aircraft Name		H-1B (short wings)	H-1B (long wings)
Registration number		NR-258Y	NX-258Y
First public flight		09/13/1935	01/19/1937
Wingspan (feet)		24.9	32
Length (feet)		27	27.6
Wing-area (square-feet)		138	191
Root Airfoil (NACA)		2418	23012
Tip Airfoil (NACA)		2409	23006
Max speed TAS MPH(KTS)	FL180	437(380)	412(358)
	FL0	365(317)	330(287)
Empty Weight		3,565	4,097
Max Take-Off Weight (lbs)		5,492	6,200
Max Altitude (feet)		29,000	29,700
Fuel capacity (gal)		250	280

Aircraft Name	H-1B (short wings)	H-1B (long wings)
V-Speeds (IAS MPH/MAX TAKE-OFF WEIGHT)		
Rotation speed V_R (clean)	120	110
Stalling speed clean V_S	91	81.9
Stalling speed Full Flaps V_{SF}	75	63.9
Climb speed V_Y	150 (3,200 ft/min)	150 (3,100 ft/min)
Never exceed speed V_{NE}	500	500
Maximum flap extended speed V_{FE}	180	180
Design Maneuvering Speed V_A	230	174
Reference Landing Speed V_{REF}	100	90
Maximum G (clean)	-2.5G/+6.0G	-2.5G/+5.5G
Maximum G (full flaps)	-1.5G/+3.5G	-1.5G/+3.5G
Max Range	2,000 statue miles	3,500 statue miles

PRATT & WHITNEY R-1535 ENGINE AND ITS DAMAGE MODEL

Every aircraft, like any other organism, needs a centre where the power for its muscles is produced. The H-1's fuselage was designed as a streamlined high-speed skin wrapped around a pilot, to give wind only minimum resistance. Don't forget the fact that the birth of the H-1 happened parallel to the end of the biplane age, where pilots were lucky, when their aircraft manufactured from wood and fabric, would not break apart in a steep dive. So to many contemporary pilots, the H-1 must have been looked like today's top-secret military jets. The engine selection was done after the engine nacelle, had been completely designed. There was no going away from that concept, because the rest of the aerodynamic design had already been tested in dozens of expensive hours in the wind-channel of the **California Institute of Technology.** So the H-1's engine needed ti have the characteristics of being a dwarf in size with the power of a giant: It should be small enough to fit in the already designed front nacelle, to keep air drag low and weight down. And most importantly, it had to provide enough energy for the acceleration of the aircraft to the desired top speed. The big problem was that no single engine on the market met those requirements: Either it was too weak or too heavy. But Hughes had good connections to some leading employees of the Pratt & Whitney aviation engine company who, behind closed doors, told him about a top secret military engine design project. Getting hands on performance data was hard. Washington's Department of Defense had ordered Pratt & Whitney directly to create a new generation of piston engines and shrouded this project in complete secrecy. So Hughes visited the factory again and again and showed interest. Some day one of the chief engineers left Hughes Jr. alone in his office, moving to another room for a faked urgent phone call. The technical drawings and detailed performance charts of the top-secret engine project were left directly under Hughes' eyes. Now Hughes knew that this engine would be the only one that could be successfully married to the H-1. He leased his R-1535 serial no. 22 on June 30th, 1934. Officially it was said it would be used for an advanced fighter design experiment for the US Army Air Force.

The engine was never paid for nor brought back to Pratt & Whitney and today it is sitting united with the H-1B Special on an exhibition platform in Hall 105 of the Smithsonian National Air and Space Museum Washington D.C., United States of America.

A major engineering problem of the leased P&W R-1535 was the lack of horsepower. Standard it was delivered with 700 HPs. It could do more, but that would shorten the lifetime of the engine rapidly. The solution came in the form of a clever mechanical manipulation of the engine and the invention of a new generation of aircraft fuel, just right on time: 100 octane AVGAS. While in the beginning 1930s the industrial products were covering only 80 to 95 Octane, the H-1 engine would need some special juice. The power-plant should not damage itself at maximum RPM, where an additional 300 HPs were badly needed to overcome the atmospheric resistance. But luckily the needed fuel type came directly out of the experimental chambers of the Californian petrochemical industry. It was extremely expensive, and as a selling unit, it was only delivered in five gallon canisters. But it had the knock-resistance and lubricant behavior that the new engine needed not self-destruct at maximum power settings. The negative side was however, that Hughes needed a small team just to empty fifty single fuel canisters into the aircraft tanks for every single flight.

The propeller was manufactured by Hamilton Standards Propellers. The design was strongly influenced by Howard Hughes' demands. The result was a two blade, aluminum alloy propeller with a diameter of 10 feet. It was a state of the art creation with governor-controlled blade angles and pilot-controlled propeller feathering mechanism for emergency situations.

The engine in numbers:	**Pratt & Whitney R-1535 Twin Wasp Junior**	
	Two-Row Radial Engine	
	Bore	**1,535 cubic inches (25.2 Liters)**
	Compression ratio	**serial 6:1** **H-1 9:1 or higher**
	Cylinders	**14**
	Supercharged	**Yes**
	Max. Power	**serial 700 HPs** **H-1 1,000 HPs**
	Fuel type	**Avgas (100 octane)**
	Max. Manifold Pressure	**48 inHG**
	Engine/Propeller Ratio	**4:3 (H-1)**
	Governor	**Constant-Speed Variable Pitch Prop**

NOTE: The H-1's engine is fed by a gravity fuel carburetor. So when pushing negative Gs or when flying inverted, the engine will deliver only minimal power output or even will cut out. The reason for this is located in the fact, that the carburetor cannot deliver fuel to the pistons under less than 0.5 G conditions.

ENGINE DAMAGE MODEL

The H-1B Special drove the performance of the R-1535 too its extremes and beyond. This fact can result in the destruction of the engine due to mismanagement by the pilot.

Knowing that the engine will not accept max power output for a long time and you are able to ride it to death like an exhausted horse you should draw your focus on what the engine can and cannot.

Special simulation algorithms were created for:

- Too low/high Fuel pressure
- Too low/high Oil Temperature
- Too high Cylinder Head Temperature
- Hydraulic circuit failure
- Shock Cooling
- Enhanced Carburetor Icing

Too low/high fuel pressure

If the fuel pressure is located below 2 PSI the engine won't run. If the fuel pressure is above 9 PSI there is high probability that the fuel pipes disintegrate. If this happens, no restart of the engine is possible anymore.

Too low/high Oil Temperature

Running the Engine at too low oil temperature can damage moving parts. If oil temperature rises above 100 degrees Celsius an oil fire is very probable. Normally this will be accompanied by an engine cutout. You should try to extinguish the fire and/or find a place for an emergency landing.

Too high Cylinder Head Temperature

Running with extreme cylinder head temperatures (CHT) will damage the piston roofs and the engine will cutout. CHT is mainly dependent on the strength of the combustion process and slipstream cooling. The first one adds temp, the second one removes it. So if you are flying slowly and with throttle forward, the cylinder heads will overheat within a short time. There is a relative linear gradient from zero to 40 inHG manifold pressure, but from that on heat production will see a steep increase. That results from the fact that an early serial R-1535 was designed for only 36 inHG maximum manifold pressure. The tuned version of the Hughes team was up to 48 inHG and at these extremes, cooling was inefficient. So include this gauge in your regular instrument scan. It is very important.
The normal working limits of the engine are between 100 and 450 degrees Fahrenheit. Inside this range, you can fly as long as your fuel lasts. From 450-475 you can go up to 5 minutes, from 475-500 up to 1 minute and from 500 and up you risk a sudden engine death every second. So keep away from those destructive realms.

Hydraulic circuit failure

If Hydraulic fails, you won't have the ability the lower/raise your hydraulic landing gear. As this was very likely in the original H-1 two separate backup-systems were integrated. This first one is a manual pump, which needs some time to use: A dozen strokes you will lower the landing gear inch by inch. But you can only lower the landing gear with this device. If it is down, it stays down. Remember that, before using this in a too early stage of your flight.
The second backup is an oil engine bypass valve. With this tool, you can redirect engine oil to be pumped into the hydraulic circuit. You won't get original pressure of 650 PSI, but it should be enough to lower the landing gear together with the help of gravity force.

Shock Cooling

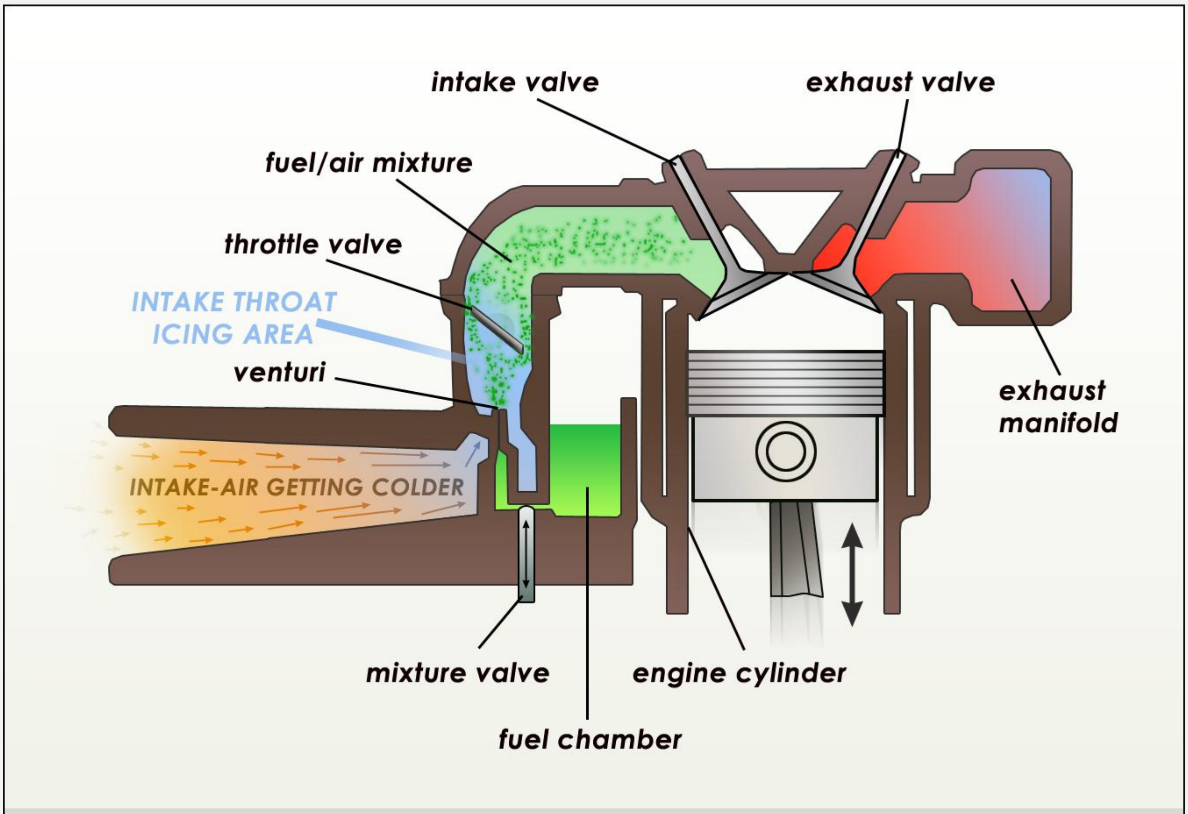
This is a situation which almost never occurs on a today's aircraft. Metal alloys have been developed, that are strong AND elastic. But the old engines, and the R-1535 is now almost 75 years old, did not have the metallurgical standards of present fabrications.
The problem is this: If you got a really hot engine, so in our case 450 degrees Fahrenheit (or above) and you cut throttle back to idle position, there will be a rapid cooling-down as a result of a steep dive by the aircraft. The front side of the engine will be hit much more by the cold and fast slipstream than the rear section. This will lead to very different temperatures of the front and rear parts of the engine.
And like hot glass that is thrown into cold water: It will crack because of its structural tension. In the case of the R-1535 it is not the massive engine housing that will crack, but fine mechanic parts like valves and nozzles. And without their help the engine is not able to keep up its function. As an indicator for shock cooling inside this simulation you will hear a squeaky sound and the engine will cut out.

Enhanced Carburetor Icing

For this project a fresh algorithm was created, to make carburetor icing feel much more realistic. Carburetor icing can affect any carburetor under certain atmospheric conditions. Carburetor icing occurs when there is humid air, and the temperature drop in the *venturi* causes the water vapor to freeze. The ice will form on the surfaces of the carburetor throat, further restricting it. This may increase the *venturi* effect initially, but eventually restricts airflow, perhaps even causing a complete blockage of the carburetor. Icing may also cause jamming of the mechanical parts of the carburetor, such as the throttle butterfly valve. Until now this was simulated not very well, but we found a fresh and better approach.
Now the process of icing is affected by air humidity also inside the simulation. So flying in dry air with critical icing temp inside the carburetor of -5 to +5 degrees Celsius will hardly bring up ice formation.
But in poorer visibility situations beginning at 20 NM range or even in clouds or fog you will face a serious danger of engine failure due to carburetor icing. To counter this, check the carburetor temp gauge at regular intervals and activate the carburetor heater if the critical range around freezing point is penetrated. But be alerted that using the carburetor heater will bring some loss of engine power with it. It's marginal, but on speed record attempts it is an important factor.

But what happens to the carburetor in detail? Let's have a look at these following illustrations.

The venturi effect is named after Giovanni Battista Venturi (1746-1822), an Italian physicist. The Venturi Effect is the drop in fluid pressure that results when an incompressible fluid flows through a constricted section of pipe. A venturi can also be used to mix a fluid with air. When the air passes through the venturi, the speed of air increases. This causes the effective pressure to drop beside of temperature, which sucks fuel through a nozzle and vaporizes it into the streaming air, effectively mixing fuel and air. That is the basic function of the carburetor. The problem here is that the gain in

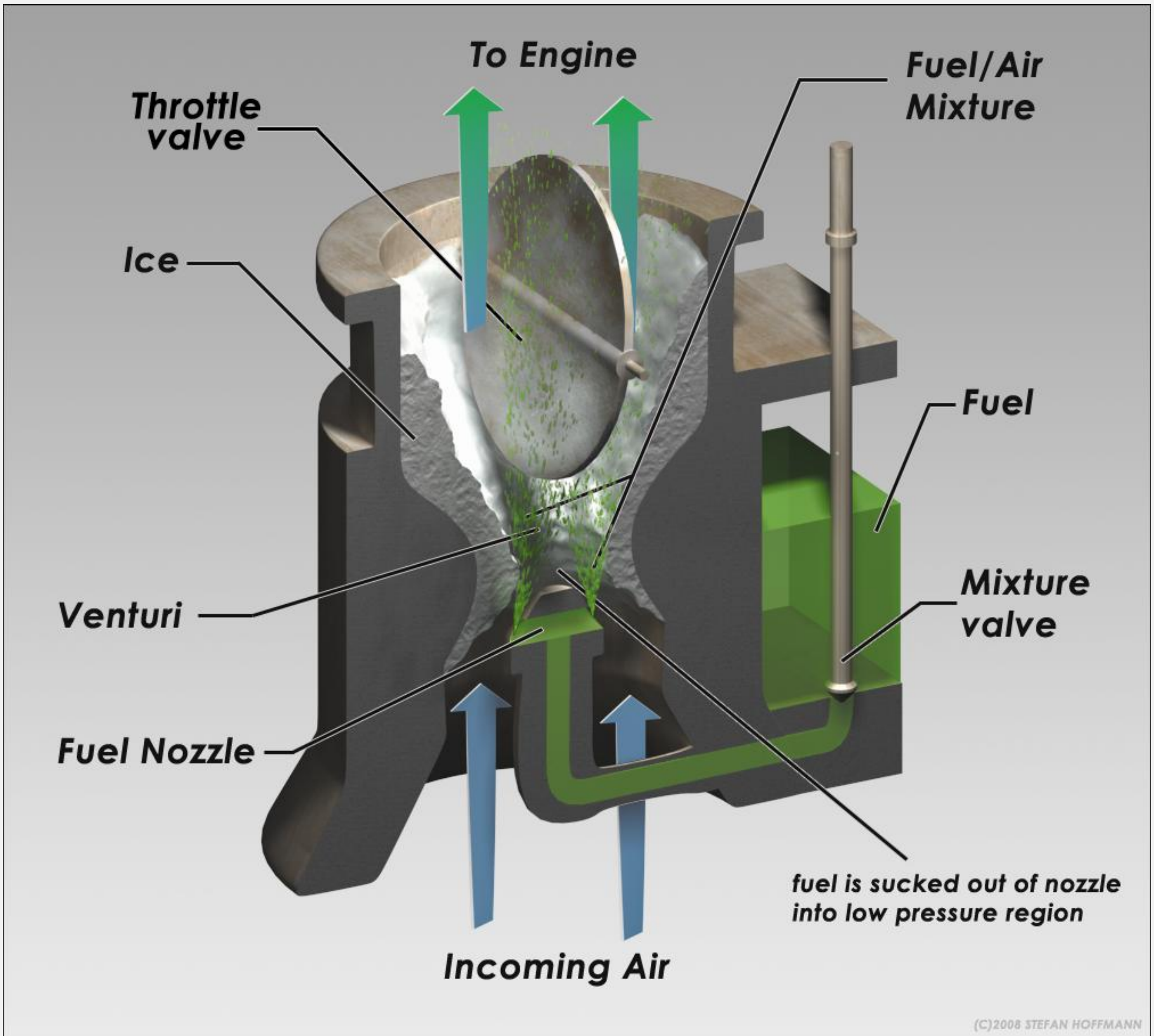


From air-intake to venturi and piston - a schematic overview

speed of the intake air results in a drop of temperature.

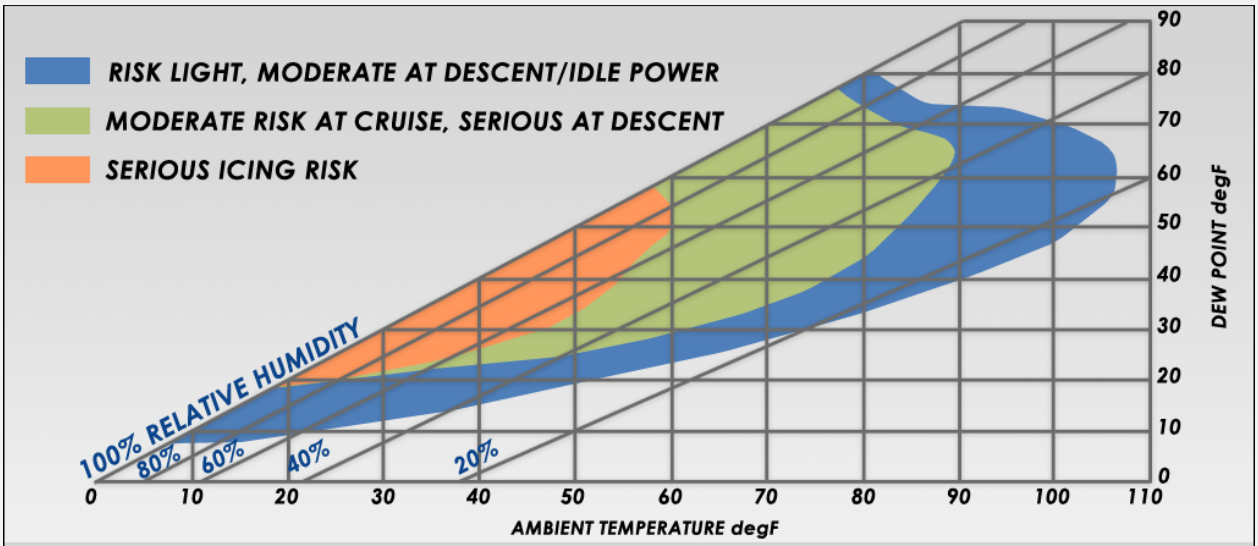
So in this special case, mother nature takes the thermal energy out of the system, to increase the kinetic energy of it. But energy can only be exchanged, neither created, nor destroyed. And so, the 1930s pilot had to live with that dilemma and used the carburetor heater when things became too dangerous. As you can see in the above illustration the intake air is getting colder as it enters the deeper realms of the carburetion chamber and gets near the venturi. If now the temperature inside this chamber falls below 5 degrees Celsius (which you can check on the carburetor temperature gauge) the danger for ice buildup is enormous. It is a difficult problem to discover how imminent an engine cut out has become because of ice formation. When ice is building in the intake valve throat, around the throttle valve, again a venturi effect is created. The ice makes this pipe smaller again and air will flow much more swiftly through it, to transport the same volume to the engine. This again cools the system down and accelerates ice formation. So again: If you read +5 degrees Celsius to -5 degrees Celsius on your carburetor temperature gauge ENGAGE THE CARBURETOR HEATER!

If air gets colder than minus five degrees Celsius inside the carburetor, the probability of ice formatting will lessen. But surely combustion will be more effective if the Fuel/Air Mixture is not too cold. 20 to 30 degrees Celsius carburetor temp is a good value.



Close up of ice formation inside carburetor throat

To experience the carburetor icing effects in a realistic way inside the simulator, real world weather is recommended. It's clear that in those data a more realistic relationship between ambient temperature, air humidity and dew point is given than in a synthetically designed default one.



Influence of ambient temp and dew point at carb icing risk

To create a better icing model we used many variables in FSX, but most important visibility. Light follows an unimpeded path when in a vacuum such as outer space. But in Earth's atmosphere, light interacts with molecules and particles in the air. Both gas molecules and particles scatter or absorb light – reducing the amount that reaches an observer, dimming the object, and decreasing visual contrast between the object and its background. This effect produces good and bad effects for the pilot. It is one of the positive sides that the pilot can estimate the relative humidity from visibility conditions.

THE COCKPIT

The cockpit of the H-1 is far away from looking like a convenient place. Here the design motto surely was that in first line form followed function. However it's a surprisingly quiet place being relatively far away from the powerful engine. The pilot sits deep inside the pit, almost like in a racing car. Together with the tail-dragger peculiarity of having a high fuselage pitch on static display (14 degrees), the pilot's view to the front of the aircraft is highly constricted while taxiing and rolling on the ground.
In order to improve the forward view, an electrically driven pilot seat was introduced which moves the pilot several inches forward and up when enabled, giving the pilot a viewpoint just above the canopy ceiling. That still doesn't give you perfect front vision, but with habituation and technique there was not a single taxiing accident in the H-1's active flying career from 1935 to 1942.
Below you can see a representation of the H-1 cockpit, like is it used within this simulation. It is very close to the historic original. But a fuel capacity gauge for example never existed inside the H-1. Fuel ran from the tanks through clear plastic tubing under and around the instrument panel. This system told the pilot if a tank was dry, but otherwise gave no indications of the remaining fuel.

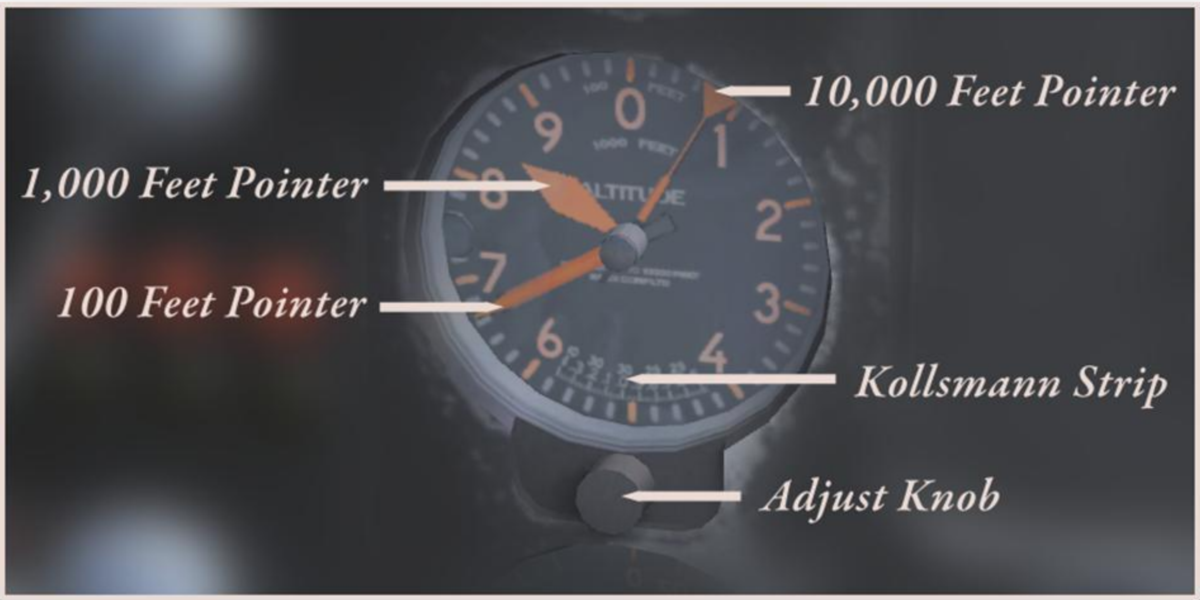
FLIGHT INSTRUMENTS

The flight instruments needed to fly the aircraft are all located at the front instrument panel. It is logically structured in a way that you get speed, direction and altitude data on the left side. These are the important things you have to check most often. On the right side of the main instrument panel you will mostly find data readouts that concentrate on the engine status, such as piston engines rotation per minute, oil temperature and pressure, fuel capacity but also flap deflection and a Yaw/Bank indicator.

Now let's have a detailed look at the cockpit instruments.

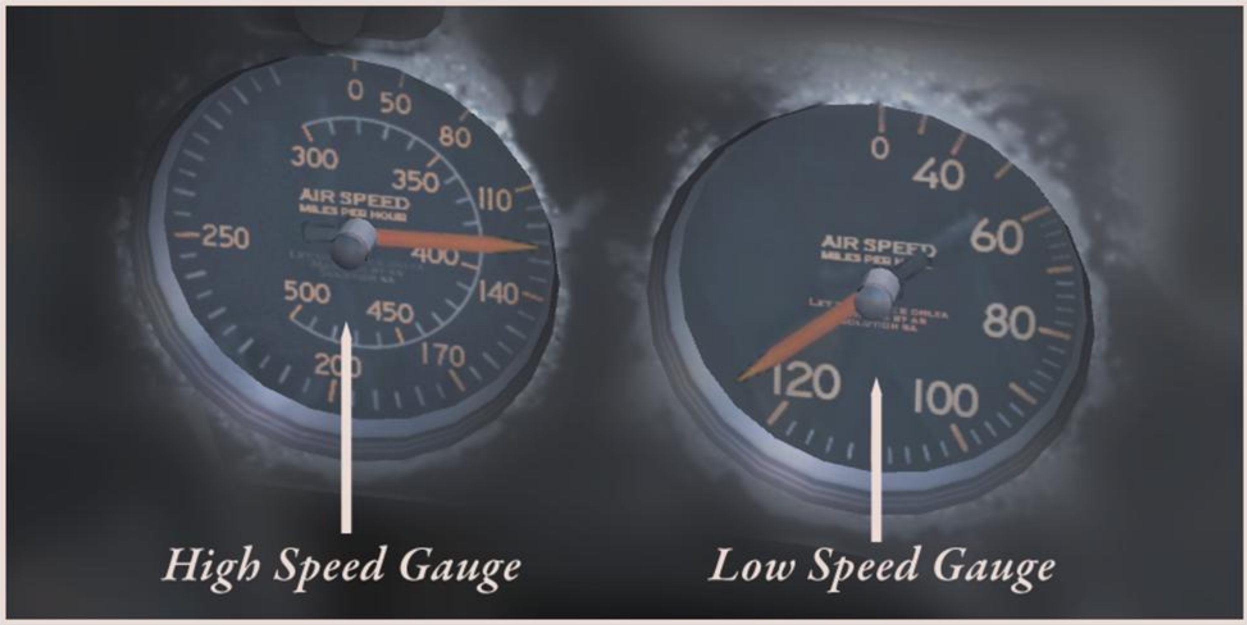
ALTIMETER

The H-1 features a three pointer barometric altimeter. This kind of classic altimeter shows the altitude relative to sea level and has to be calibrated by a setting knob, which can be found at the bottom front of the gauge. To make this effort easier a circular Kollsman strip has been added. There you can set the reference pressure to the current barometric pressure at sea-level (QNH). Note, that the outside pressure changes with one inch mercury every 1,000 feet near sea level.



AIRSPEED INDICATORS

The H-1 features a double set of airspeed gauges. The reason is that a single airspeed indicator wouldn't have given detailed readouts at low speeds, were flying close to stall speed is required. In that dangerous speed regime every knot is of utmost importance and so the gauges were split up. The airspeed on these instruments is measures in Miles per Hour (MPH). One knot equals 1.15 MPH.



CARBURETOR AIR INLET TEMPERATURE INDICATOR

The carburetor air temperature gauge is attached in the air scoop elbow immediately upstream from the carburetor entrance, as the temperature measured at this location is the most reliable means of determining ice formation conditions. The data readout gauge itself does not show the air outside temperature. Do not get confused with that. When the outside air enters the carburetor air scoop it flows into a funnel-shaped pipe, which after a physical principle, accelerates the air in flow. At the same time the pressure of that air lowers and so does the temperature. Thus it can happen that you are taxiing on a sunny day at twenty degrees Celsius outside temperature and experience carburetor icing, which means the airscoop is closed by ice and allows no or only a small amount of air into the carburetor. The effect on the throttle will be that you can get only a fracture of engine power or simply none at all. While on the gound this does not immediately mean big trouble for pilots, it will highly probable lead to disaster in a descent. So when you are coming down from high altitude (temperature loss of eight degrees celsius on average per 1,000 meters), you will bring the throttle back to descent minimum and the motor is getting really cold. But the humidity of air in lower atmosphere rises too, bringing higher icing risk. And without using the carburetor heater the air scoop will close itself with ice, but the pilot will feel the impact much too late. When he opens the throttle again, it is almost dead, because with a closed airscoop it cannot breathe. So keep an eye on the Carburetor Inlet Temperature and enclose it in your regular instrument scan. Critical temperature here is +5 to -5 degrees Celsius.

On the image below you can see, what the Carburetor Inlet Air Tempurate Gauge looks like.

As you can see there is a second interesting spot on that: The Detonation Area. A carburetor air intake temperature above 60 degrees celsius will very probably lead to a carburetor explosion. Fuel is a volatile subtance on its own, but mixed with hot air it's like a bomb. An explosion or fire inside the carburetor will disable your engine permanently. So keep an eye on the upper edge to the carburetor temperature scale too.

ENGINE CYLINDER HEAD TEMPERATURE GAUGE

This gauge measures the effective temperature directly on the aluminium cylinder heads of the engine. This temperature is affected by the airflow around the engine, which means a higher airspeed brings more cooling effects. Mirrored in the other direction, low airspeed with high engine performance will bring the cylinder temperature to critical levels very fast. That means that at a certain temperature the cylinder heads will begin to deform, destroying the engine in that process. But below the 'END-TEMPERATURE' you can also damage cylinder valves, cylinder walls and piston rings. So it is clear for the responsible pilot to stay within healthy engine parameters, which are described as following:

Regular temperature range for continous usage ------------------------------ 0 – 450 degrees Fahrenheit
Lower extreme performance range for five minutes usage ------------------ 450-475 degrees Fahrenheit
Upper extreme performance range for one minute usage ------------------- 475-500 degrees Fahrenheit
No go zone – engine damage within short time ------------------------------ 500-up degrees Fahrenheit

For better understanding, the next illustration shows how the aluminium of the engine's cylinder heads gets weakened by high temperatures.

Please note the small 'knob' on the face of this gauge is not a mistake in modeling but something the real gauge has as well.

ENGINE FUEL PRESSURE GAUGE

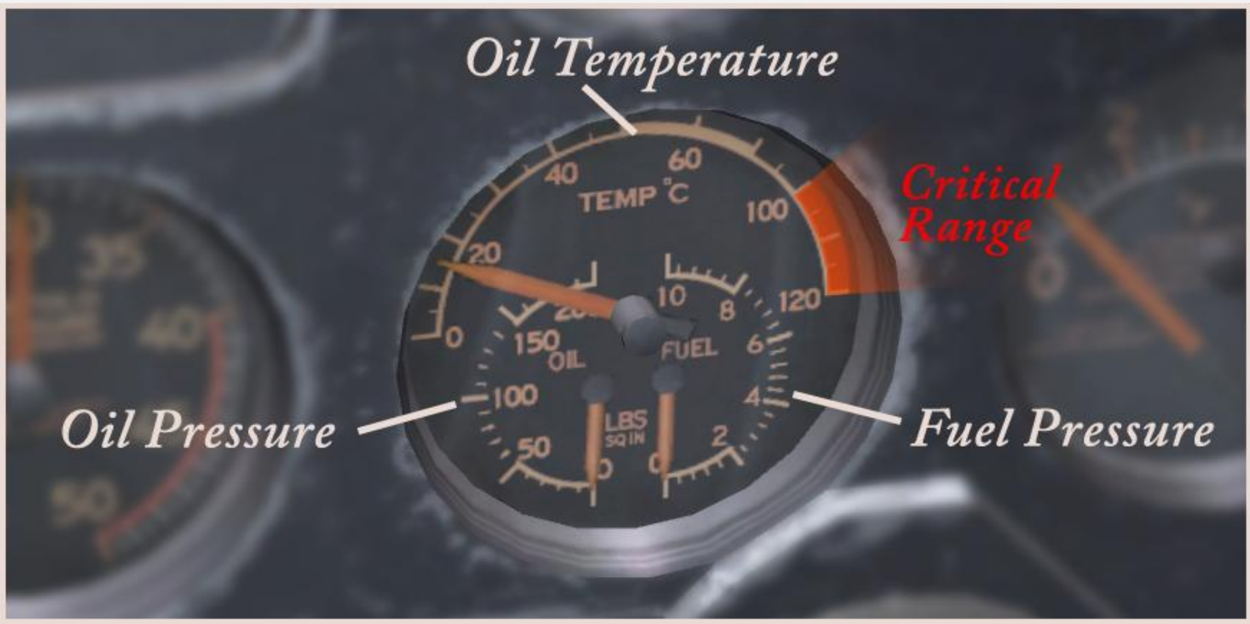
This gauge shows the pressure, at which the fuel is delivered from the tanks to the carburetor. The regular working pressure is between 4 and 7 PSI while the engine is running. If the pressure is too low it will bring the engine to a stop, if the pressure is too high it can damage the fuel tubings. The pressure gauge is also important for starting the engine, because the pilot must first pump 4 PSI starting fuel pressure into the fuel system via a wobble pump. When the engine runs stable, its suction pressure is used to achieve a stable fuel pressure on its own.

ENGINE OIL PRESSURE GAUGE

This gauge shows the pressure, at which the oil is delivered to important areas inside the engine. This oil supply is necessary to bring lubricants to heavily used metal parts moving closely to each other. Without oil, they would be damaged by their friction forces. But with oil, they don't touch each other directly but float on the oil surfaces instead. When oil pressure gets too low, the oil cannot reach its working areas and metal surfaces will run blank on each other, damaging themselves. If oil pressure is too high, the engine can be damaged, too. Normal working range for oil pressure is 70 to 90 PSI.

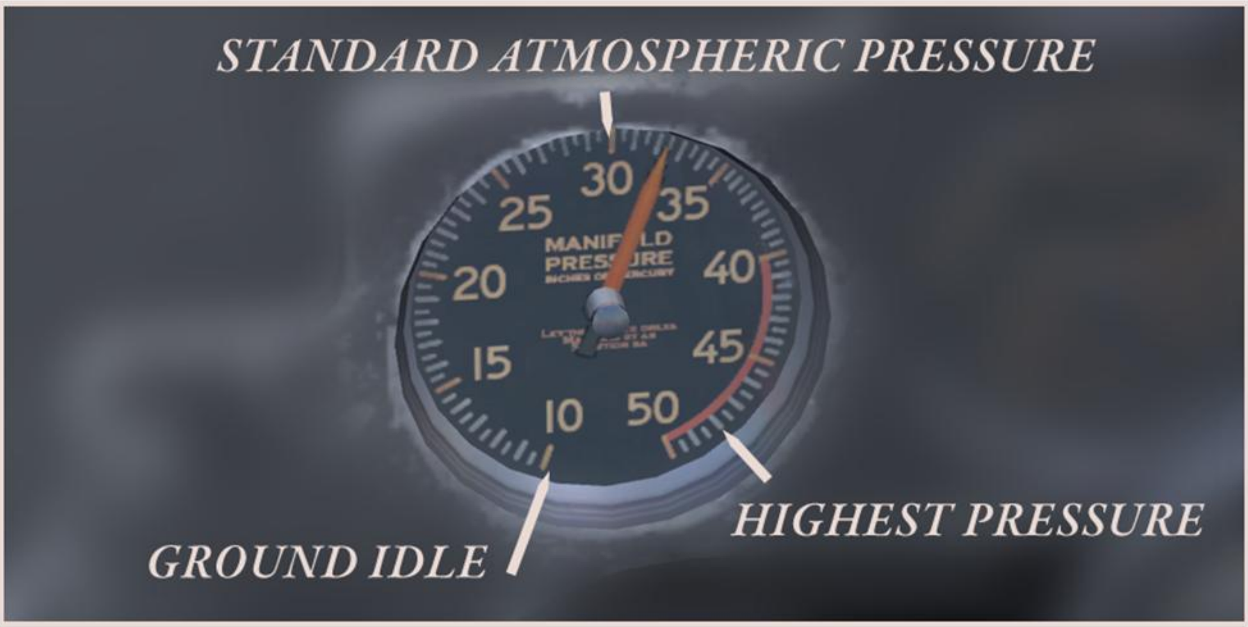
ENGINE OIL TEMPERATURE GAUGE

The oil temperature is also very important. Lubricants are made of similar ingredients like the ones that fuel is made out of. So getting over 100 degrees Celius will increase the risk of setting the engine on fire. Oil temperatures below 40 degrees are risky, too, because then the oil will be no be fluid to reach all angled areas of the engine.



ENGINE MANIFOLD PRESSURE GAUGE

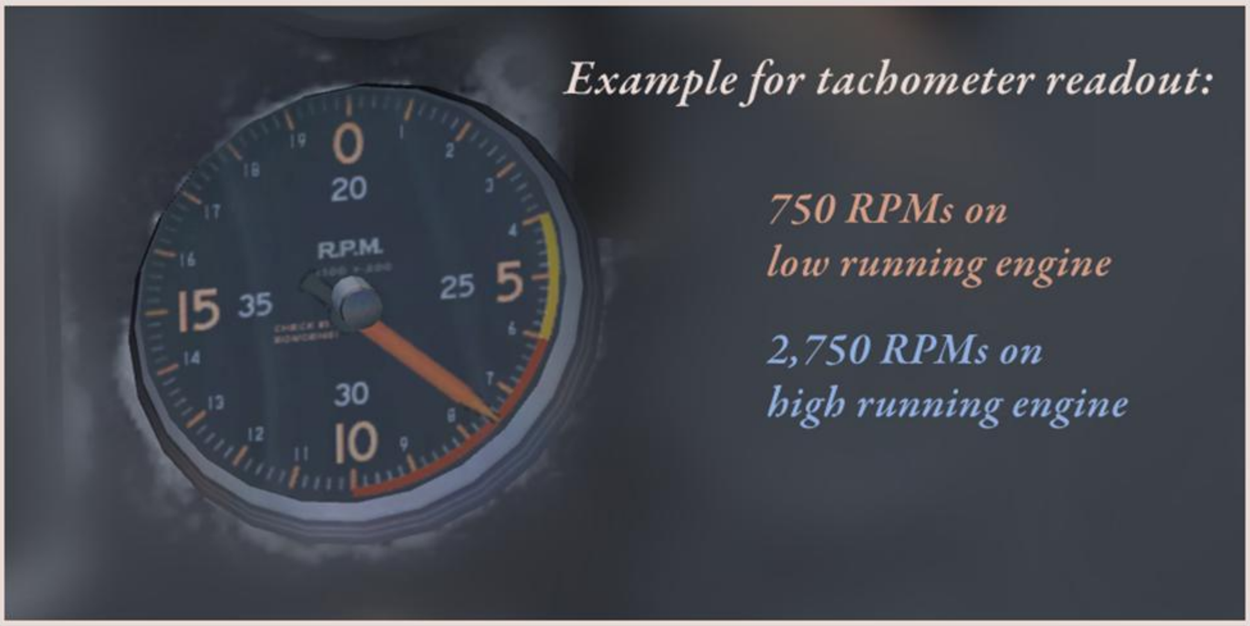
This gauge shows the quantity of air forced into the cylinders, mixed with a certain amount of fuel. Since the energy released by combustion is proportional to the weight of the charge, this gauge readout is an important index for the power generated by the engine. It is measured in inHg. The throttle lever is used to control a butterfly valve sitting directly on the air intake. At Idle RPM, the valve's opening allows only a discrete amount of air to reach the carburetor, so the engine runs stable at the lowermost RPM.



With increasing flight altitude the atmospheric pressure will drop and so will the maximum manifold pressure available. Up to a certain alitude the H-1's supercharger will deliver additional pressure that is needed to keep the maximum manifold pressure upright, so the aircraft can outplay its engine power also in atmospheric regions with lower air density.

ENGINE TACHOMETER GAUGE

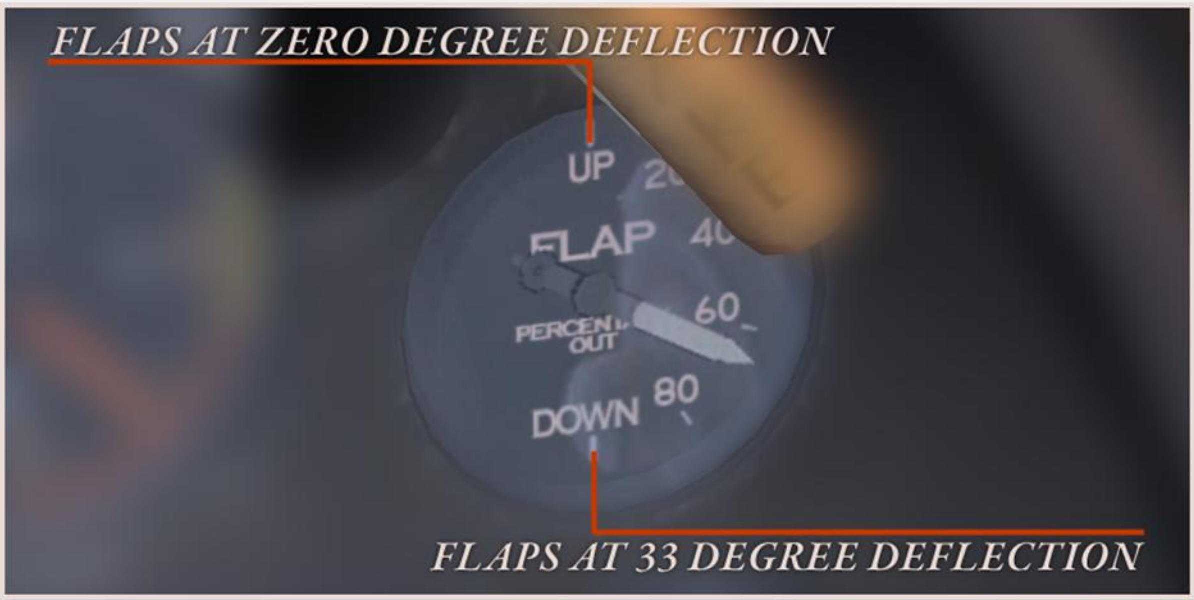
This gauge counts the revolutions cycles the engine pistons do within a minute. Those revolutions get higher, if more power is released by the combustion process. It is also an indirect display for the reciprocating loads that exist within the engine. So higher RPMs cause higher frictions inside the engine's mechanic systems, for example at bearings, piston and cylinder walls and crankshaft gears. Maximum RPM counts used for longer times or with insufficient lubricant support, will cause damage to the engine systems. Note that the pointer of the H-1 tachometer version will rotate almost 480 degrees around its bearing to show zero to 2,675 RPM values (engines maximum). An image of the gauge is displayed on top of the next page.



The bordering yellow and red colored arc is used for keeping the pilot alerted, that he can't stay in the red longer than five minutes and 15 minutes in the yellow area without shortening the lifetime of the engine rapidly.

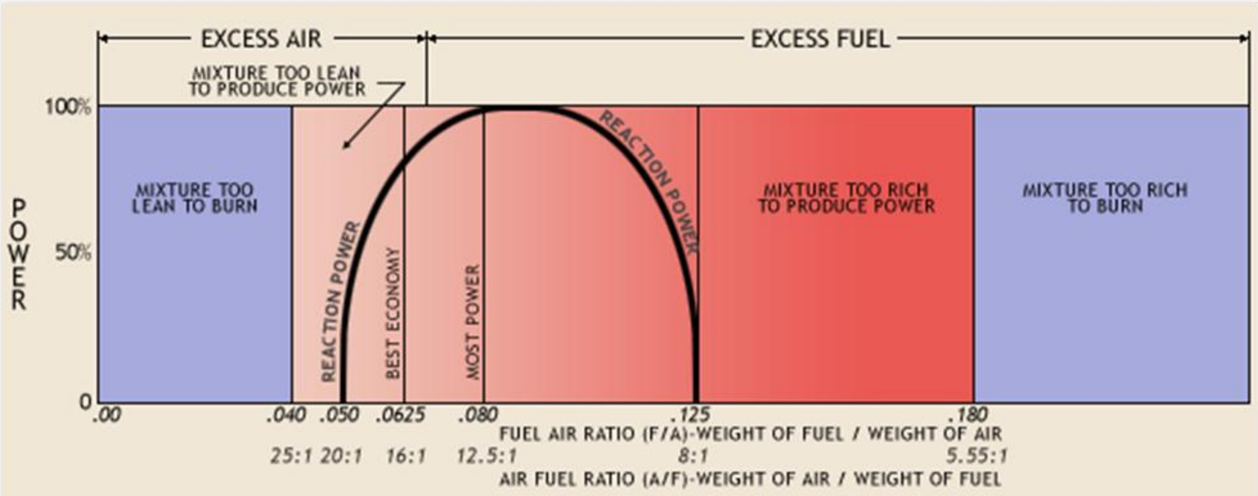
FLAP DEFLECTION GAUGE

This gauge indicates at what angle the gauges are currently extended. The value shown is percent, so flaps fully up means zero percent. Flaps fully down is then 100 percent.



FUEL-AIR MIXTURE RATIO GAUGE

Inside the engine the mixture made by the carburetor out of air and fuel is burned. But as the density of air differs with altitude and temperature, you will need to control the mixture of air and fuel, because the engine itself only works well at a very special mix of the two important ingredients. To better understand what that means, look at the graphics displayed below.



On the far left you can see the so called 'lean mixture'. This mixture has too much air and too little fuel in it. You can say, that the engine is starving here, getting too little fuel.

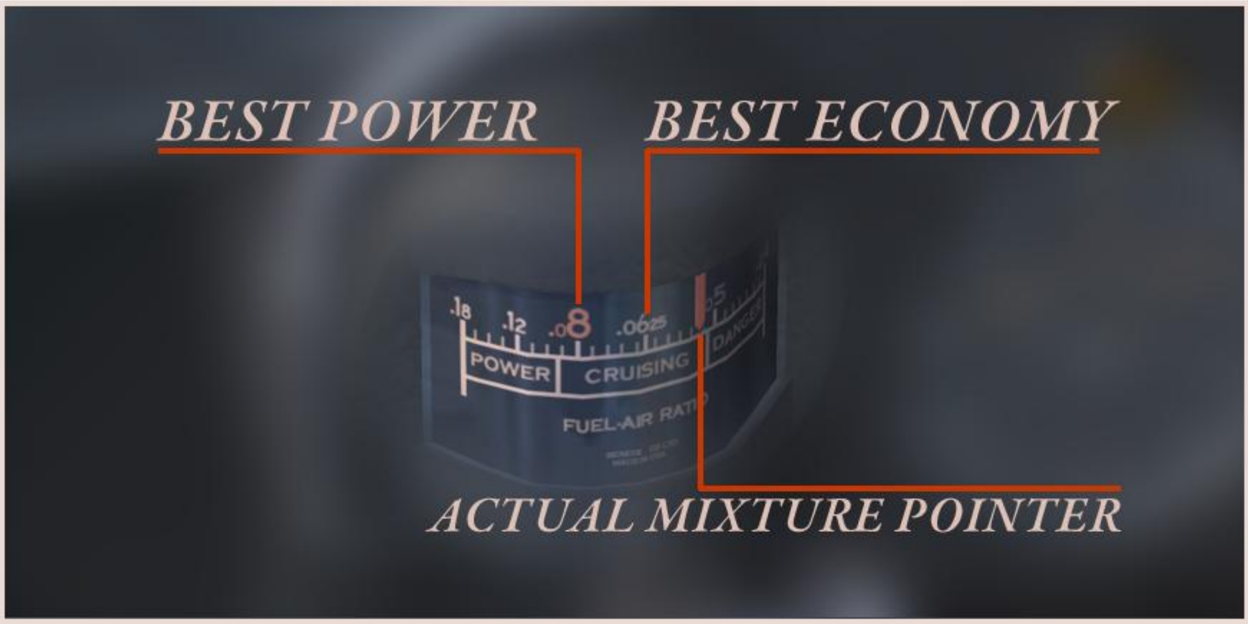
To the far right, you can see the opposite case: FUEL-AIR mixture which has too much fuel in it, so it can't be burned up completely during the combustion process because it lacks oxygen for a good combustion reaction. So in this case, fuel is wasted and the spark plugs are covered with sooth.

To make the engine work right, you should concentrate on two important values:

The first is called MOST POWER, which contains the perfect amount of fuel and air, so the R-1535 can produce the maximum power. The second value is called BEST ECONOMY. This mixture is a little bit reduced in fuel, so it brings a bit less horsepower. But the advantage is that you will extend your flight range enormously.

But how will the pilot control the fuel mixture that will have to be adapted for every flight altitude change? For that case a Fuel-Air Ratio Gauge is located at the right bottom of the instrument panel. It shows the current Mixture Ratio as function of Weight of Fuel divided by Weight of Air.

Don't be frustrated if this is slowly getting a bit complicated. In most cases you have to look only for two numbers at the front display of the Fuel-Air Ratio Gauge: When the instrument's pointer is at the number '.08' you get most power out of the engine. Every setting left of that is wasting fuel and drowning the engine. The other important value is '.0625', which is for very efficient long range cruising. Going right of this will starve the engine.

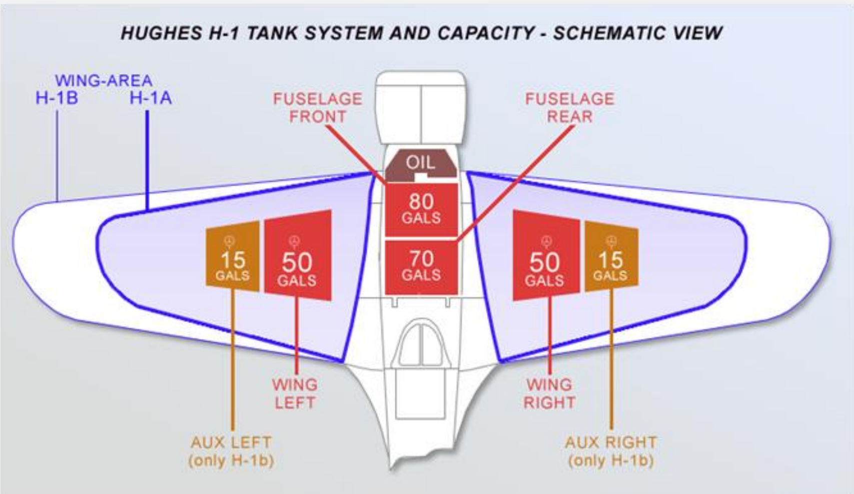


The mixture is controlled via the mixture lever. It's the right of the two levers with silver balls on the end, at the front-left of the cockpit. Moving the mixture lever forward and backward will directly affect the Fuel-Air Ratio Gauge Pointer to move left and right to richer and leaner mixtures.
The engine startup is done with a full rich mixture. Flight settings vary with the situation. Engine shutdown is done by completely leaning the mixture, which means taking the fuel away from the engine that it needs for a stable combustion.

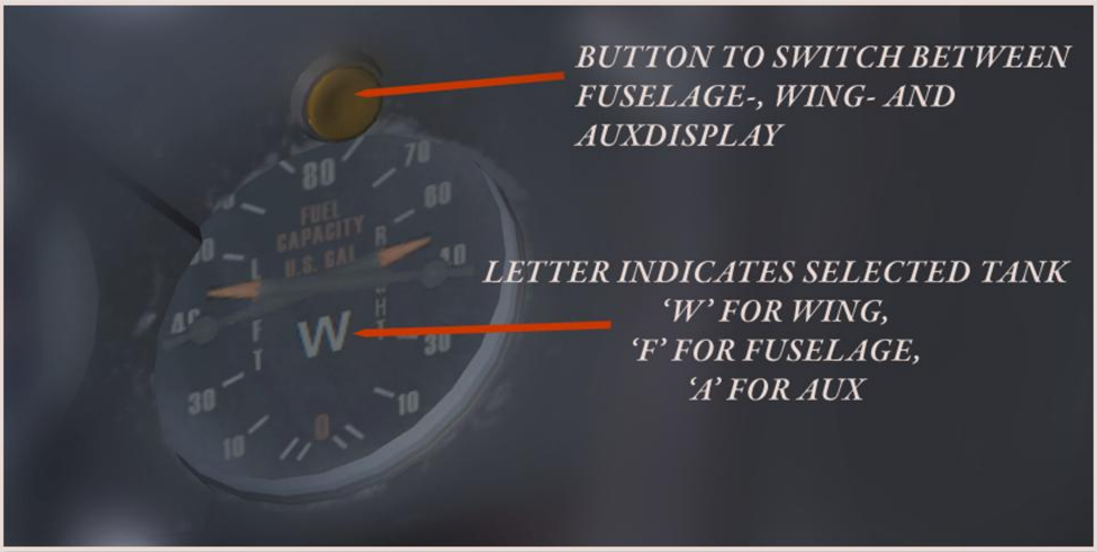
If the engine is running with an over-rich mixture, there is also a thin sooth trail coming out of the exhaust pipes of the H-1 directly in the simulator.

FUEL CAPACITY GAUGE

This gauge shows the remaining fuel capacity in the H-1 tank system. The system is logically structured into Fuselage-, Wing- and Auxiliary-Tank. Positions can be seen in the graphics to the right. Please note that the auxiliary tank is only available in the long-winged version of the H-1.



This gauge presents itself with a display which shows two scales at the same time. This is for the left and right part, because all tanks exist as pairs, so for example Left Wing Tank and Right Wing Tank. Shown in the picture below you can see the letter 'W' in the centre of the gauge. This means that this gauge is currently showing data for the Wing Tank section and we can identify that both tanks have 50 gallons fuel left each. If you press the brown button on top of the gauge, the letter in the center will change to 'F' (for fuselage) and 'A' (for auxiliary). So the button can be used to circle through the three different tank sets in an effective manner.



LANDING GEAR INDICATOR

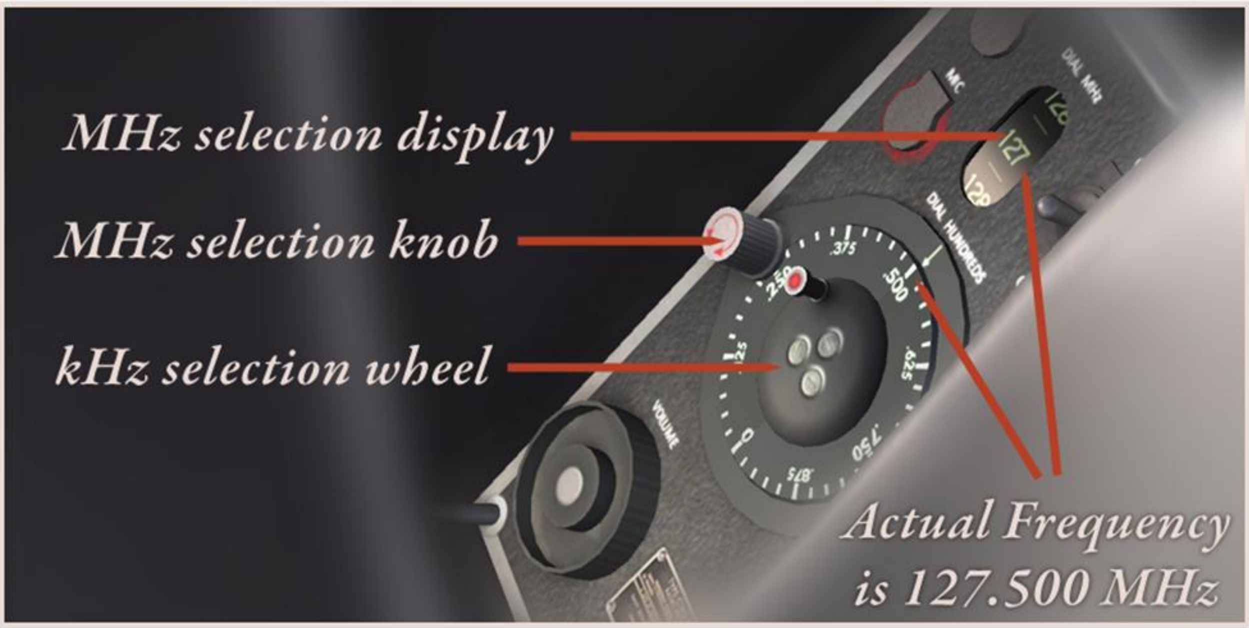
The landing gear indicator lights inform you about the static and transitional situation of the landing gear elements. The indicator consists of two rows which are subdivided by three lamps each. The upper row is connected with the raised gear status. When the gear is retracted completely they will glow reddish. When gear is extended fully, the second row will glow in green completely. The left two lamps belong to the left main gear. The center column belongs to the retractable tail skid. The right column stands for right main landing gear.

MAGNET COMPASS

This is a simple compass with a magnetized pointer which aligns itself with the earth magnetic field lines. The advantage of this device is that it does not need calibration. The disadvantage is the high failure rate when moving through areas with magnetic anomalies, as for example zones with large amounts of iron ore under the surface and when the aircraft accelerates or decelerates. Thus long range navigation becomes problematic and is better done with a gyroscopic compass. But the good old magnet compass is the last thing you will have, when all other navigation devices have failed.

RADIO CONSOLE

This small radio console, which is only a part of the communications equipment behind the pilot's seat, connects you to the outside world when you are airborne. If you want to speak with another person, you have to tune the radio to a special frequency that your partner is using too. The frequency itself consists of six digits, which are divided by a comma in their center… 127.500 MHz for example. When you want to set the radio to that frequency, you first click on the 'MHz selection knob. Left and right clicking will bring up the desired frequency sooner or later on the MHz-display, which is located at the top of the radio. Once this is correct, you go back down to the 'kHz selection wheel'.



Here you can see a circle of numbers consisting of three numbers, which are the kHz Numbers, e.g. 127.XXX MHz. Turn the wheel until the desired number (here .500) shows up directly below the pointing arrow. Now you would have the radio tuned to 127.500 MHz and ready to send and receive radio messages.

SPERRY AUTOPILOT AND GYRO INDICATORS

This device is almost a chapter by itself and it revolutionized aerial navigation in the 1930s. The autopilot is made up of gyroscopes as its core functional principle. Like the children's toy, those gyroscopes have an almost absolute stable rotational axis, if they are kept at high speed rotation. So if you install those things in an aircraft with flexible ball bearings, free to rotate except along the rotational axis which is stiff by natural law, you could easily judge the airplane's relative position to it. And this easy and fantastic idea made Mr. Sperry a rich man. His product was also built into the H-1, helping navigating on long distances and with a connected autopilot it reduces pilots' fatigue a lot. But let's have a look at an image of that device, please note this version is more complex than the standard Sperry that comes with FSX.

The Sperry-Autopilot-System's front is divided into two major parts. On the left side there is the gyrocompass, with its reference to the plane's current course. The compass scale is split up again into an upper part, which shows the selected course that the autopilot will use when engaged and a lower part that shows the direction the plane is effectively flying at. So when the autopilot has been engaged via the Autopilot ON/OFF knob at the bottom right side, the scale reading will be similar after a short time. The gyrocompass doesn't know any direction by itself. So before takeoff you must calibrate it. With the Autopilot Course Adjust Knob, you can set the course that the airplane should take when the autopilot is activated. Also inside the autopilot mode you can change the course anytime. The plane will follow your wishes. Altitude changes can be made the same way, using the Pitch Adjust Knob on the right of the Autopilot Course Adjust Knob. The right side of the Sperry Autopilot Front Panel houses the artificial horizon, which under bad visibility conditions helps you not to crash your plane into the ground. If the Pitch-Line is centered behind the wing symbol, you fly just level. The wing symbol itself can be raised and lowered, just as you like it, because the readout depends on the pilot's body size and

view-point position. The suction gauge on the right top shows the same suction pressure as the suction gauge on the center bottom of the instrument panel. It is important, because the gyros here are suction driven. So when the suction system fails, the autopilot will too, or it will give you a wrong reading. The thick white arc around 4 inHG shows the normal working pressure.

If you are activating the autopilot you will experience some serious differences to a modern product. The heading section is easy to understand but the setting of an altitude hold is somewhat more complicated. Using an modern airliner autopilot you would enter the desired altitude, hit the 'GO' button and the flight computer would perfectly complete the job. The Sperry autopilot does not have any computer parts. There you adjust the aircrafts pitch for climb, descent and altitude hold manually. If you want to keep the aircraft at level flight, you must fine-adjust the pitch like with the pilots stick, but on the Sperry autopilot this is done with the pitch adjust knob. Click left to increase the H-1's pitch, right to decrease the pitch attitude of the plane. This has to be done until the plane is more or less at level. Yes, this cannot be perfect, but we are in the mid 1930s, gentlemen! So from time to time this has to be readjusted. But it was a big relief for that pilot having that and not having to use the control stick with his hands non-stop, eight hours long.

SUCTION GAUGE

The Suction gauge displays the effective vacuum pressure that the engine provides. This is especially important for the various flight instruments, which are driven by suction power. Normal working condition is around value 5. If the suction pressure is too high or too low it will lead to instrument malfunction.

TURN AND BANK INDICATOR GAUGE

The turn and bank indicator, also called the turn and slip indicator, displays the direction of turn and the rate of turn. An internally mounted inclinometer – a metal ball that moves through a tube filled with liquid – displays the 'quality' of the turn, i.e. whether the turn is coordinated correctly, as opposed to an uncoordinated turn, where the aircraft would be either slipping or skidding.

VERTICAL SPEED INDICATOR GAUGE

The Vertical Speed indicator shows the rate of climb or descent in feet/minute. When the pointer showing zero, you fly perfectly level. This gauge measures the rate of climb only up and down to 2,000 feet/minute. The H-1 can climb and dive faster than this, but the original instrument also ended here.

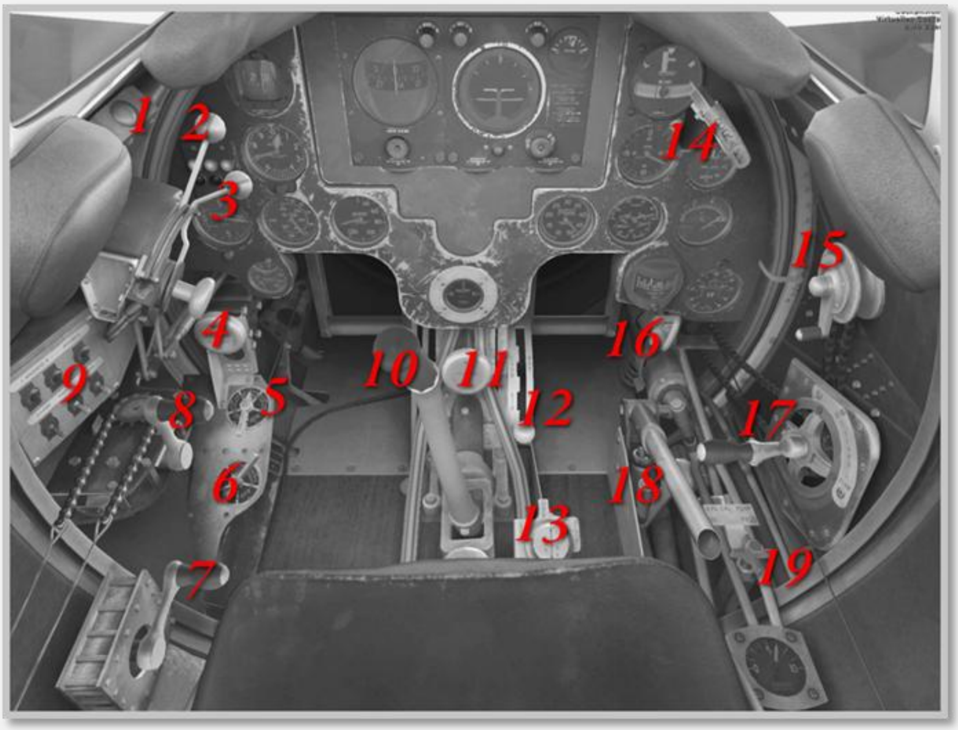
HYRDAULIC PRESSURE INDICATOR GAUGE

Hydraulic pressure is needed to lower and retract the aircraft's landing gear. If it's failing, the landing gear cannot be lowered or raised via the landing gear lever on the right side of the pilot's seat. The normal working value is around 700 PSI. If the hydraulic circuit fails, you will have two alternatives of lowering the landing gear manually: 1) A pipe handle which functions with muscle power and needs a long time to lower the gear and 2) a bypass vent which transfers engine oil pressure to the hydraulic system.

LEVERS, CURBS AND SWITCHES

On the black and white graphics below, you can see all levers, curbs and switches labeled with red numbers to better identify their locations to the user.

1	Propeller Feathering Button for dead engine
2	Throttle Lever
3	Mixture Lever
4	Aileron Trim Knob
5	Fuselage Tank selector
6	Wing Tank selector
7	Canopy Crank
8	Elevator Trim Crank
9	Electric Box switches (described in detail later)
10	Flight stick and Foot pedals
11	Rudder Trim Knob
12	Carburetor Heater Lever
13	Aux Tank Selector
14	Parking Brake
15	Propeller Control Crank
16	Seat Adjust Handle
17	Flap Deflection Crank
18	Emergency Manual Landing Gear Extending pipe handle
19	Emergency Engine Oil Bypass Valve (lowers landing gear with engine oil pressure)
20	Landing Gear Lever (not visible here – located at the right side of the pilot seat)
21	Wobble Pump (not visible here – located at the left side of the pilot seat)



PROPELLER FEATHERING BUTTON (1)

This button triggers a spring-loaded mechanism inside the propeller body, when the engine failed and the propeller governor was not able to feather the propeller before standstill. To get optimal conditions for a successful belly landing air-drag needs to be reduced to a possible minimum and that is the sense behind bringing the propeller blades to full feather. Once the button is pushed, the propeller blades will be fully feathered. This action can't be reversed.

THROTTLE LEVER (2)

The throttle lever can be moved forward and backward. Its mechanics are connected to a butterfly vent at the air-intake of the engine. When the throttle lever is pushed forward the butterfly vent opens, letting in a larger amount of air which is used to increase the combustion energy inside the cylinders. At first this will accelerate the engine's RPM, thus also increasing the Propeller RPM and finally it also increases the thrust output.

MIXTURE LEVER (3)

Located directly at the right side of the throttle lever, this lever controls the amount of fuel that is mixed into the air coming from the air-intake. The engine is able to burn the fuel-air mixture efficiently only at a certain mixture ratio. In our case this is 0.08 (best power) and 0.0625 (best economy). Those numbers can be found on the front display of the earlier described FUEL-AIR RATIO GAUGE, which is located at the lower right front panel. If you move the mixture lever forward and backward, you will see that the red pointer on the FUEL-AIR RATIO GAUGE will move left and right with those inputs. When you bring the red pointer over the orange digits 0.08, you enable the engine to output most power it can produce at a certain mixture. When you move the pointer to 0.0625 it will produce a bit less power, but with much less fuel consumption, so your flight range will extend very much. At sea level, a fully-rich mixture setting will probably produce a perfect ratio (0.08) of fuel to air. But when we climb higher, air becomes thinner. If the mixture settings remain constant, the engine will receive the same amount of fuel, but much less air. Because there's so much more fuel compared to air, this mixture will get too rich and not burn efficiently or even damage the engine by unwanted fuel detonation. By using the mixture lever it is the job of the pilot to manually correct the fuel air ratio. In our case, when we climb higher, we have to pull back the mixture lever to 'lean' the mixture, so again the FUEL-AIR RATIO GAUGE shows us the desired values of 0.08(best power) or 0.625(best economy).

In order to enrich mixture:
Push the mixture forward.
In order to lean mixture:
Pull the mixture lever backward.

[CONTROL]-[SHIFT]-[F1] to set full lean
[CONTROL]-[SHIFT]-[F2] to lean the engine
[CONTROL]-[SHIFT]-[F3] to enrich the engine
[CONTROL]-[SHIFT]-[F4] to set full rich

AILERON TRIM KNOB (4)

With that metal knob you can adjust the middle settings of the ailerons to a non-symmetric value. In other words, if you turn it left or right, the according aileron will deflect continuously. This is useful for example if the wing tanks are asymmetrically fueled up or emptied for any reason. Without that trim knob, you would have to push the flight stick in the opposite direction of the heavier wing the whole time. This would be extensively strenuous and in the long run it would even endanger the pilot's security. Turning the knob left will bring the left wingtip down, by turning it right the right wingtip will go down. The red point up shows that the knob is centered.

FUSELAGE TANK SELECTOR (5)

With this rotating selector you can tell determine which specific tank should be used to feed the engine. The fuselage of the H-1 houses an 80 gallon (FRONT) and a 70 gallon (REAR) tank, which should be used up first in flight, before accessing the others for Center of Gravity reasons. The tanks can be also used in a CROSS-FEED connection. In order to do that, you have to bring the switch simply to 'BOTH ON' in the top-mid position.

WING TANK SELECTOR (6)

This tank selector switch lets you choose between the left and right main wing tanks, which house 50 gallons of AVGAS each. Again you have CROSS-FEED available here by bringing the switch to point at the up-mid section 'BOTH ON'.

CANOPY CRANK (7)

The canopy lever is used to open the canopy via a chain driven mechanism. Once engaged, the canopy will split up in two segments and slide down into the fuselage. There it will remain until the pilot wishes to close it again. Note that the open canopy will influence the aerodynamics of the streamlined H-1, bringing down your possible top-speed because of chaotic vortex air streams.

a) Click the canopy lever itself inside the virtual cockpit.
b) Press the keyboard combination that opens the main exit to manipulate the canopy.

ELEVATOR TRIM CRANK (8)

This trim device is the mostly used, because it frees the pilot from constantly adjusting the pitch angle with the flight stick. When the handle is rotated inside the cockpit, a small metal trim tab located at the trailing edge of the elevator will move into the slipstream opposite to the control surface's desired deflection. In the case of the H-1 a push forward on the elevator trim curb will bring the nose of the aircraft up, if it is pulled back beyond neutral it will bring the aircraft's nose down. A centered curb will neutralize the trim effect completely.

ELECTRIC BOX SWITCHES (9)

There is a bright aluminum box located just at the left sidewall of the forward cockpit area. It contains six ON/OFF switches that control the complete electrical system.

In the top row from left to right you can see the two magneto switches (Left and Right) and the Master Avionics switch.

The magneto switches are able to turn the electric circuits to the engine's spark plugs on and off. So if both are in the OFF position, it is impossible for the engine to run. Normally the magneto switches are kept in the ON position during the complete flight. These switches are especially important at startup, because every engine cylinder houses two spark plugs. The cylinder normally would run with one spark plug alone, so the double plugs are meant as backup for one another. The spark plugs are organized under two independent electric circuits. At engine startup you will let the engine run for a short time, with either the LEFT or the RIGHT spark plug circuit. If everything is OK the engine RPM will drop only a little. If one or more spark plugs of one spark plug-circuit are non-functional there will be a slight offset between the displayed RPMs. In that case the engine should be stopped and new spark plugs should be set into the cylinders.

The master-avionics switch delivers power to the Sperry gyro-device and the radio transmitter/receiver. If it is set to OFF none of those devices will work. Note that it also FUNCTIONS AS THE MAIN POWER SWITCH, so it needs to be ON to run the engine.

Now to the second row:

The red switch is the engine starter-switch. If all of the needed settings and conditions for the engine run-up are at correct values (they are described in detail later in the operating manual), you hold this switch up to start the engine. Because the H-1's power-plant has around 25 Liters displacement to be fired, you will have to keep the switch pulled up a certain amount of time. If you see the combustion process become stable, you can release the switch.

The 'PITOT HEAT' switch triggers triggers an electric heater circuit which sits on the root of the left wing pitot. This small aluminum rod is formed like a tube and measures the plane's airspeed with the help of the incoming air of the slipstream. If the aircraft moves faster, air is pressed in with greater force. The needle of the airspeed gauge will draw to a higher speed. When the aircraft flies slower, slipstream pressure on the pitot will decrease and so will the position of the needle on the air-speed meter. When conditions are humid and cold, ice will build up inside the pitot opening and cover it completely.
So the airspeed gauges will not get proper pressure data anymore and fail to show the correct or even any airspeed. But airspeed indication is crucial for operating the aircraft correctly and so the PITOT HEATER will melt the ice away from the pitot tube, making the speed gauges work again.

The last switch of the second row is the 'LIGHT' switch. It activates two light bulbs which illuminate the instrument panel. There are no additional lights on this aircraft.

FLIGHT STICK AND FOOT PEDALS (10)

The flight stick is the interface, which transports the mental will of the pilot to fly the aircraft in any direction to the flight control surfaces of the aircraft. The bottom end of the flight stick is therefore directly connected to elevator, ailerons und rudder via a wired tackle system. If this stick is pushed into the nose-direction of the aircraft the plane will go into a dive. If the stick is pulled back to the pilot directly, the plane will raise its nose and climb. When the stick is moved far left, the H-1 will roll to the left along its longitudinal axis. If moved to the right, the plane will roll to the right. The rudder, which is for fine-tuning the plane's position in turns and correcting the heading in level flight, is controlled by two pedals that you can find in the two leg-tunnels directly under the main instrument panel. If you kick the left pedal, the plane will yaw to the left in level-flight. If you kick the right pedal, it will yaw to the right. Additionally the pedals are used to control the aircraft's direction while taxiing. Some inches up the main foot-rest is a small lever which can be pushed with the tip of your feet. This will engage the differential hydraulic brake on the specific landing gear side. So if you kick the left pedal's brake lever, that wheel will resist to rotate. While the right wheel will rotate at will, the plane will make a left circular turn while rolling on the ground.

RUDDER TRIM KNOB (11)

This trim device is the mostly used, because it frees the pilot from constantly adjusting the yaw angle with the rudder pedals. When the curb, sitting behind the flight stick base, is rotated left or right, the rudder will be brought continuously into the slipstream by a small offset. So if you turn the trim knob to the left, the aircraft will yaw to the left continuously at a discreet value. The right variant works accordingly for the opposite direction.

CARBURETOR HEATER LEVER (12)

This lever activates mechanical vents in the engine area, which bring warm air from the engine cylinder surfaces back to the carburetor. There it will help to prevent the formation of ice, which endangers airflow to the carburetor. If that airflow was cut, the engine would be not able to run. Especially in cold, humid zones and when the engine is on low RPM (which means the engine is producing low heat too) this should be set to 'HOT' or 'ON'. The 'descent' is the flight situation, where the use of the carburetor heater is a must to prevent deadly surprises.

AUXILIARY TANK SELECTOR (13)

This tank selector controls the flow of fuel between the two wing auxiliary tanks and the engine. Each auxiliary tank contains 15 gallons of AVGAS. Note, that those tanks are only available in the long-winged version as they were fitted for the transcontinental record fight of Howard Hughes in 1937 only. The standard position of this selector is centered at OFF. If the switch is rotated to the left, the Left Auxiliary Tank will send its fuel to the engine. The same procedure is acquired for the right tank when the switch is turned to the RIGHT.

PARKING BRAKE (14)

This wooden handle with the letters BRAKE burned into it, will engage the strong parking brake in both landing gear wheels. It should be applied at ground parking, but also for engine tests down on the tarmac, so that the aircraft can't simply roll away.

PROPELLER CONTROL CRANK (15)

This small metal crank is one of the most important pieces of engine control equipment inside the cockpit. The propeller control crank is connected to a propeller governor unit at the front of the engine, which in turn adjusts the propeller blades. A propeller typically has an efficiency of around 85% when operating in the best regime. Propellers' aerofoil sections are designed like a low drag wing and as such are poor in operation when at other than their optimum angle of attack. So the governor is required to counter the need for accurate matching of pitch to flight speed and engine speed. And that is the piece of equipment you are controlling via the propeller control crank. For takeoff and landing a small but powerful high pitch setting is required. This could be compared to a car's low gear which is powerful but slow too. Once in the air, you surely want to go faster. And like in a car with gear shift, you go faster in higher gear with less power but more speed. Inside the H-1 you have to pull the propeller control to 75 percent flying at sea level to obtain maximum speed. So engine and propeller reduce the RPMs a bit, but the propeller blades rotate at their optimal angle of attack, helped by the governor or 'mechanic master-brain'. Now in low pitch, the propeller pushes much more air backward than in high pitch mode, which accelerates the aircraft to its top speed.

Note: A prop RPM of about 0% will not in every case lead to a prop feathering situation. The blade pitch itself is controlled by relationship of airspeed, counterweight position due Prop RPM and governor. So when you keep Prop RPM crank below 100% settings a slow aircraft will bring the prop control mechanism too to a low pitch position to keep up the RPM revolutions as defined by the crank. Because if the propeller would keep its high pitch angle instead, the prop RPM would very fast decrease at slower airspeeds. But because we have a constant speed system here, blade pitch will be altered to keep revolutions as wished and as long possible.

When flying at higher altitudes, for example at 16,000 ft, you can bring down the Propeller RPM to 65 percent because air is thinner there and the propeller faces less air resistance, but can also move only a smaller mass of air, because of the lower density.

Note: The system to change the blade pitch has primary a hydraulic nature. So blade pitch changes are only possible with a running engine. Without engine running, no hydraulic pressure will be produced and prop crank movement will have no effect.

SEAT ADJUST HANDLE (16)

Via electric motors this handle forces the pilot's seat to move several inches up and forward. So the head of the pilot ends up above the secure windshield, giving him better vision around the aircraft while taxiing and during take-off and final landing. Note that an open canopy and raised seat will increase the H-1's air-drag in the simulator, just like it would in reality.

NOTE: There is a limitation within FSX, which sometimes sets the pilot seat back to a wrong position when driving it back into lowered position via the Seat Adjust Handle. That happens if the seat is used at static pitch and later at in-flight position. Please avoid this by using 'SHIFT+E' or similar command for closing aircraft exits.

FLAP DEFLECTION CRANK (17)

This crank lowers and raises the flaps of the H-1. It's a purely manual mechanism, which converts the pilot's muscle power to the flaps gearwheel system. When the flaps are lowered, drag increases rapidly slowing down the aircraft for landing. On the other hand the airflow will be slowed at the lower side of the wing too, enlarging the pressure difference to the air flowing at the wings topside. So lift at low speed is greatly improved and together with the low flying speed, keeps landing distances much shorter than without flaps. On the image above you can see the H-1B long-wing variant with fully extended flaps. Note, that at 50 Percent Flaps deflection the ailerons too will follow the flaps…

…some way down to support their function. During this period the roll behavior of the aircraft will be reduced. Flaps should be applied at speeds below 170 MPH only, to prevent damaging. The flaps were moved fully variable without any detents in the 1935 original, but the simulation cannot give that function full credit. So the flaps will be moved down and up through 10 steps each covering three degrees deflection angle. If you press the specific flap button key on your stick 10 times in advance it will slowly extend the flaps to their full angle. So you do not have to wait until each deflection step has finished.

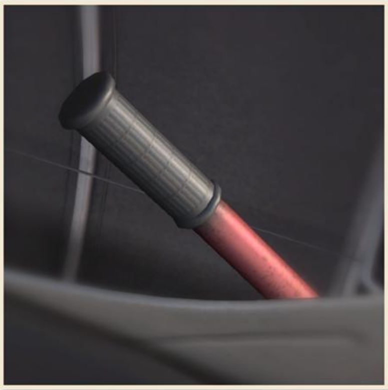
EMERGENCY MANUAL LANDING GEAR EXTENDING PIPE HANDLE (18)

This handle is like a life insurance when your landing gear's hydraulic system fails. The normal way of lowering the landing gear would be to push the landing gear lever down. That would trigger a hydraulic valve in the wings, which would, with the help of the hydraulic pump system, force the landing gear down or in the opposite case, raise it into its wing housing. The system functions like the opposite of an air pump. Suck the air out of the pump cylinder and the handle will slide in, push air into the pump body and the handle will be forced out. The function of the landing gear system is very similar, but this one works with hydraulic oil to achieve stronger work-forces. It is a natural law that if systems can fail they will fail. And for that case the clever aircraft designer and pilot wants a 'Plan B' for a failure of the hydraulic system. Plan B is to pump the landing gear down manually. This is a real adventure because you have to keep the eyes on the flying path, left hand on the flight stick to control what direction the airplane is flying in and with the right hand you have to do almost 30 push'n'pull-cycles to bring the landing gear down fully. You cannot retract the landing gear with that lever! But in the end, it is better to touch the ground with your tires and not with the belly of your aircraft!

EMERGENCY ENGINE OIL BYPASS VALVE (19)

The use of this red-colored valve could be called 'Plan C'. It is also used in emergency situations in connection with the landing gear hydraulic system. This time oil from the engine's internal circuit is guided to the hydraulic system. This is also a risky venture, because it will lower the effective oil pressure within the engine. So you will have much less lubrication and cooling of pistons, cylinder walls and bearings inside the power-plant. It also destroys the normal hydraulic fluid and your mechanic will have to flush the system and replace the fluid. So if you choose to do this after first looking for a more convenient way to lower the landing gear, you should not force the engine to maximum performance any more. If you insist on maximum power output and the oil pressure gauge shows below 50 PSI sooner or later something really important will break inside the engine. Therefore decide wisely which way suits your character better: hard muscle work but security for the engine or a convenient rotation on a valve and danger for the engine.

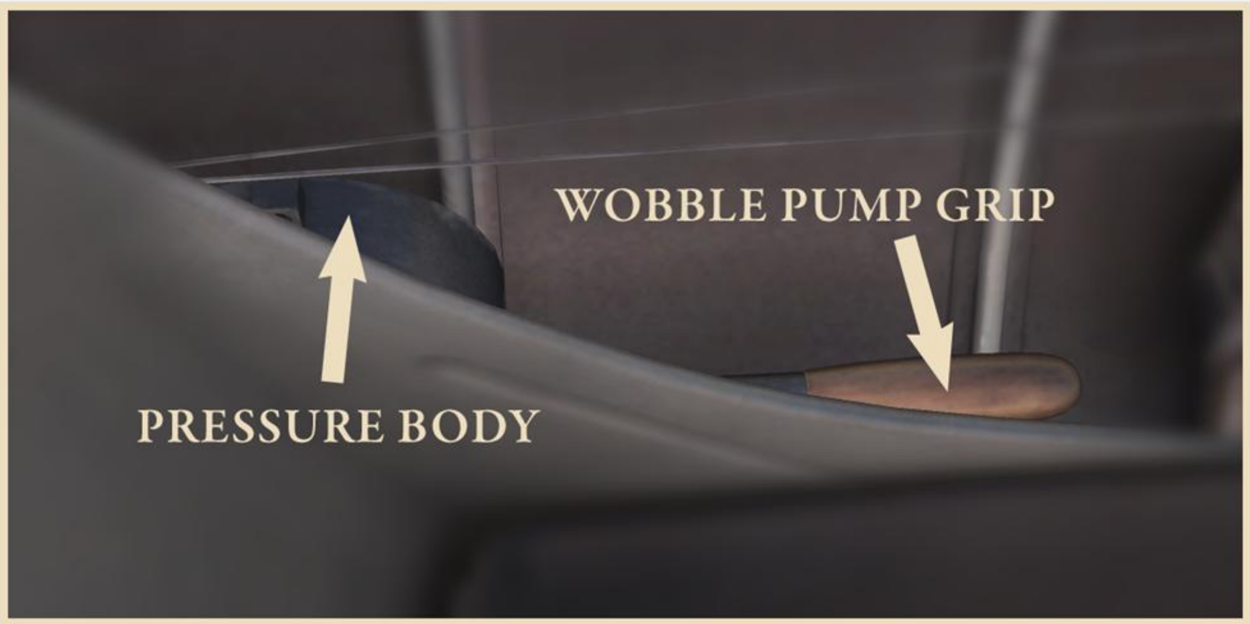
LANDING GEAR LEVER (20)



The landing gear lever is the usual way to raise and lower the landing gear and sits at the lower right side of the pilot seat. If it is pulled up, the landing gears will raise. If it is pushed down, the landing gear will be lowered.

WOBBLE PUMP (21)

This mechanic pump has the function to build up fuel pressure before the engine starts. It is located at the lower left side of the pilot seat. The H-1 has only an engine-internal pump to transport fuel from the tanks to the engine's carburetor and later cylinders. But this pump only works, when the engine is running. So before the engine is running, 4 PSI of fuel pressure (the engines minimum to run correctly) have to be generated manually. This is done by wobbling the wooden pump grip until the fuel pressure gauge pointer shows exactly or something above 4 PSI. Note, that when you wobble too high a pressure into the fuel tubes, they will be damaged and leak. This will happen above 8 PSI. Below you can see an image of the wobble pump.



At this point the SYSTEMS MANUAL ends. After you have learned what instruments the pilot of the Hughes H-1 uses to operate the aircraft, we will proceed to the GENERAL OPERATION INSTRUCTIONS which will tell you, how to fly the H-1 in detail.

GENERAL OPERATING INSTRUCTIONS
GROUND OPERATION

ENGINE STARTING

1. **Control Position Check – EXTERNAL (NOT SIMULATED)**

   By walking round the aircraft and checking all the visible parts the pilot makes certain that the aircraft is not damaged, ready for flight and that no objects block the path of the aircraft.

2. **Do eight revolutions of the propeller by hand – EXTERNAL (NOT SIMULATED)**

   After the previous shutdown, the warm residual oil clinging to the power section surfaces flows downward towards the lower cylinders. Some of this oil seeps past the piston and piston rings, accumulating in the combustion chamber. If sufficient liquid is present, the true compression ratio will be raised and extremely high pressures will be produced when the piston of the cylinder is moved downward during the compression stroke. This pressure can rise to an extent that will result in damage to the cylinder, piston, or link rod. In extreme instances the piston may actually 'bottom' against the liquid. Do not pull through in the reverse direction of normal propeller rotation. 'Backing up' the engine will result in pushing the liquid into the intake pipe, where it will be ready to return to the cylinders on the next intake stroke.

3. **Make sure all switches are in 'OFF' position (switches down)**

4. **Make sure propeller control is at 100% (HIGH RPM-LOW PITCH)**

5. **Engage Parking Brake**

6. **Push AVIONICS switch up to 'ON' (this is also the electric circuits master switch)**

7. **Move FUSELAGE-TANK-SELECTOR to 'BOTH ON' position**

8. **Wobble at least 4 PSI fuel pressure with WOBBLE PUMP (check at fuel pressure gauge)**

9. **Open throttle lever a tiny bit at airports above 3,000ft pressure elevation**

10. **Push mixture lever fully forward to 'RICH MIXTURE'**

11. **Turn both magneto switches to 'ON' (upward)**

12. **Pull up starter switch and hold until engine is running/ open throttle a bit if RPM tends to fall below 500 RPM but keep below 1,000 RPM when oil is cold**
    At airfields/airports which are located near sea level you usually not have to open throttle more then to idle position. But if your take-off position is located above of that, you have to open the…

…throttle for some fractions of inches. Don't overdose this, only try to keep the engine RPM above 500 RPM until combustion has stabilized. The source of the problem is that at altitude you have much more fuel relative to air contained inside a rich fuel/air mixture, then with startups at sea level. With lack of air during startup the engine fuel is burning badly, resulting in the drowning of the cylinders/spark plugs with fuel.

13. **If engine runs stable, bring back the RPM to idle by pulling the throttle slowly full back, stable IDLE RPM should be achieved between 550 and 600 engine RPM**

NOTE: In the 1935 original H-1 no electric starter was implemented. The engine was started in a completely mechanical way. On the left forward fuselage of the H-1, only some inches behind the end of the engine cowling, there was a hole in which a crank was fitted. Then a strong man would have to rotate a 100lb inertia wheel with that crank, standing on a wooden ladder, until it made a special high noise tone as a sign of the correct RPM. Then the sleeping engine was moved by the inertia forces of the rotating wheel. If the forces were high enough, combustion kicked in inside the cylinders and the engine came to a stable life by itself.

ENGINE WARM-UP

1. **Check if oil pressure rises and stabilizes between 70 and 90 PSI (If not turn engine off)**

2. **Bring up 1,000 RPMs to the engine again and check if oil temperature rises above 40 degrees Celsius. Check repeatedly while going forward in procedures. (If oil-temperature is not rising, turn off engine)**

   After starting some time will be spent in warming up the engine. This is done at 1,000 RPM with the propeller in high RPM (low pitch) position. One thousand RPM is specified as this engine speed will ensure freedom from spark plug fooling. The propeller pitch position results in the lightest possible load at this RPM. Cold, undiluted oil is too thick to flow through the various lubrication passages, and vital engine parts would lack lubrication even though high pressure shows on the oil pressure gauge. Additionally the engine designer has established the clearances between the working parts AFTER considering the effects of expansion when the material has warmed up. In many instances, the cold clearances are not sufficient to allow satisfactory oil flow.

3. **Check carburetor temperature gauge/ if under 6 degrees Celsius – turn on Carburetor Heater**

4. **Magneto Safety Check**

   During warm-up running, the magneto safety check can be performed. Its purpose is to ensure that all ignition connections are secure and that the ignition system will permit operation at the higher power used in the ground check to be conducted later. The magneto safety check is conducted as follows:

(1) RPM -1,000
(2) Propeller – High rpm (low pitch)
(3) Switch – From 'Both' to 'Right' and return to 'Both'
(4) Switch - From 'Both' to 'Left' and return to 'Both'

While switching from 'Both' to a single magneto, for example 'Both' to 'Right', a slight but noticeable drop in RPM should occur. This indicates that the opposite magneto has been properly grounded out and that the connection to the single operating magneto is secure.

5. **Check fuel pressure / Should be between 4 and 7 PSI**

6. **When oil temperature has risen to between 40 and 70 degrees Celsius undertake second engine test**

(1) Correct mixture ratio to 0.08 at FUEL-AIR-RATIO gauge
(2) Open throttle to manifold pressure equal to field barometric pressure (sea level ca. 30inHG)
(3) Switch – From 'Both' to 'Right' and return to 'Both' (Normal drop 25-50 RPM)
(4) Switch - From 'Both' to 'Left' and return to 'Both' (Normal drop 25-50 RPM)
(5) Check Fuel pressure (5-6 PSI), Oil pressure (80-90 PSI)
(6) Retard throttle

7. **Check cylinder temperature**

Little, if any, cooling airflow is available on the ground, and operation at a greater than warm-up rpm must be kept to a minimum, especially if the aircraft is not headed into a good wind. It is essential that cylinder head temperatures never exceed the maximum specified for operation, and it is desirable to keep them at least 50 degrees Fahrenheit (30 degrees Celsius) below the maximum limit (500 degrees Fahrenheit).

8. **Raise Pilot seat for better sight**

9. **Taxiing**

Use a smooth flow of power or smooth changes of power during taxiing. Rapid and frequent 'jazzing' sometimes interferes with the operation of the accelerating pump, with the result that backfires occur because of the low manifold pressures just after sharp closing of the throttle, while the engine is still turning at a high RPM.

Like any tail dragger the taxi stage is not easy. Controlling where the tail goes takes some practice and visibility is limited. You'll see tail-draggers zigzag during taxi because that's the best way to be able to see in front of the aircraft. While you taxi you have to check the brakes and see that the turn needle, heading indicator and compass are operational. During a turn you should see some movement in the attitude indicator. For optimization of the pilots vision, the H-1 features a moveable pilot's seat which lifts the pilots some inches up and forward. When the canopy is opened, simply pull the SEAT ADJUSTMENT HANDLE to get a better look around.

FLIGHT OPERATION

GENERAL

Obstacle Clearing

When you need to clear obstacles on takeoff you can pull the aircraft off the ground at 100 mph and if you are careful you can keep the aircraft below 120 mph for a while. You'll think you're in a helicopter, but you are in a dangerous flying mode. You have no speed left for solving any problem.
On landing you can clear a 50' obstacle and still land in 1,500 feet.

Stalls

The H-1 stalls with a gentle nose dive and a tendency to roll left. Stall speed is at 91.2/82.5 mph with flaps up and 70/63 MPH with flaps fully down (short-winged/long-winged H-1). In order not to stall the aircraft you have to push the nose down to regain airspeed. If you are in midst of a spin (aircraft is rotating wildly around its center) you have to use additional full rudder against the spin direction until the aircraft gets back into a stable flight condition. Finally come back to level flight.

Engine out gliding

The H-1 is not very suitable for gliding. It is important to keep a certain air speed and to feather the propeller to reduce air-drag.

Note: A prop RPM of about 0% will not in every case lead to a prop feathering situation. The blade pitch itself is controlled by relationship of airspeed, counterweight position due Prop RPM and governor. So when you keep Prop RPM crank below 100% settings a slow aircraft will bring the prop control mechanism too to a low pitch position to keep up the RPM revolutions as defined by the crank.
Because if the propeller would keep its high pitch angle instead, the prop RPM would very fast decrease at slower airspeeds. But because we have a constant speed system here, blade pitch will be altered to keep revolutions as wished and as long possible.
When the engine is down, you can't extend the landing gear, because the hydraulic system is down too. And it's better to keep the landing gear in and try a belly landing, because the landing gear struts are consuming much airspeed. So go into a controlled dive that helps you keep the airspeed between 150 and 120 MPH. At 50-70 ft above SUITABLE ground pull hard on the stick. That will bleed out kinetic energy of the plane promptly. Below 80 MPH the plane will drop like a stone, so you should make ground contact exactly at that speed. You will surely not have to kick the brake, but watch your limbs and head during the rough ground journey.

Slow Climbing

Steady climbing below 140 MPH should be avoided because the high risk of engine overheating.

TAKE-OFF

1. **Align aircraft straight to runway/strip**

2. **Trim aircraft as desired (you will almost need no trim if tanks are all fueled up)**

[CONTROL]-[4]	Aileron trim left (or click in VC directly)
[CONTROL]-[6]	Aileron trim right (or click in VC directly)
[1]	Elevator pitch down (or click in VC directly)
[7]	Elevator pitch down (or click in VC directly)
[CONTROL]-[0]	Rudder trim left (or click in VC directly)
[CONTROL]-[4]	Rudder trim right (or click in VC directly)

3. **Use Flaps as needed**
   Note that the long-winged H-1 needs usually no flaps for take-off, but usage will shorten take-off length, especially when there is no wind around blowing directly head on.
   The short-winged racer version *needs* the deployment of flaps to two detents at take-off.
   As the airfoil gives minimum resistance to slipstream, it also provides poor lift at slow speeds.

4. **Slowly open throttle up to 40-42inHG and counter the aircraft getting off the center line**
   Note that the rudder achieves its full effect above 40kts. A too rough acceleration out of the stand will throw the aircraft off the runway due the strong p-effect at steady pitch angle.

5. **After tail got up between 55 to 70 MPH, open throttle smoothly to fullest setting**

6. **Accelerate to 110 MPH (short-winged H-1 120 MPH) and climb at 500 ft/minute**

7. **Retract landing gear and check back at landing gear lights if retracted completely**

8. **Retrieve flaps completely (if extended)**

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CLIMB

9. **Pull propeller control lever back to 90 Percent Prop RPM, 35 inHG MAP**

10. **Climb at 1000 ft/minute at 150 MPH (only recommended) to desired altitude**

11. **Check Cylinder Head/ Oil Temperatures are not getting too high/manage mixture**

12. **Keep mixture settings within efficient levels (0.08-0.0625)**

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CRUISING

13. **Propeller control lever back to 75% Prop RPM for cruising altitudes between 0 and 9,000 feet / 65%Prop RPM for 9,000 feet and above, Speed at 250-330 MPH, MAP 30-40inHg**

    Cruise level is your own choice. When you reach your cruising altitude you lower the nose and let the speed increase. At the same time reduce the manifold pressure and lean the engine, RPM stays at 2000-2100. If the aircraft is loaded correctly you'll find that she will need just a touch of trim (or no trim at all) to stay stable. Without an Autopilot you'd better spend some time trimming.

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DESCENT

14. **Manifold pressure 15-25″, 75 Percent Prop RPM, Speed at 200-250 MPH**

    Here it is of prime importance to check the Carburetor Temperature. If under five degrees Celsius, engage Carburetor Heater. Keep vertical speed between 500 and 1,000 feet/minute.

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APPROACH

15. **MAP 20-30″, 90% Prop RPM, Speed 120-140 MPH, Slope -5 to -6 degrees before flaring**

    When you get close to the airport you've got to stabilize the aircraft in the approach settings. The H-1 will need some time to bleed out its high airspeed due to its low air-drag. So expect to fly some additional circles to reduce speed. Flaps should be extended fullest when you go below 120 MPH. Keep vertical speed of descent between 500 and 750 feet/minute.

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LANDING

16. **Manifold pressure 15-25″, 100 Percent Prop RPM, Speed at 85/95 MPH (long-/short-winged)**

    On final you've got to bring your airspeed down to 95 MPH. Reduce to 15-20 inHG manifold pressure during flare maneuver but not completely retard throttle. That would let you bounce onto the ground. You can land the long-winged H-1 very soft at 90-80 MPH, the short-winged version needs 90-95 MPH to settle down perfectly. Try to let the main gear touch first, retard throttle and bleed out the H-1s remaining speed.
    Use pedal brakes to bring the plane down to taxiing speed and leave runway/strip when you can.

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SHUTDOWN

1. **Find parking position**
2. **Place aircraft into parking position**
3. **Set Throttle to Idle RPM.**
4. **Activate Parking brake.**
5. **Let Cylinder head temperature settle below 300 deg Fahrenheit**
6. **Slowly retard Mixture lever to FULLY LEAN position (towards pilot) until engine cuts out**
7. **Push Magneto switches to 'OFF' Position**
8. **Push 'Light', 'PITOT' and Master to 'OFF' Position.**
9. **Retrieve flaps.**
10. **Unfasten seat-belt.**
11. **Exit aircraft.**

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VIEW MODES IN FSX

FSX uses the [S] key to select the view mode and the [A] key to change the view inside the view mode. In a default FSX with the Hughes H-1 installed this leads to this structure:

Select MODE with [S] and select VIEW with [A]

Cockpit Mode **Outside Mode** **Tower Mode** **Aircraft Mode**