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Douglas Aircraft Co., Inc.
Santa Monica, Calif., U.S.A.

ENGINEERING DEPT.

TECHNICAL DATA

RECOMMENDATIONS

for the

OPERATION

of the

DOUGLAS TRANSPORT MODEL DC-2

By C.T. Reid

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June 1934

COPY NO. 1

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RECOMMENDATIONS FOR THE OPERATION OF THE DOUGLAS TRANSPORT

I. STARTING OF ENGINES

A. Preparation for Starting

Suggested procedure for starting is as follows:

1. Set tank selector valve (on left of control pedestal) to tank desired.

2. Set engine selector valve (on right of control pedestal) to "both on".

3. Work wabble pump until pressure of 3 pounds or more shows on both fuel pressure gauges.

4. Priming is not necessary if engines are warm. If cold, five shots should be enough. Note: Working of throttles will flood these carburetors. If throttle is opened full once only gas will drip from carburetor. Throttle working more than this is not recommended.

5. Do not start engines with carburetor heat control in the "hot" position.

6. Set main switch to airplane's battery or battery cart and then push main ignition switch "on".

7. Turn on engine ignition switch and then set starter selector switch for engine desired.

8. Push starter button. If engine loads up, open throttle wide and turn engine over with starter until it clears out.

B. Spark Retard and Booster Ignition

Spark is retarded automatically by a special solenoid working in unison with the starting solenoid when the starter button is pushed. Booster ignition also goes on automatically when the starter button is pushed. In order to allow spark to advance, it is important that the starter button be released immediately when engine fires.

C. Hand Cranking

If starting with the hand crank, it is necessary to push the starter button in order to get spark retard and booster ignition.

II. WARMING UP

A. Oil Pressure

It will usually take some seconds after starting before oil pressure begins to show on the oil pressure gauges. When oil pressure is up to at least 40 pounds, the throttles may be opened up to warming-up revolutions, 800 to 1000 r.p.m., (with propeller in low pitch). Engines may be warmed up safely at this engine speed since better lubrication will result from higher rotating speeds. Normal oil pressure should be between 50 and 80 pounds at all times during flight.

B. Cylinder Temperatures

Cylinder head temperatures should be watched closely while warming up because they are likely to rise more quickly during idling on the ground than at full throttle in the air, because with pressure baffling very little air can go through the engine when it has no forward speed. Cylinder head temperatures should be at least 300 degrees Fahrenheit before takeoff, but should not go above 475 degrees on the ground. There is only one thermocouple on each engine; this shows head temperature of No. 7 cylinder, which is usually the hottest.

C. Oil Temperatures

Oil temperatures should be at least 100 degrees Fahrenheit before takeoff. The oil temperature gauge shows "Oil in" temperature instead of "Oil out" as on some former installations. It will, therefore, take longer to get the oil up to normal takeoff temperature indications. Cold oil usually results in more damage to engines than relatively hot oil, providing oil pressure does not drop because of excessive temperature.

III. MAXIMUM GROUND REVOLUTIONS

A. The limit for opening up the engines on the ground is 34.5 inches Intake Manifold Pressure although in takeoff this may be increased to 37 inches. Power output is higher at 37 inches manifold pressure at high altitude than at sea level airports because of the reduction in back pressure on the exhaust. However, it is permissible to use this pressure for takeoff at any altitude as takeoff time is of short duration.

IV. TAXIING

A. Tail Wheel Lock

Taxiing is made easy if the tail wheel lock is used whenever it is possible to taxi in a straight line. It is not sufficient that the locking handle be in the locked position; the tail wheel must be straightened in order to allow the locking pin to engage. Taxiing may be accomplished with little use of the brakes if this tail wheel lock is used whenever possible.

B. Tail Wheel Unlocked

When taxiing with the tail wheel unlocked, control for turning will be improved if the inboard engine is run fast enough to prevent the inboard wheel from stopping entirely. This will also prevent tearing up the airport runway.

C. Extreme Brake Effectiveness

In order to obtain extreme differential brake action, the brake lever should be released, pedals put over in their extreme position and then the brake lever pumped once or twice. This will lock the desired brake and entirely release the other. Ground looping can be definitely avoided by keeping the tail wheel in the locked position on takeoff so that it will be locked when landing.

V. TAKEOFF

A. Low Pitch Propellers

Propellers are to be in low pitch for takeoff.

B. Pilot's Check Chart

In preparing for takeoff, the pilot's check chart on the instrument panel will furnish a quick way of insuring that all necessary conditions of takeoff (such as propellers being in low pitch, wing flaps up, cabin sign on, tail wheel lock engaged, etc.) have been complied with.

C. Use of Wing Flaps

Normally wing flaps should not be used on takeoff.

D. Raising Tail

Takeoff is accomplished most quickly in this airplane by raising the tail at once when the throttles are open. For long fields, however, normal takeoff will give greater passenger comfort.

E. Manifold Pressure

Throttle stops are not provided, therefore, the manifold pressure gauges must be watched closely during takeoff to insure that manifold pressures do not exceed 37 inches. More pressure than this is liable to damage the engines and will give very little increase in takeoff performance.

F. Mixture Control

Mixture control should normally be left full rich for takeoff at sea level. At altitudes, even though best ground revolutions are obtained with mixture half lean, mixture control should be richened up considerably before takeoff. The reason for this is that cylinder head temperatures will rise very quickly if takeoff is made with a lean mixture.

VI. CLIMBING

A. Retracting of Wheels

Once the wheels are off the ground it is desirable to retract the landing gear immediately and hold the airplane nearly level until it accelerates up to its best climbing airspeed. Instructions on the operation of the retracting gear are given on Pages 10 and 11.

B. Climbing Airspeeds

For normal transport operation, shift propellor pitch to high and climb at high speed along a flat climbing path. For this climb, 140 miles per hour indicated airspeed, up to 6000 feet, with 34.5 inches manifold pressure, will hold the power down to 75% up to 6000 feet where the climb becomes full throttle and the power drops off rapidly. This climb will not exceed 460 feet per minute rate-of climb, which is considered a normal maximum for passenger comfort.

C. Power Control

If takeoff is made from a 5000 or 6000 foot airport, the throttle may be left full open for high pitch, 140 miles per hour indicated airspeed climb, without stressing the engines beyond a 75% power output.

D. Climbing Limits

If it is desired to maintain a very high rate-of-climb, the propellers should be left in low pitch and an airspeed of 100 miles per hour (indicated) maintained during a full power or nearly full power climb. The climbing limits of 34.5 inches manifold pressure, 1950 RPM, 500 degrees cylinder temperature and 180 degrees oil temperature should be carefully adhered to during all climbs.

VII. USE OF CRUISING AND AIRSPEED CORRECTION CHARTS

A. Cruising

See Chart, page 7.

1. The cruising chart is plotted to show the variation with altitude of true airspeed for various values of engine power and RPM. It is intended that the desired power output in level flight at any altitude can be obtained by regulating the engine RPM. Since the RPM and percent power depend upon density altitude, a scale is given on the left for deriving the density altitude from the pressure altitude (altimeter) reading and the temperature of the atmosphere. In level flight the manifold pressure depends upon pressure altitude and requires no correction for temperature.

2. The following example will serve to illustrate the use of the chart: Pressure altitude, 4500 ft. (altimeter zero setting at 29.92" hg.), air temperature 70°F. For operating at 177 MPH true airspeed, the various characteristics are found as follows: From the steep diagonal line marked Standard Temperature in the altitude correction scale at the left, locate the pressure altitude of 4500 ft. (Point "a"), move diagonally upward to right along the pressure altitude lines to 70°F. (Point "b"). This gives the density altitude of 6200 ft. Then move horizontally to the right to get the percent power and corresponding engine RPM, which for 177 MPH are respectively 64% power and 1675 RPM (Point "c"). Manifold pressure can be checked against pressure altitudes as follows: From point "a" (Pressure altitude of 4500 ft.), move horizontally to the right to a position again at 177 MPH (Point "d") directly under point "c". This point shows that 28 1/2" Hg. manifold pressure is required.

3. It should be particularly noted that engine RPM and power which are determined from density altitude and the manifold pressure which is determined from pressure altitude are not obtained at the same vertical location on the chart when the air temperature is other than standard. These points will lie on the same vertical line of true velocity.

4. The permissible cruising region of altitudes and velocities is bounded by engine limitations on power, RPM and manifold pressure and by the maximum altitude for comfort of passenger. The boundary for high cruising speed at high altitude is set by the 75% power limitation. At low altitudes it is set by the 28 1/2" manifold pressure limitation. The minimum allowable cruising velocity is determined by the 1600 RPM limitation which is necessary to avoid resonant engine vibration. The highest allowable altitude for normal operation is 14,000 ft. density altitude which should not be exceeded without permission from the passengers.

5. These four limitations bound a region which is recommended for cruising. All normal operations should be carried out within this region.

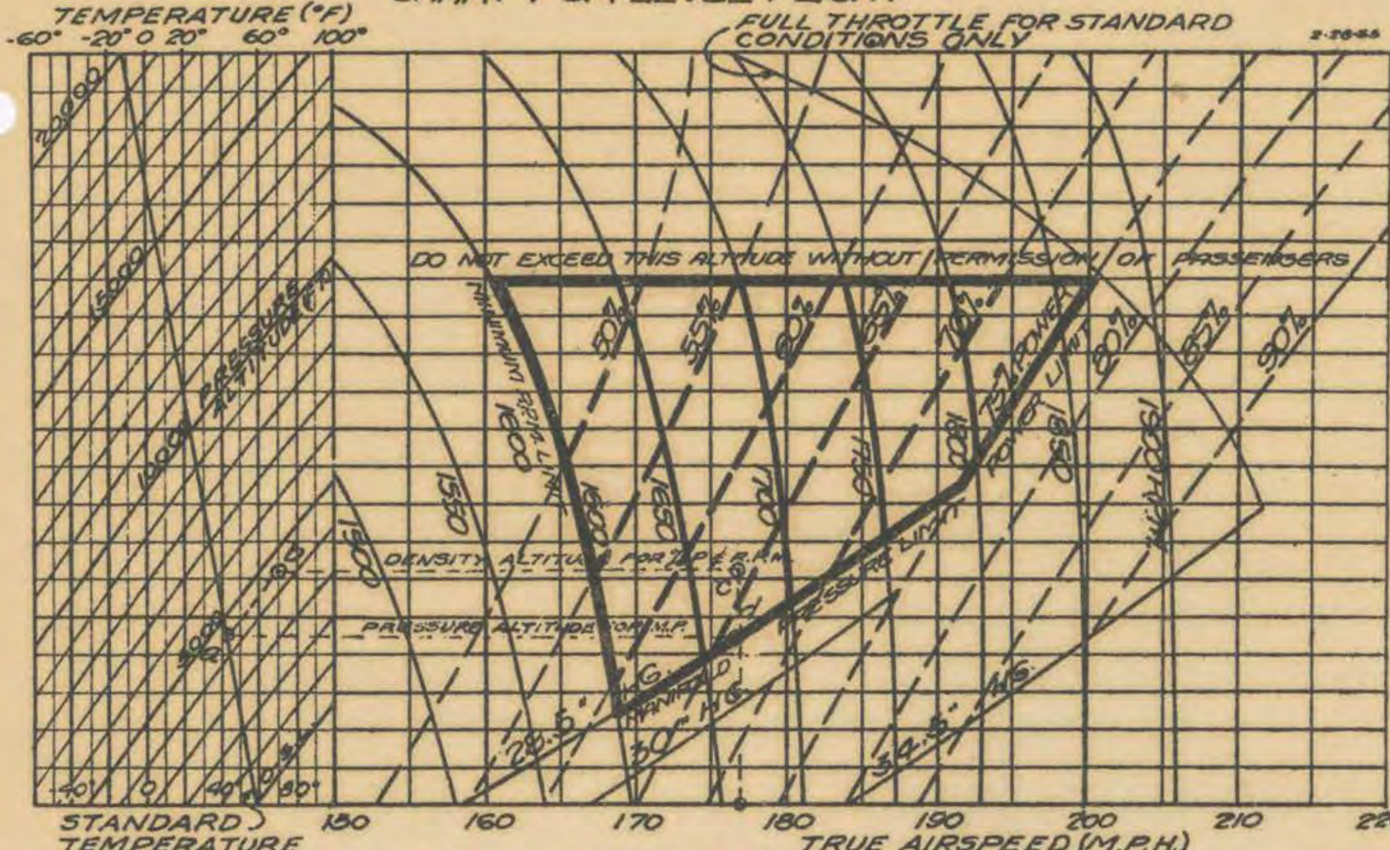
B. Airspeed Correction

See Chart, page 7.

1. The airspeed correction chart can be used to calculate the true airspeed from the indicated airspeed meter reading. The density altitude is used since the indicated airspeed reading depends upon the density of the air. The correction chart given includes the normal sea level calibration of the airspeed meter. It will be noted on the horizontal airspeed scale at sea level that the indicated airspeed and true airspeed have different values. These differences arise from the normal sea level calibration of the instrument. The various indicated airspeed lines, moving diagonally upward to the right on the body of the chart, show the variation of true airspeed with indicated airspeed as the altitude increases so that the true airspeed determined from this chart includes all corrections necessary (that is, for pressure altitude, temperature, and normal sea level calibration of the instrument).

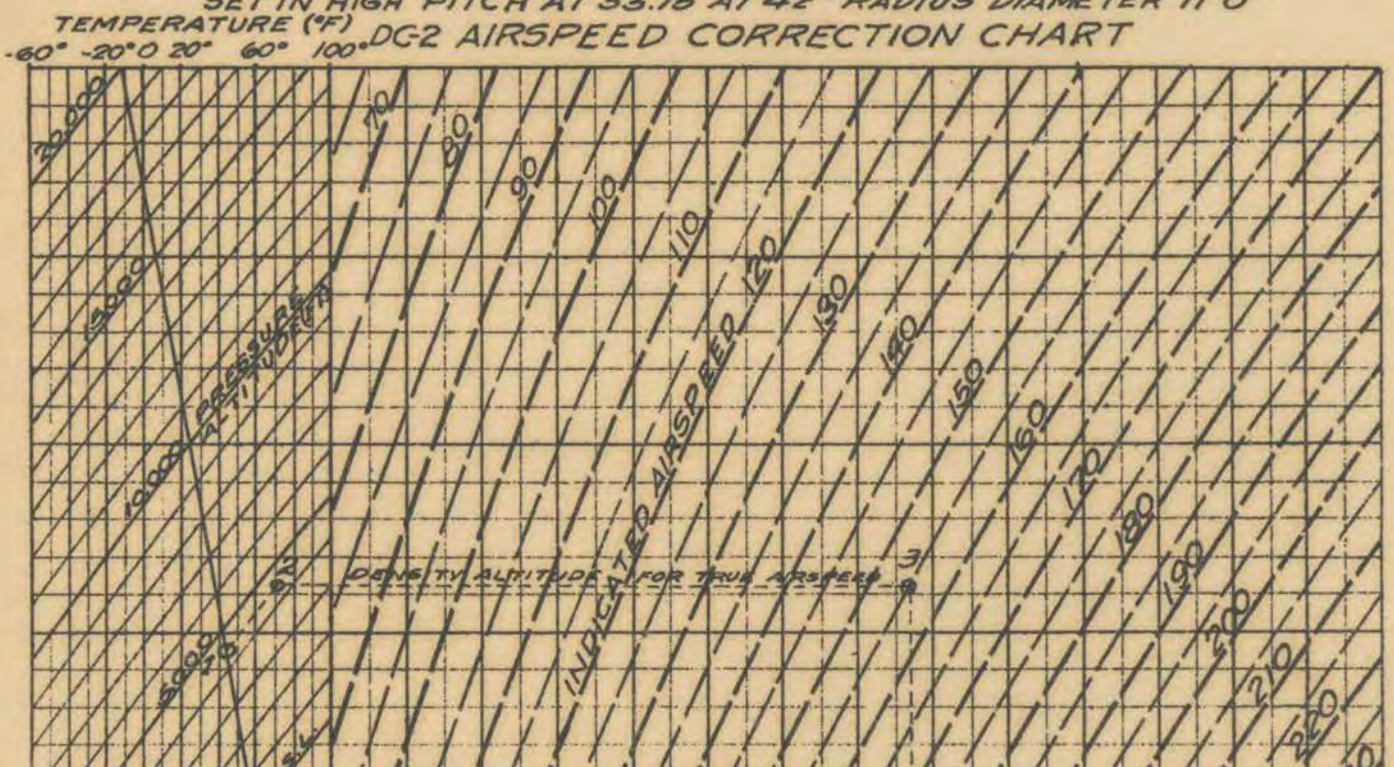
2. For an indicated airspeed reading of 155 MPH @ 4500 ft. and 70° F. move up the line marked Standard Temperature to 4500 ft. (Point "1") then move diagonally upward to the right along the pressure altitude to 70°F. (at point "2") which gives 6200 ft. density altitude, then move horizontally to the right to 155 MPH (Point "3") and obtain 177 MPH actual true airspeed of the airplane, (Point "4").

DOUGLAS TRANSPORT DC-2 CRUISING CHART FOR LEVEL FLIGHT



POWER CONTROL IN CRUISING LEVEL FLIGHT BY ENGINE REVOLUTIONS
AT ANY ALTITUDE AND ATMOSPHERIC TEMPERATURE
TWO WRIGHT CYCLONE SGR-1820-F3 ENGINES
HS 3-BLADED CONTROLLABLE-PITCH PROPELLER DESIGN NO. 6111
SET IN HIGH PITCH AT 33.75 AT 42" RADIUS DIAMETER 11'0"

DC-2 AIRSPEED CORRECTION CHART



EXAMPLE: 4500 FT. PRESSURE ALTITUDE, 70° F.
<u>CRUISING CHART</u>: FOR 64% POWER: R.P.M. = 1675, M.P. = 28.5" HG.,
TRUE VELOCITY = 177 M.P.H.
<u>AIRSPEED CHART</u>: FOR INDICATED VELOCITY OF 155.0 M.P.H.
TRUE VELOCITY = 177 M.P.H.

VIII. DESCENT

A. Limitations on Descent

The ideal method of descent consists of a very flat high speed and high power gradual loss of altitude covering a distance of from 50 to 100 miles before the terminal is reached. Maximum rate of descent, for passenger comfort, is 400 feet per minute. Maximum power during descent should be approximately 60 percent in order to keep engines from turning up beyond their limiting revolutions in this high speed flat angle flight path. Indicated airspeeds should be kept down to a limit of 200 miles per hour during this descent. It will usually be found that this limit cannot even be approached without either exceeding maximum rate of descent allowable or maximum engine revolutions allowable.

B. Effect of Wing

This flat angle flight path should be continued as close to the airport as possible. After a few such trips the pilot will discover at what point he must start his descent in order to maintain a steady rate of descent in this manner for the maximum possible distance. Head or tail winds will, of course, vary this distance and extremely bumpy weather will counsel against maximum speeds if passenger comfort is affected.

IX. LANDING

A. Use of Wing Flaps

Wing flaps should be used for all landings not so much because of their decrease in landing speed as because of their increase in the steepness of the glide, just before landing and their reduction in the landing roll. Airspeed should be reduced to 100 miles per hour before the flaps are lowered. Considerable assistance in reducing airspeed will be obtained by lowering the landing gear first. This will increase drag of the airplane very greatly and lend additional assistance toward steepening the gliding angle.

B. Partial Use of Wing Flaps

There will be no gain from a partial use of wing flaps for any landing emergency or maneuver. With flaps fully down, control as well as safety of the airplane is improved.

C. Overshooting

In case of overshooting a landing, the field can be circled with wing flaps and landing gear both down (propellers in low pitch). In case of overshooting with one engine dead, however, it is vital to get both flaps and landing gear up immediately because drag of the airplane is tripled with them down. The impression that one is going to overshoot will be very common at first until the pilot is completely familiar with the very steep gliding path possible with the wing flaps down, especially if a slight side slip or forward slip is added to increase drag.

D. Landing Gear Control Mechanism

The landing gear retracting control mechanism consists of a valve lever handle having three positions ("up", "down" and "neutral"), and a pump handle which is pumped up and down with the valve in either the "up" or the "down" position. Both the raising and the lowering operation should end with the valve in "neutral".

E. Landing Gear Indicating System

1. WARNING HORN

A horn located on the wall at the rear of the co-pilot sounds whenever the throttle is closed if one or both sides of the landing gear are retracted, unlatched, or the control valve handle is not in the neutral position. The horn is operated by three two-circuit switches in parallel; one on each landing gear truss and one on the control valve.

2. WARNING LIGHTS

The retracting pump valve handle in the pilots' compartment has a two-circuit switch which, when the valve is in the neutral position, operates a green light. The switches on the upper truss of the landing gear are in series with the valve switch and must be closed, by the wheels being in the safe landing position, before the green light will go "on". When the valve is not in the neutral position, a red light will be "on" in the panel to the right of the electrical panels.

3. PRESSURE GAUGE

The pressure gauge located in the pilots' compartment indicates the presence or absence of fluid pressure acting on the retracting strut when in the extended position. (It records the actual pressure but this is unimportant. See Paragraph 3, Page 11.)

4. Summary of Signal Meanings

a. Green light, no horn at closed throttle and pressure showing on gauge indicates both wheels in safe landing position and control valve in neutral position.

b. Red light and horn at closed throttle indicates either one or both of the following are not in correct position: Control valve not in neutral position and/or landing gear not in safe landing position.

F. Operation of Retracting Gear

1. To Retract:

a. Pull control valve handle up. Red warning light will go "on" as soon as valve leaves neutral position.

b. Operate pump until gear is retracted. The accumulation of pressure in the line will be felt on the pump handle. After the wheels have come up into place, a hard push or pull on the pump handle will insure that they are fully up against the pillow blocks in the nacelle structure. If this is not done, the wheels may hang slightly out of the nacelles.

c. Return control valve to neutral position immediately. This will keep wheels fully retracted.

2. To Extend:

a. Push control valve handle to "down" position. If throttle is closed, horn will sound until wheels are in safe landing position.

b. Operate pump until gear is fully down. This will be indicated by the building up of pressure in the system which may be felt on the pump handle and indicated on the pressure gauge. Indicated pressure should be between 300 and 500 lbs./sq. inch at the time the valve is closed. Any subsequent change in pressure gauge reading will have no significance.

c. Return control valve to neutral position. If wheels are latched in safe landing position, horn will stop sounding, red light will go "off" and green light will go "on".

NOTE: Approximately 15 seconds are required to extend the gear and approximately 25 seconds to retract.

3. To Land Without Latch Engaged:

a. The airplane may be landed whether the wheel latches are engaged or not provided the gear is fully down on both sides with the fluid in the system under pressure. The horn will keep on sounding and the red light will stay "on" as the latch is connected with the horn switch.

b. The actual amount of pressure on the gauge is immaterial as the only requisites are that the system contain a full column of fluid and that the control valve handle be moved to the neutral position. Solid resistance felt on the pump handle when the gear is fully down indicates that there is sufficient pressure.

4. To Land Without Fluid Pressure:

The airplane may be landed with no pressure maintained in the system provided the latches are engaged. This will be indicated by the green light.

X. EMERGENCIES

A. Forced Landing With Wheels Up

In case of an emergency landing on rough ground where there would normally be danger of nosing over, the airplane can be landed with wheels retracted to lessen the danger of the crash. Such a landing will result in damaging the propeller blades. Full brake control is available when the wheels are in the retracted position.

B. Engine Failure

In the event of an engine failure the operation of the airplane on the remaining engine (there is, contrary to general opinion, practically no difference in performance with one rather than with the other engine dead) should be as follows:

1. Airspeed must be kept very close to 100 miles per hour (indicated) and never allowed to get under 95 miles per hour.

2. Rudder flap should be set over to relieve heavy rudder load caused by one dead engine and airplane should be flown level laterally for minimum drag and minimum power required.

3. Propellers must be in low pitch.

4. Landing gear must be up and wing flaps up.

5. Excess fuel may be dumped if conditions require. Amount of fuel to be saved can be controlled very readily by watching tank gauges and pulling dump valve closing handle when required amount has been dumped. Gasoline flows from these dump valves at approximately 100 gallons per minute. Dump valves are on the main tanks only.

6. Supercharger manifold pressures may be carried up to 37 inches for this emergency.

7. Engine revolution emergency limit is 2050 RPM.

8. Mixture control must be kept well on rich side of best power setting, and cylinder temperatures watched very carefully to prevent their rising above emergency limit of 580 degrees. Cylinder temperatures will be found very sensitive to changes in mixture control. They can often be lowered more easily by richening the mixture than by throttling the engine.

9. The single-engine ceiling with usual load is above 10,000 feet. At 8000 feet the airplane can normally be flown with one engine in level flight at approximately 80 percent power. Near sea level single-engine climb should be allowed to be very gradual and the throttle position held at the minimum possible for maintaining the required flight.

10. Turns should be moderate and toward the live engine wherever possible.

C. Use of Low Octane Fuel

87 Octane fuel is specified for Cyclone F-3 engines. If inferior fuel is used in emergencies, the supercharger manifold pressure limitations for takeoff and single-engine operation will be reduced in proportion to the Octane rating of the fuel. Great care should be exercised to use as little power with inferior fuel as possible. Cylinder head temperatures will have to be watched carefully and mixture controls kept full rich or nearly full rich until it is absolutely certain that there is no danger of cylinder temperature rise. The knocking qualities of a fuel are dependent upon cylinder temperatures as well as upon manifold pressure. Even 87 Octane fuel may detonate at 37 inches manifold pressure if cylinder temperatures are too high. 80 Octane fuel is limited to operating supercharger manifold pressure of 31.5 inches.

D. Icing of Carburetors

The carburetor air temperature control levers on the throttle control pedestal will be found to be quite sensitive in raising the temperature of carburetor intake air. The two carburetor air temperature gauges are directly above the ice warning indicator. If flying in any ice forming weather, it is recommended that the formation of ice be prevented by applying enough heat to keep the mixture above the freezing point of the moisture contained in it. After ice has formed in the carburetor or intake manifold, it is often difficult or impossible to clear it out. A temperature of 100° Fahrenheit will usually prevent ice formation without a serious loss in power. If there is any danger of ice forming even at this temperature there should be no hesitation in using a good deal more heat because the reduction in power will not be as serious as the formation of ice.

E. Emergency Exits

Two emergency exits are provided, one in the rear of the cabin and one in the pilots' compartment. Both have doors that are carried away when the release handles (painted red) are rotated. Both doors would probably damage the tail surfaces badly if opened by mistake.

F. Dropping Flares

The flare release handles can be reached from either pilot's seat by reaching back by the right wall of the aisle just below the ceiling.

G. Lashing Down

Lashing down may be accomplished at three points: namely, each wing tip and the jury tail skid. Tie down cables are stowed in a leather bag carried on the rear wall of the baggage compartment. The cables may be attached to fittings on the wing structure near the tips of each outer wing panel, and to a bolt in the jury tail skid.

XI. PASSENGER COMFORT

A. Heating and Ventilating

The heating and ventilating system includes a boiler on the exhaust stack of the right engine and an air inlet duct in the nose of the airplane. The boiler sends steam into a radiator which also receives all air entering the air duct. Incoming air is thereby heated and passed on into the cabin and distributed through ventilating ducts along the floor at either side of the cabin and to the pilots' compartment by ducts which lead under the pilots' flooring. The amount of heated air needed in the cabin is thermostatically controlled but may be controlled manually, if so desired. The manual controls are located under the right front passenger seat. A key, carried in a bag on the wall of the passageway, inserted in the control unit makes possible turning the heat off entirely or setting the temperature at any desired point. The use of this manual control renders the thermostat control inactive. Heated air to the pilots' compartment is controlled manually by a lever under the pilot's seat. A cold air duct along the cabin wall on either side, with individually operated outlets at each passenger seat, supplies unheated air to the passengers as they desire. A shut-off is provided in the air duct inlet in the nose of the airplane and is controllable by a lever mounted on the pilot's instrument board. In extremely cold weather it is advisable to vent all the air from the radiator so as to insure maximum heat. This can best be accomplished while warming up the engines by opening the valve at the funnel on the left wall of the passageway until steam escapes. This funnel may also be used to replenish the water supply in flight, if necessary. (Use distilled water only.)

B. Synchronized Engines

As the general noise level in this airplane is lower than in others, the beat of unsynchronized engines is very annoying. It may be difficult to recognize the lack of synchronization in the pilots' compartment but it is very audible in the cabin.

C. High Rates of Climb and Descent

The high rate of climb and the extremely high ceiling of this airplane make necessary a special precaution regarding passenger comfort during rapid climb. Normally 450 feet per minute rate of climb is regarded as the maximum for passenger comfort, and 15,000 feet a maximum safe passenger ceiling. Rate of descent must be guarded more cautiously because of the high recommended airspeeds during this part of the flight. The trip charts show the average speed based on a descent at 195 m.p.h. indicated airspeed, 400 feet per minute descent and the maximum permissible power. Only practice will show the pilot where to begin this descent from any altitude.

XII. CARGO LOADING

A. Effect Upon Stability

The loading chart mounted at the cargo compartment and also shown on Page 17, specifies the distribution of cargo between front and rear compartments for various passenger loads. Range between the specified limits for the forward compartment controls the maximum forward and rearward center of gravity locations. Beyond the rearward limit the airplane tends to become neutrally stable longitudinally.

B. Effect Upon Landing

Beyond the forward center of gravity limit for loading it becomes difficult to get the tail down in landing. The airplane can be landed tail high safely but the more tail heavy loading is to be preferred. The pilot should see to it that the load is distributed toward the tail heavy limit of loading range.

C. Ballast

For an extreme loading condition with no cargo and up to ten passengers, ballast is not necessary provided the passengers are seated from the rear of the cabin. For other seating arrangements with no cargo, ballast or cargo must be carried in the rear compartment in accordance with the loading chart shown on Page 17.

XIII. AUTOMATIC PILOT

A. Preparation for Operation

1. Before taking off make sure that the Sperry Pilot is disengaged.

2. When in flight, make sure that the <u>air vacuum</u> is at least 4 inches and that <u>the oil pressure</u> is 110 lbs./sq.in.

3. Be sure the knob marked "LEVEL" is turned in the "off" direction as far as it can go.

4. Uncage the horizon gyro and wait at least three minutes (the time required for the gyro to settle) before putting the Sperry Pilot into operation.

AERONAUTICS BRANCH DEPT. OF COMMERCE
LOADING SCHEDULE

DOUGLAS DC-2 SERIAL 1237 NC-13711

Weight Empty 12012 Lbs. Gross Weight 18000 Lbs.

Max. Pay Load is 4178 Lbs. with 215 Gal. of Fuel & 24 Gal. of Oil
Max. Pay Load is 2303 Lbs. with 510 Gal. of Fuel & 38 Gal. of Oil

This loading Schedule applicable to airplane "301" (Factory Serial 1237) only. For others, see schedule posted in cargo compartment.

PASSENGERS	NONE	TWO	FOUR	SIX	EIGHT	TEN	TWELVE	FOURTEEN
Maximum Cargo	2000	2000	1900	1800	1800	1800	1800	1800
Maximum Fuel	510 Gal.	503	465	429	377	325	271	215
Maximum Oil	38 Gal.	38	37	34	30	26	24	24

For Total Cargo Loads Up To And Including 300 Lbs.
Ballast Rear Compartment To Minimum Load Required

BALLAST NOT REQUIRED WHEN PASSENGERS ARE SEATED FROM THE REAR

DISTRIBUTION OF CARGO TO REAR COMPARTMENT
(Remainder of Load to be Placed in Front Compartment)

Total Cargo Load		100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
PASSENGERS 0	Maximum	230	230	300	400	500	600	700	790	830	860	900	930	970	1000	1000	1000	1000	1000	1000	1000
	Minimum	230	230	260	290	320	350	380	420	450	480	510	540	580	610	640	670	710	800	900	1000
1 or 2	Maximum	320	320	320	400	500	590	620	660	690	730	760	800	830	870	910	940	980	1000	1000	1000
	Minimum	320	320	320	350	380	410	440	470	500	540	570	600	630	660	700	730	760	800	900	1000
3 or 4	Maximum	350	350	350	400	450	480	520	550	590	620	660	700	730	770	800	840	880	910	950	
	Minimum	350	350	350	370	400	430	460	490	530	560	590	620	650	690	720	750	780	810	900	
5 or 6	Maximum	330	330	330	350	380	420	450	490	520	560	590	630	670	700	740	770	810	840		
	Minimum	330	330	330	350	380	410	440	480	510	540	570	600	640	670	700	730	770	800		
7 or 8	Maximum	260	260	280	310	350	380	420	460	490	530	560	600	630	670	710	740	780	810		
	Minimum	260	260	270	300	340	370	400	430	460	490	530	560	590	620	650	680	720	800		
9 or 10	Maximum	150	200	280	310	350	380	420	450	490	520	560	600	630	670	700	740	780	810		
	Minimum	150	160	200	230	260	290	320	350	390	420	450	480	510	550	580	610	700	800		
11 or 12	Maximum	100	200	300	350	380	410	450	490	520	560	590	630	660	700	740	770	810	840		
	Minimum	20	50	80	110	140	170	210	240	270	300	330	370	400	430	500	600	700	800		
13 or 14	Maximum	100	200	300	400	440	480	520	550	590	620	660	690	730	760	800	840	870	910		
	Minimum	0	0	0	0	0	30	60	90	130	160	190	220	300	400	500	600	700	800		

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Engineering Inspector D. of C.

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B. Operating the Sperry Pilot

1. Shifting control to the Sperry Pilot

   a. Be in level flight and have the airplane in trim.

   b. Set directional gyro card on the heading desired and uncage, then, with the knob marked "TURN", set the upper card to coincide (such as $\frac{270}{270}$).

   c. Set the indicator pointer on the top of the horizon to coincide with the pointer on the top of the black field, using the knob marked "BANK".

   d. Set the pointer on the right side of the horizon to coincide with the bar, using the knob marked "CLIMB".

   e. Move the engaging lever to the "on" position slowly as far as it will go and the Sperry Pilot will take over the controls. When throwing in the Sperry Pilot, keep the airplane under manual control until the automatic control synchronizes with your manual control. This is necessary to avoid violent leveling out of the airplane (it requires approximately twice the normal power on the controls to overpower the Sperry Pilot).

2. Maneuvering

   a. Flat turns may be made for small directional changes by rotating the knob marked "TURN" in the direction desired.

   b. Correctly banked turns can be made by rotating the knob marked "BANK" in the direction desired for banks up to 40° and then rotating the knob marked "TURN" at a rate to keep the ball bank centered. Spiral climbs or glides can easily be made by turning the knob marked "CLIMB" in the direction desired.

c. The "CLIMB" knob is used for changes in altitude. Climbs and glides can be made up to 30°.

3. Shifting to Manual Control (Normal Operation)

a. Move the engaging lever to the "off" position as far as it will go and then take over the controls.

4. Shifting to Manual Control (Emergency Operation)

a. To take over controls without bothering to disengage the Sperry Pilot, as stated before, will require approximately twice the normal pressure on the stick and pedals to overpower the Sperry Pilot.

b. When the emergency is over, the Sperry Pilot will return the airplane to its original course and attitude.

5. Operating Conditions

a. Full automatic control can be maintained at engine speeds as low as 1000 r.p.m.

b. If the Sperry Pilot acts sluggish or fails to control, one or more of the following will be the cause:

(1) Engaging lever is not fully on.

(2) Oil supply low.

(3) Oil pressure too low.

(4) Air pressure under 3-1/2" hg.

(5) Gyros still caged.