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Douglas Aircraft Co., Inc.

Santa Monica, Calif., U. S. A.

ENGINEERING DEPT.

TECHNICAL DATA

HANDBOOK OF OPERATING TECHNIQUE

for the

Douglas Transport Model DC-1

BY
C.T. RE

NOTE

This book has been hurried to preliminary completion in order to deliver it with the airplane. Several absent portions here represented by dummy pages will subsequently be forwarded for insertion. A number of editorial refinements will also be made as will a few minor revisions to agree with last minute changes in the airplane.

The Douglas Aircraft Company will welcome receipt of any and all comments upon or criticisms of the book by TWA personnel. Suggestions for its improvement are solicited.

Douglas Aircraft Co. Inc.
Engineering Dept.

HAT-82

FORM 25-BG

HANDBOOK OF OPERATING TECHNIQUE
FOR THE
DOUGLAS TRANSPORT MODEL DC-1

Douglas Aircraft Company, Inc.
Santa Monica, California
October 1933

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INTRODUCTION

This pilot's manual is prepared not as a reference book to be used in flight but in response to a need expressed by the TWA pilots in anticipation of the new problems introduced by the change in flying equipment and necessarily therefore also in flying technique.

Some of the pilots wished a handbook of instructions regarding the new devices and mechanisms of the Douglas AIRLINER. Some of them wished an explanation of flying technique in the new manner which makes possible continually higher cruising speeds as one cruises at higher altitudes, and some wished primarily to know all of the engine operating conditions which might cause undue wear or damage to the engines, since the limits between damaging engine-operation and recommended operation for efficient performance are very narrow indeed, and a slight misunderstanding of one of the new variables may mean that an able pilot will inadvertently misuse the engines.

In an attempt to supply all of this necessary information in as brief a manner as possible, this manual has been condensed into an outline form with as many graphical illustrations as it was believed would be useful. The manual does not discuss any technique of flying which is not a departure from the older technique of flying Fords, Alphas, Fleetsters and Lockheeds. Only the features which are unusual have been explained. To promote a clearer understanding by the pilot of efficient flight and power-control with this radically different airplane, it is necessary that certain fundamental general principles be discussed with special reference to the Douglas AIRLINER (Model DC-1). If the pilot will study the small charts and tables in this section and will ask for explanation where necessary, the illuminating clarification of his task will amply repay any effort expended upon this study. It will become a fascinating problem to operate his airplane-engine combination at maximum efficiency and at minimum power output for the scheduled operation and to adjust his flying technique most adequately to the new apparatus. The chart and corresponding table in each figure represent two ways of giving the same information. They illustrate each general principle and instruct in shorthand form each technique.

We have here the conception of accurately controlling the power of the engines at any desired percentage of their rated output, throughout the varying conditions of flight (changing altitude, changing angle of flight in climbing, leveling out, and descending, changing propeller pitch) by means of the interrelation of engine revolutions and supercharger manifold pressures. This is considered fundamental, and it is the purpose of this manual to explain this fully.

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SECTION I

GENERAL PRINCIPLES

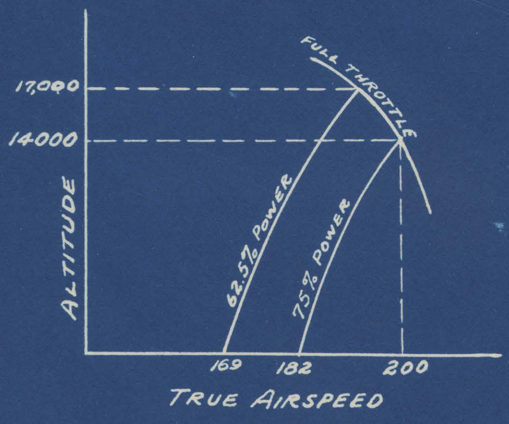
A. Increase in Velocity with Altitude at Constant Power

1. If the horsepower of the engines is held constant by increasing the throttle opening at higher altitudes, the velocity of the airplane in level flight will increase very markedly up to the altitude at which it is no longer possible to maintain the constant power. This altitude is the optimum cruising altitude for that power. If the chosen power is 1050 h.p. (75% rated power) this altitude will be 14,000 feet for standard atmospheric conditions.

2. This increase in airspeed will not be shown on the normal airspeed meter because the airspeed meter requires a density correction as shown in Figures V and VI.

3. The chart and the table, Figure I, show that at 75% power (1050 h.p.) the airplane flies at 182 miles per hour at sea level and 200 miles per hour at 14,000 feet altitude, a gain of 18 miles per hour at the same power-output simply by flying in air of lower density, giving less resistance.

FIGURE-I



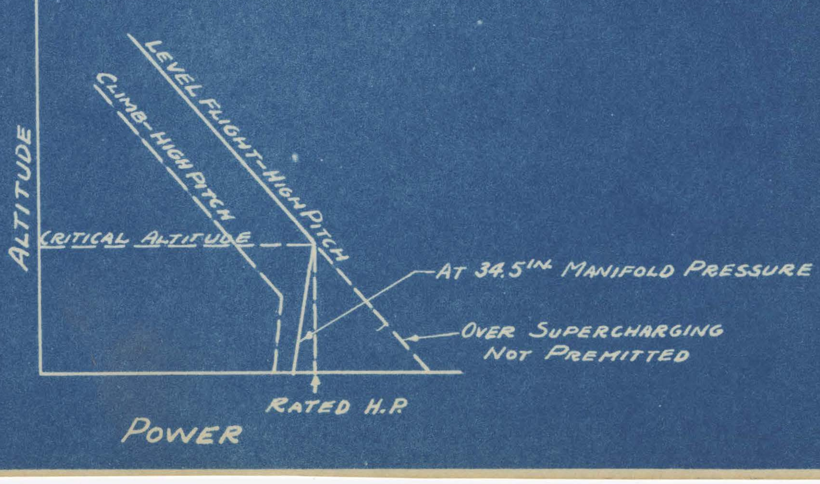
B. Decrease in Power with Increase in Altitude

1. The full-throttle power of the engines decreases at higher altitudes because of the decrease in density of the atmosphere. Full throttle power also decreases with engine revolutions. If propellers are in high pitch the full throttle revolutions will be lower than if the propellers are in low pitch. If the airplane is climbing, the full throttle revolutions will be lower than if it is in level flight. Both these conditions will give lower power in full throttle operation at any given altitude than low pitch or level flight. (See Figure II)

2. Altitude has a throttling effect on an engine just like reducing the throttle-opening with the throttle levers. Both throttling and altitude cut down in the same manner the supply of air and therefore the amount of power. Both methods reduce the intake manifold pressure, which may then be used as a guide to the power-output. Thus, it will be possible for the pilot to cruise at any percent-power by merely flying level full-throttle at the altitude (as seen from the charts in Section V, page) corresponding to that percent-power. This will be the optimum cruising altitude for that power.

3. It will be possible also for the pilot to cruise at the same percent-power at any other lower altitude by partially throttling to manifold pressures and engine revolutions corresponding on the charts to the desired percent-power and the desired altitude. (See Figure XV, Page 72)

FIGURE -II



C. Critical Altitude

1. Because of the obvious gain in velocity obtainable without any increase in power but merely by an increase in altitude, and because also of the fact that this power is usually not available at higher altitudes where it would be most useful, these engines are supercharged to maintain cruising power at optimum cruising altitudes. They are then rated at an altitude of 8,000 feet where they will deliver their full horsepower if propeller pitch and airspeed are correct to let them turn their rated revolutions at full throttle. This altitude is called the critical altitude. From this altitude upward they behave like any sea-level-rated engines do from sea level up; i.e., they fall off in power from the critical altitude upward as shown in Figure II.

2. Below critical altitude more power is available than is permitted for normal operation. If the throttles are opened wide at sea level, the engines can be quickly damaged because of the excessive supercharging which occurs at this high density. The engines are protected by:

(a) Throttle stops

(b) Supercharger (intake manifold) pressure gauges.

(c) Cylinder head temperature gauges.

(d) Tachometers

(e) Correct use of the controllable pitch propellers.

The use of these protective devices and indicators is relatively simple if certain fundamental principles are understood. It is one of the purposes of this manual to simplify the correct operation of the power plants of the DC-1 in such a manner that the maximum performance can be realized, and at the same time the engines safeguarded from overstrain. It will be readily seen that with improper operation the full cruising performance of the airplane will be missed and at the same time the engines may be overstrained.

D. Limits for Cruising Performance

1. For maximum engine life and minimum wear and overhaul costs, certain limits are placed upon cruising performance. These limits may be exceeded for short periods because excessive wear is a function of length of time under adverse operation. The second set of limits can be exceeded safely only for emergency and then only for very short periods because the life of the engine is reduced to a matter of a few hours or less under excessive supercharging. See FIG. III

2. These limits may be reached singly or altogether. None of the limits should be exceeded. At lower altitudes, manifold pressure will be the limiting factor while at high altitudes, engine revolutions will be the factor controlling operation.

3. If it is necessary to use the emergency limits, a notation should be made in the engine log book giving the emergency limit used, length of time operation was at emergency limit and the reason for emergency operation.

4. The controllable pitch propellers are provided to enable engines to deliver a larger part of their rated power on take-off and protect them from turning up too fast at cruising speeds. If wrongly used, such as allowing low pitch in level flight at full throttle the engines will seriously race.

5. The throttle stops are installed merely to be a rough guide during take-off and operation below critical altitude so that the manifold pressure gauges will not have to be watched constantly during take-off. It is not possible to set the throttle stops to limit the manifold pressure and revolutions under all conditions of operation. They are set for one set of conditions; for all other conditions they will be only an approximate guide and they will need to be supplemented by watching the r.p.m., manifold pressures, and cylinder temperatures.

FIGURE III

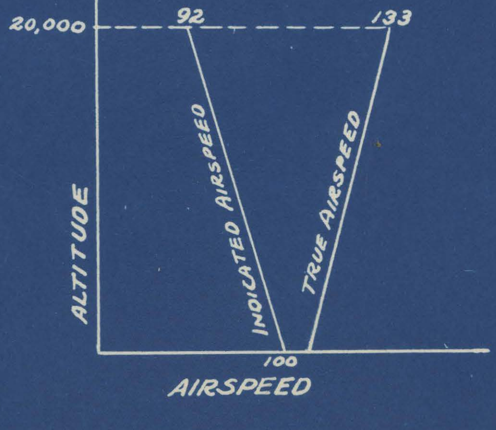
	Cruising Limits	Climb Limits	Take-off and Emergency Limits
Manifold Press.	32"	34½"	36.8
Engine Revolution	1850	1950	2050
Cyl. Temperature	475	500	580
Oil Temperature	160	180	200

E. Correct Climbing Speeds

1. For maximum rate-of-climb at any altitude or for optimum rate-of-climb at cruising power it is necessary that the indicated airspeeds during climb be kept at the correct values given in the chart and table, **Figure IV** . If the full 950 feet per minute, which this airplane will climb with full load at 8,000 feet altitude is desired, it will be accomplished at 103 miles per hour indicated airspeed. At any other airspeed, either higher or lower, the rate-of-climb is reduced. The reason for this is that climbing is done with the excess of power-available over power-required, both of which vary with airspeed. At only one airspeed is this excess power-available over power-required a maximum, and at only this airspeed, therefore, is the climb a maximum. In single-engine operation, a variation of even two or three miles per hour will make a very appreciable difference in both climb and ceiling.

2. For normal transport operation maximum rate-of-climb is not desired, but rather a flatter climbing angle, a more gradual, steady, rate-of-climb, and a greater distance covered on the course during the climbing period. This has the advantage of promoting engine cooling and passenger comfort. The charts and directions in Section IV give the recommended climbing speeds for this gradual climb.

FIGURE - IV



F. True Airspeed at Altitudes

1. The present airspeed indicator shows dynamic pressure of the air in the pitot tube. This is a function of air density; the indicator will therefore read less than true airspeed at altitudes where the density is less than at sea level. True airspeed can be determined for any given indicated airspeed (after a small calibration correction has been made) by dividing the indicator reading by the square root of the density ratio for that altitude. This can be done graphically by use of the following chart which shows true airspeed for any combination of airspeed indicator reading, pressure, and temperature, and the table which shows certain selected values.

2. The chart and table are two ways of showing the same relationships. The chart shows an infinite variation of temperatures and altitudes and indicated airspeeds; the table is restricted to four altitudes with three temperatures for each altitude, standard temperature and 30° F above and below standard. Standard temperatures are an arbitrary average scale for which all computations of airplane performance are made.

FIGURE V

TABLE OF AIRSPEED CORRECTION FACTORS

ALTITUDE	TEMPERATURE (°F)	AIRSPEED CORRECTION FACTOR ($\sqrt{\rho/\rho_0}$)
SEA LEVEL	29 59 (STANDARD) 89	.97 1.00 1.03
4,000	14.7 44.7 (STANDARD) 74.7	.913 .942 .969
8,000	0.5 30.5 (STANDARD) 60.5	.859 .885 .912
12,000	-13.8 16.2 (STANDARD) 46.2	.806 .832 .857

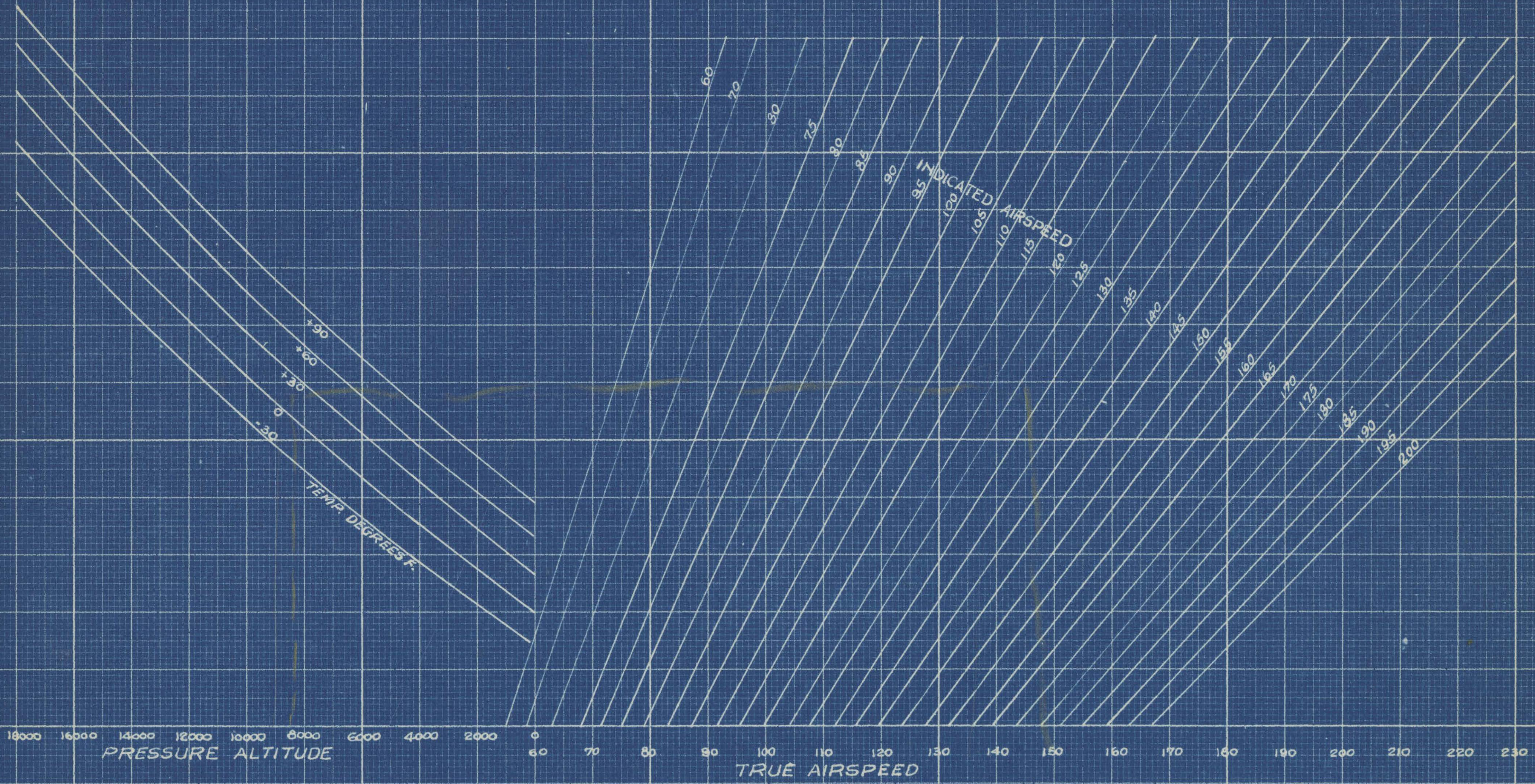


FIGURE-VI

AIRSPEED CORRECTION CHART
FOR DOUGLAS "AIRLINER" No. 1 ONLY

F. COLLBOHM
E.T. ALLEN

G. Optimum Cruising Altitude

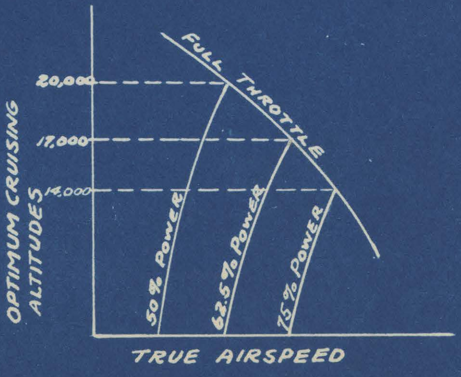
1. From a consideration of Figures I and II together it can be seen that there is an altitude for every desired cruising power-condition at which that given percent-power can just be reached by full-throttle operation. When the airplane is flying level full-throttle at this altitude, it is cruising. The altitude determines the cruising percent-power and this percent-power can be read directly from Figure VII. This cruising full-throttle operation may be at but 50% of the power if the altitude is high enough. For the DC-1 50% power-cruising would occur full-throttle at 20,000 feet. If 62.5% power-cruising is desired this can be obtained by flying full throttle at 17,000 feet altitude. If 75% power-cruising is desired this can be obtained by flying full throttle at 14,000 feet altitude. These altitudes are optimum cruising altitudes.

2. These cruising-power conditions (at 50, 62.5, 75%, etc.) can be obtained also by throttling at lower altitudes than the optimum cruising altitudes for these power-conditions but only at a sacrifice of speed. The maximum cruising speed for any percent-power is obtained at the altitude at which that power is a full-throttle condition. Under these conditions the economy of operation (miles per gallon and miles per overhaul-dollar) is also at a maximum.

3. Figure VII shows the relationships between altitude, velocity, and percent-power. It illustrates how full-throttle operation forms an envelope of limits for each percentage-power.

4. Figure VIII shows the same relationship plotted in a different manner and it will be useful principally to illustrate how velocity increases as one goes up on a constant-power line until the full-throttle curve is reached, at which point we have an optimum cruising altitude. The pilot can reduce power with altitude instead of with the throttle levers, and the effect will be exactly the same as far as engine-wear and engine-strain are concerned. It will be superior as far as velocity is concerned. This conception of optimum cruising altitudes is vital for the attainment of the best capabilities of the airplane.

FIGURE - VII



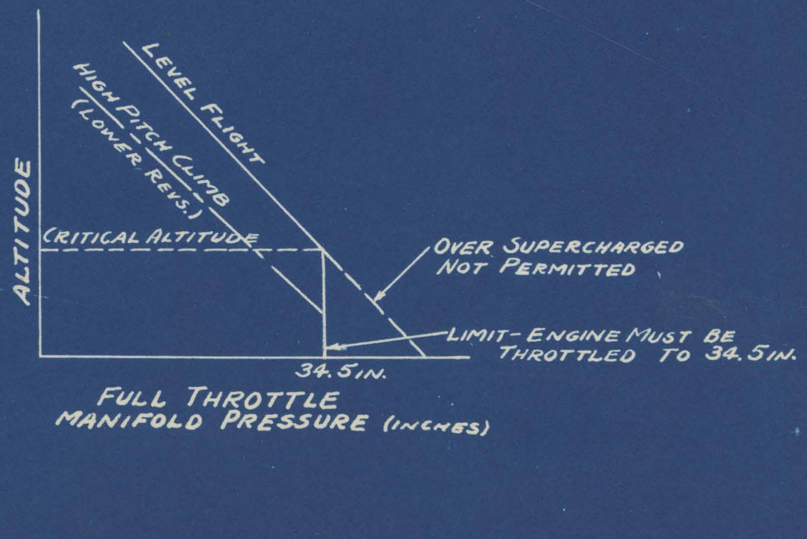
H. <u>The Concept of Intake Supercharger Manifold Pressure As a Guide to the Pilot.</u>

1. Intake manifold pressure is one of the most important variables entering into the determination of engine power. Since it is relatively easy to measure it accurately, it has become a principal guide for the pilot during flight in climb and cruising. Intake manifold pressure is proportional to Mean Effective Pressure, which is a determiner of power.

2. Engine revolutions and altitude are also determiners of power, partially independent of manifold pressure in their effect. This group of variables, which includes also the attitude of the airplane and the condition of the propeller, is in a constant state of balance; a change in any one variable affects all of the others in their mutual relationship. It is possible to show this relationship for two or three elements at a time; to show more than this number on a single graph may be confusing.

3. Manifold pressure in level flight at full-throttle will decrease with increase in altitude as shown in Figure VIII Engine power can be determined easily from a knowledge of manifold pressure, engine revolutions, altitude and temperature. Manifold pressure is dependent also upon engine revolutions. If propeller pitch is reduced, or airspeed is increased by nosing down, the manifold pressure and power will be increased because the number of revolutions increases.

FIGURE-VIII



SECTION II

OPERATING TECHNIQUE

A. Starters

1. The direct drive starters on the DC-1 draw a very high current from the battery. It is recommended that the engines be properly prepared for starting before this heavy drain is applied so that the battery will not be pulled down by long continued starting. Except in cold weather, priming will not usually be necessary but the throttles may be worked three or four times until gasoline starts to drip from the carburetor.

2. In warm weather the engine loads up fairly easily without much throttle-working. If loaded up, open throttle wide and turn engine over forward, not backward, since turning backward will merely back up the charge into the blower section.

3. In cold weather or if engines are obviously not loaded up it may be necessary to be sure that gasoline is flowing freely into the carburetor. Unless gas pressure is upon the left engine, working the throttle will not flood the left carburetor. It will usually be necessary to turn the gas cock on to left engine only and use the wabble pump for some minutes before the left gas gauge shows pressure. The right gas gauge does not have this peculiarity.

4. The primer suction line comes from the left engine gas gauge line and the primer will not suck gas unless pressure is up on the left gauge.

5. Suggested procedure for starting is as follows:

   (a) Set tank selector valve to tank required.

(b) Set engine selector valve to "Both-on". (The primer takes off the left fuel pressure gauge line).

(c) Work the wabble pump until pressure shows on both gauges.

(d) Prime engine desired. (If engines are not cold no priming will be necessary.)

(e) Set main switch to airplane's battery or battery cart.

(f) Push main ignition switch on.

(g) Set engine switch for engine desired.

(h) Set starter selector switch for engine desired.

(i) Push starter button. (Remove finger as soon as engine starts)

<u>Note</u>: The spark is retarded automatically by a special solenoid working in unison with the starting solenoid when the starter button is pushed. The booster ignition also goes on automatically when the starter button is pushed.

6. For starting either engine with the hand crank it is necessary to push the starter button in order to get booster ignition and spark retard.

7. It will usually take some minutes after starting before the oil pressure gauges are up to their normal indication. When oil pressure is up to normal the throttles may be opened up to 800 or 1,000 r.p.m. (with propeller in low pitch) and the engines may be warmed up safely at this higher r.p.m. because better lubrication will result from higher rotating speeds.

B. Oil Indicators

1. The oil temperature gauge shows "oil-in" instead of "oil-out" as on many former installations. This change will result in lower oil temperature indications than with the older installations. It will also take longer to get the oil up to normal take-off temperatures but it will be safe to take-off with a lower oil temperature indication than before, because this temperature indication is the temperature of the entire body of the oil in the tank.

2. Before take-off the oil temperature should, if possible, be at least 100° F although in winter it may not be possible to get the oil up to this temperature. If take-off has to be made with oil temperature below 100° F, engine power should be kept as low as consistent with safe flight during take-off and climb until oil temperature is up to safe warmth.

3. Cold oil usually results in more damage to the engines than relatively hot oil as long as the oil pressure does not drop. Oil temperature of 160 is considered a limit for cruising operation. 180 is allowed for climb and 200 is considered emergency limit. See table of limits Figure III. If 200 is exceeded in any emergency the oil is very apt to foam, overloading the scavaging system, and spray out in large quantities from the breather. A great loss in engine power will immediately result.

4. Oil pressures should be between 50 and 90 lbs. per sq.in. at all times. In starting it is well to wait until the pressure gauge shows at least 40 lbs. per sq.in. before the engines are turned up to the warming-up revolutions (800 to 1,000 r.p.m.). If the pressure falls below 50 lbs. per sq.in. while flying, this is evidence that something is seriously wrong with the engines. Oil temperatures above 180 will usually result in a slight loss of oil pressure. This should not be allowed to continue below 50 lbs. pressure.

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C. Warming Up

1. Warming up will be slightly different on these engines than on the former ring-cowled engines because of the complete pressure-baffling of these Cyclones. The cylinder head temperatures should be watched closely when warming up at the higher engine speeds because they will go to the temperature limits much more quickly idling on the ground than they will at full throttle in the air. Cylinder head temperatures should be at least 300 before take-off and should not be greater than 450. See Table of Limits, Figure III

D. Maximum Ground Revolutions

1. In opening up the engines on the ground the supercharger pressure gauge (intake manifold pressure gauge) may be allowed to go up 34.5". In low pitch the ground revolutions will be approximately 1700 at sea level and considerably higher at such altitudes as Albuquerque because of the increase in power at altitudes when constant manifold pressure is maintained and because of the simultaneous decrease in propeller resistance at altitudes. Great care is necessary in opening up the engines on the ground because of the possibility of over-supercharging with full throttle.

2. The engines can be seriously damaged in a very short time if the throttles are opened wide at sea level either on the ground or in the air. When opening up to 34.5" pressure the cylinder head temperatures will quickly rise to their limit because the pressure-baffling prevents cooling air from going through the engine when it has no forward speed. There is only one thermocouple on each engine showing the head temperature of No. 1 cylinder, which is usually the hotest. See Table of Limits Figure III

E. Taxiing

1. Taxiing is made easy if the tail wheel lock is used whenever it is possible to taxi straight for even a short distance. It is not sufficient that the locking handle be in the locked position. The tail wheel must be straightened in order to let the locking pin engage. Even in a strong side wind with the very large fin and all the rear of the fuselage adding sail area, it is still possible to taxi with little or no use of brakes, except for the instant of latching the tail wheel lock in the correct direction.

2. The differential use of the throttles will, of course, be the principal aid in taxiing in a side wind or in turning. In order to obtain the extreme differential brake action the order of operations is reversed. The brake lever should be released, the 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 brake. Ground looping can be definitely avoided by keeping the tail wheel in the locked position except when it is desired to turn at low speed.

F. Take-off

1. Take-off is accomplished most quickly in this airplane by raising the tail at once when the throttles are open. Of course, if it is not necessary to clear any obstructions or to get off the ground in a very short run the usual method of take-off will give greater passenger comfort. The controllable pitch propeller permits, with the low pitch setting, a short take-off run with full load. The engines may be opened up at once to 34.5" manifold pressure (in emergency ~~38~~"). 36.8"

2. Normally wing flaps should not be used on take-off.

3. The tail wheel lock should be engaged on take-off to insure against shimmying or ground looping on landing. After turning at the end of the field, preparatory to take-off, a very short taxi in a straight direction with the tail wheel locking handle in the locked position will insure the engaging of the locking pin.

4. Limiting engine revolutions for take-off are 2,050, limiting head temperatures 580, limiting manifold pressure ~~38"~~. The manifold pressure is the only limit which is likely to be reached during actual take-off. 36.8"

5. Mixture control should be left normally full rich for take-off even though more engine revolutions could be obtained by leaning out. A lean mixture will give considerably greater ground revolutions and more power during take-off but cylinder temperatures will rise to dangerous values while the pilot is busy with the take-off and initial climb.

G. Engine Failure on Take-off

1. In case both engines fail on take-off through a fuel system failure or some other general failure, it would be desirable to get the flaps at least partially down in order to slow up the landing speed and improve lateral control in a complete stall. The character of the ground directly ahead will probably determine whether the wheels are to be left up or down for this emergency landing.

2. With the flaps down the indicated stalling speed, power-off, is 60 m.p.h.; with flaps up it is approximately 70 m.p.h. This indicated stalling speed remains constant at high altitude above sea level. At Albuquerque, the airplane will land at 60 m.p.h. indicated with a full load, flaps down.

3. In case of single engine failure on take-off or after the airplane has gotten beyond a point on the runway where it could safely be landed straight ahead by cutting the other engine, the procedure should be approximately as follows:

(a) Open up the remaining engine full throttle or to 36.8 ~~38~~" manifold pressure and maintain an airspeed of between 95 and 100 m.p.h.

(b) Get the landing gear up as quickly as possible. This will decrease the resistance by 30%. It is doubtful if the airplane will maintain its altitude on one engine unless the landing gear is retracted.

(c) Be sure that the flaps are up.

(d) Set the rudder-flap over to balance the single-engine couple. With this rudder flap in neutral the rudder force required for single-engine flight would be between 100 and 200 pounds.

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(e) Keep the airplane level and do not turn except very gradually because both the turn and bank increase the drag.

(f) Throttle down the single-engine to the lowest point at which it is possible to maintain altitude.

(g) Use mixture control very sparingly or not at all unless at 8,000 feet or higher, watching the cylinder head temperatures constantly. It is easily possible to burn up a supercharged engine within a few minutes with too lean a mixture.

(h) Be sure to leave propeller in low pitch.

(i) Do not allow airspeed to get below 95 m.p.h. because single-engine climb and ceiling are very dependent upon proper airspeeds.

(j) Hold airspeed for single-engine operation to between 100 and 102 m.p.h. indicated at all altitudes.

H. Climbing

1. Once the wheels are off the ground it is desirable to retract the landing gear at once and to hold the airplane down until it accelerates up to its "best climbing airspeed" because of the fact that

   (a) The climb will be more rapid at this speed and will decrease very greatly at low airspeeds (except zooming).

   (b) Engine cooling will be improved.

   (c) Controllability is increased.

   (d) Passengers are more comfortable when the climbing path is flat.

If it is desired to maintain the maximum rate-of-climb the propellers should be left in their low pitch and the climbing airspeeds of Figure X should be maintained.

2. It is very important for the life of the engines that intake manifold pressure be kept below 34.5" (See Figure III) during climb at low altitudes. If it is not necessary to attain the maximum rate-of-climb the propellers may be put in high pitch soon after take-off and the climbing airspeeds used corresponding to the desired power condition.

3. If a pilot climbs at considerably higher airspeeds in order to cover as great a distance as possible during the climb, he may be guided chiefly in guarding his engines from over-strain by the tachometer, because it is possible that the engine-revolution-limit will be reached before the manifold-pressure-limit.

4. If climbing at 75% power in high pitch, the throttles will be approximately half open at sea level gradually increasing to wide open at approximately 61,000 feet.

5. If the take-off is made from a 6,000 foot airport, the throttle position for 75% power climb will be considerably greater than at sea level but throttle positions should be entirely disregarded as a guide on these engines. The throttle stops are to be used merely as a rough indication

during take-off at sea level. They are set for holding the manifold pressure to the emergency limit at the instant the wheels leave the ground. At any other airspeed or any other altitude the throttle stops will not be a safe guide and they should be disregarded entirely. The manifold pressure gauges and tachometer (and, of course, temperature gauges) are the only guides to safe operating conditions.

6. It will be noted that if the airplane is climbing at any given power-condition and then leveled out without throttling down, the revolutions will increase, the manifold pressure will increase, and the power may easily go up to a dangerous point.

7. Everyone of the curves in the charts which follow, refers very specifically to <u>only one attitude of flight</u>, either level flight or climb, and when they are used as a guide this distinction should be kept clearly in mind.

8. Especial care should be ex~~c~~ercised to avoid leveling out with low pitch because with the increase in revolutions, resulting from leveling out, the supercharger impeller speeds up 10 times as fast as the revolutions speed up.

9. 1850 r.p.m. is the limit allowable for cruising, and although this may be exceeded in a climb up to 1950 and in an emergency, such as single-engine climb, up to 2050, these limits should not influence the increase in the cruising-speed-limit.

10. There is a strong temptation to climb at lesser airspeeds than those given in the tables because the rate-of-climb meter shows a momentary rise when pulling up the nose to a higher climbing angle and it shows a decrease in rate-of-climb when pushing the nose down to the correct optimum airspeed. This is an unsafe guide. There is no ultimate gain obtainable in zooming. The best climbing rate is found in steady holding at the correct airspeed.

I. Cruising

1. There are a number of factors which will influence the altitude and power conditions for cruising. Disregarding for the moment weather conditions and altitude of terrain which must be flown over, it can be said that for maximum cruising speed at any percent power, the optimum cruising altitude shown in Figure IX will give the best results.

2. With no wind or little wind or for conditions where the counter-wind gradient is not greater than the cruising speed gradient up to optimum cruising altitude, the effect of wind also can be disregarded in determining the flight conditions.

3. All the charts, tables and discussion of optimum altitudes throughout this manual disregard the effect of altitude on passengers. Considerable experience with passengers can be the only guide to this question. It will be found, however, that with this airplane, whose ceiling is over 25,000 feet with a full load, there will be a tendency to climb with passengers to altitudes which may cause serious discomfort, loss of vision, unconsciousness, heart attacks or even hemorrhages. Nothing in this manual should be taken to recommend any altitudes which would be disturbing to passengers. The manual merely indicates the great gain in cruising speed obtained from flying at higher altitudes.

4. A second condition limiting the efficient use of high altitude flying will be the danger of exceeding the cruising limiting engine revolutions. With 1850 r.p.m. as the cruising limit and a propeller which can be set at only 34.5 degrees in high pitch, it will be found that the airplane cannot reach the optimum cruising altitude condition without turning up too fast at the higher power conditions

5. 75% power will be obtained at full throttle at 14,000 altitude and here the revolutions will be 1850. At this point the true airspeed will be 200, a gain of 18 m.p.h. over the speed at sea level with this same power. At 62.5% power cruising, maximum speed is reached at 17,000 altitude and here the engines will be operated at full throttle and 1775 r.p.m. The speed at this point will be 190, a gain of 21 m.p.h. over the speed at sea level with this same power.

6. On the chart showing the change in velocity with altitude at any given percent power (Figure I) it will be seen how the speed drops off at lower altitudes as one comes down a constant power line, throttling to maintain this constant power. Figure XII gives the cruising speeds for 75% power and 62.5% power for all the altitudes at which the airplane will be normally flown. These figures were obtained in flight tests with this airplane fully loaded and fully equipped as it left the factory. It is important to note the fact that the indicated cruising speeds will drop off at altitudes, while the true cruising speeds increase with altitude. In the columns headed true speeds are shown the indicated airspeeds corrected for pressure and temperature and for the instrumental calibration error.

7. These performances will be reduced if the pitch settings (34.5 degrees high pitch) are altered or if the engine is reduced in power. The cruising performance will be greatly reduced if the full cruising power is not used. The Wright Aeronautical Corporation, manufacturers of the Cyclone F-3 engine, has approved the method of cruising operation of their engines here specified. All of the cruising limits here recommended were determined by the engine manufacturers.

J. Fuel

1. 87 Octane fuel is specified for the F-3 engines. If inferior fuel is used in an emergency these engines may have much higher cylinder-head temperatures, may detonate with intake manifold pressures normally used in cruising, and are very apt to be badly damaged. The cylinder head temperature gauges and the intake manifold pressure gauges should be watched closely, especially at altitudes under 8,000 feet, and the mixture control should be leaned out only enough to obtain smooth running.

2. With 87 Octane fuel there will be no detonation as long as the cylinder temperatures are kept within the specified limits. It will be found that the cylinder temperatures are very sensitive to the use of the mixture controls, and the limits between excessive cylinder temperatures and low power form a narrow range of operating conditions.

3. The thermocouples are a much more sensitive guide for mixture control operation than the tachometers. The former practice of leaning out the mixture until revolutions decrease slightly and then enriching it until the lost revolutions were regained can not be used as an infallible guide. With these more higher supercharged engines, especially if the airspeed is low as in a climb so that the cooling air velocity through the pressure baffles is reduced, there is danger of overheating by leaning out the mixture. The thermocouples can now be regarded as the most important

and vital instruments in the airplane. They should be kept calibrated, serviced so that there are no loose connections, and watched constantly whenever the mixture is leaned out or the throttles opened or the altitude reduced.

4. A proper mixture at one altitude will be too lean a mixture at a lower altitude. For take-off, the mixture control should not be leaned out more than is required to obtain smooth operation. There is some danger that if mixture control is used up to the point of maximum revolutions while running the engines up on the ground the engines will seriously overheat during take-off while the pilot's attention is withdrawn from the thermocouple.

5. The knocking qualities of a fuel are dependent upon the cylinder temperatures as well as upon manifold pressure and other variables. For example, 87 Octane fuel which is specified for these engines <u>may be</u> safe from detonation even at ~~37.8~~" 36.8 if cylinder temperatures are not excessive. If cylinder temperatures are excessive even 87 Octane fuel will detonate and cause serious loss of power. 80 Octane fuel is limited to operating supercharger manifold pressures of 31 1/2 inches. It should be remembered that high cylinder temperatures reduce anti-knock rating.

K. Carburetion and Icing

1. 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° F 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.

L. Controllable Pitch Propellers

1. The low pitch setting of controllable pitch propellers is such as to allow maximum power and maximum permissible r.p.m. during the take-off. This setting also permits maximum climb in emergency. The high pitch setting is such as to hold the cruising r.p.m. down to the cruising limit, (1850 r.p.m.) for full throttle level flight at 75% power at 14,000 ft.

2. These propellers can be used in two positions only, full low pitch and full high pitch. The range between these extremes is but 10°. The control lever is mounted on the front face of the control pedestal near the base. When it is in the "up" position the propellers are in the high pitch position, and when in the "down" position the propellers are in the low pitch position. The propellers cannot be controlled individually. The lever handle should be in either the lower position or the extreme upper position. No intermediate positions will correspond to any intermediate pitch but will merely allow the oil to leak into or out of the controlling cylinder more slowly.

3. At high altitudes or when extremely cold, the pitch changes more slowly than at other times because of the change in viscosity of the oil. Ordinarily it requires approximately one-half a minute for the change from low to high pitch to take place.

4. If there is any doubt about the propeller pitch at any time it can be quickly settled by watching the cylinder in front of the hub on the propellers. If the rear of the cylinder is tight against the hub, the propeller is in high pitch. If it is about 3" away from the hub, it is in low pitch.

5. The change in pitch can be made at any speed or power. It is not necessary to throttle the engine for changing pitch. The only evidence that something is happening to the propellers will be a gain or loss of approximately 400 r.p.m. during the shift in pitch.

6. Low pitch should always be used for take-off because it will allow the full power to be taken out of the engines and will enable the propeller blades to work at an efficient angle during take-off and climb. If high pitch is used for take-off the propulsive efficiency will be very low during the initiative part of the take-off run and it will require a long time to get the airplane up to take-off speed. It is doubtful if the airplane will get off at all fully loaded, if the propellers are left in high pitch, except on an extremely long runway.

7. Once the airplane is off the ground and up to at least its best climbing airspeed the pitch may be shifted to high pitch if desired. The only difference in climb will be that for any given throttle position and airspeed the number of r.p.m. and rate-of-climb will be greater for low pitch than for high pitch.

8. Unless it is desired to obtain the maximum or nearly the maximum rate-of-climb it will be preferable, from the point of view of engine strain, to use high pitch for climbing and to climb at a relatively high airspeed and a relatively flat angle. The chief difficulty with low pitch climb is that the engines will be turning up too fast unless one throttles down to approximately 60% power or less. At such low power the climb will be inefficient.

9. The controllable propeller makes practicable for the first time an airplane having an extremely high speed range and efficient loading. It has, however, the disadvantage of requiring greater care and watchfulness on the part of the pilot. If the propellers are in low pitch during climb, and the pilot then levels out or noses down very slightly without throttling the engines they may turn up to 2200 r.p.m. or more before the pilot notices that anything has happened, if his attention is engaged with weather conditions or other items of his flight technique. The sound insulation of the airplane prevents his attention being called to the high speed of the engines until they are racing.

10. In the appended charts and tables there will be found the performance with rates-of-climb and indicated airspeeds for best climb for both the low pitch and the high pitch condition.

11. Single-engine operation will, of course, be done in low pitch with the engine revolution limit at the emergency level. Altitude can not be maintained on one engine with the propellers in high pitch and this is another good reason for insisting upon low pitch take-offs, because, should an engine then fail during take-off, no change in pitch will be necessary to maintain altitude or climb on the remaining engine.

33

M. Wing Flaps

1. The wing flaps are useful for the following two purposes:

(a) Decreasing the landing speed.

(b) Increasing the drag during glide, landing and roll on the ground.

2. These two functions together (namely increase in lift and increase in drag) are very effective in decreasing the flatness of the gliding path and making possible a much more abrupt and easily adjusted approach to a landing. It is not intended that the use of the flaps should normally decrease very greatly the airspeed of approach to a landing or the airspeed of the landing. These can, however, be decreased on tests 8 to 10 m.p.h. with the use of the flaps.

3. The great advantage of flaps is their increase in drag and their effect in steepening the gliding angle. The long flat gliding angle of an efficient airplane makes the approach to a small field a difficult and dangerous procedure. The use of the flaps removes this difficulty entirely and makes an approach in such an airplane much safer than it is for most inefficient airplanes.

4. The flaps are controlled by the crank on the right hand side of the pilot's seat. It will be found normally that the co-pilot can manipulate them during an approach to a landing more easily by standing in the aisle between the seats.

5. If the slip stream is removed from the flaps by throttling the engines and if the airspeed in a glide is reduced to 65 to 75 m.p.h., the load on the flap-operating handle will be reduced to half what it is when the engines are slightly on or the airspeed higher.

6. It is recommended that until the pilots obtain great familiarity with the use of the wing flaps they lower them on the approach to landing at approximately 1,000 feet from the ground and a mile or two from the airport. This will permit the maximum possible adjustment of the gliding path and the best feeling out of the controls during a flap-down glide.

7. The change in longitudinal trim introduced by bringing the wing flaps down is very slight on this airplane but it will be appreciable and can easily be balanced out with a slight adjustment of the elevator trimming flaps.

8. The principal precaution to be observed in the use of the wing-flaps is with regard to the limiting speed at which they may be used. Naturally the stress on them will be greater the greater the flap angle, and consequently the limiting speed can be modified somewhat for different flap angles. It will be advisable to limit the use of the flaps to speeds of under 100 m.p.h. although they may be started down safely at 120 m.p.h.

9. The load on the flaps is a function of indicated airspeed, not true airspeed, and therefore airspeed corrections can be neglected as far as the flaps are concerned.

10. On account of the enormous increase in drag (approximately 200%) caused by the use of the flaps, it is vital to insure that, in case of single-engine failure or in case one has overshot the field and must circle it again, the flaps be raised as quickly as possible.

11. In case of overshooting a field with one engine dead, it is, of course, vital to get not only the flaps up but the landing gear up also, because maintenance of altitude with a full load will hardly be possible on one engine with either wing flaps or landing gear down. The flaps add, however, much more than double the drag which the landing gear adds.

12. Wing flaps should be raised after coming to a stop on landing in order to prevent their damage by stones thrown from the propellers during taxiing and also to insure that they will be up before the next take-off.

13. The full movement of the control handle brings the wing flaps down 45°. The airplane can be landed and taken off and flown with this full use of the flaps or any partial use. For landing, the maximum advantage from the point of view of maneuvering during glide, is obtained with the full flap angle. Any lesser angle will cause considerably less drag and an appreciably flatter gliding angle. If one is used to landing always with the flaps fully down and then makes a landing with them only partially down, one is very apt to overshoot the field.

14. Take-off with the flaps down decreases the take-off run slightly but increases the length of time required to accelerate up to take-off speed. The partial use of the flaps may assist in take-off from soft fields or in clearing a low obstacle at the end of a short runway, but normally the take-off should be made with flaps full-up as the decrease in take-off run is relatively small and the use of flaps during take-off gives an entirely different feel to the controls which may be confusing to the pilot who is not thoroughly familiar with it. This is because an entirely different balance condition and control condition are introduced. For take-off with flaps down the following points should be observed:

(a) The flap-down take-off should be practiced under favorable conditions before general service use in order that the pilot may become thoroughly familiar with the difference in control characteristics.

(b) With the wing flaps down the airplane will be found nose heavy, requiring the use of the elevator trimming flaps to balance.

(c) Any degree of opening of the flaps may be used. If the full angle is used the airspeed indicator should be watched carefully, keeping the airspeed up to normal take-off and climb values. With the unaccustomed condition of drag which makes the speed pick up slowly, one is apt to misjudge the take-off speed. The feel of the controls is also different, and it is thus relatively easy to pull up into a stall. This is especially serious because the stalling angle with the flaps down is entirely different than the stalling angle with them up.

(d) The wing flaps should be raised as soon as the airplane has cleared the obstructions because the rate-of-climb is less with them down.

15. In no case should the wing flaps be fully down at over 100° m.p.h.

16. The drag of the airplane is tripled when the wing flaps are down.

N. Control Surface Flaps

1. The "control surface flaps" referred to in this manual are the small controllable panels built into the trailing edges of the main control surfaces and variously called trimming tabs, trailing edge flaps, Flettners, surface stabilizers etc. The Douglas Aircraft Company has settled upon the term "flap" used in conjunction with the name of the surface upon which the little controllable panel is mounted, as being the simplest and most appropriate naming.

2. The elevator flaps serve the same purpose as the old adjustable stabilizers. That is, they relieve the stick forces for changes in loading conditions and changes in condition of flight. For take-off they may ordinarily be set at zero. At any different setting the control force may be high one way or the other. For take-off with wing flaps down the control force may be quite high, and it would be therefore advisable for such a take-off to set the elevator-flap toward the tail heavy position.

3. For very nose-heavy loadings, such as with no baggage load and no passenger load, it may be found very difficult to get the tail down on landing. In the extreme cases of forward center-of-gravity it may be necessary to pull back with 50 or 60 pounds on the wheel at the instant of touching the ground. The use of the elevator flap to relieve this high control force for landing with a nose-heavy airplane will result in a decrease in the effectiveness of the elevators because the elevator area taken up by the elevator flap is then removed from the effective elevator area pushing the tail down. In such a case it is preferable to leave the elevator flap nearly at zero, a condition which will increase elevator loads but also increase the elevator effectiveness.

4. The change in balance caused by passengers moving from the front to the extreme rear of the cabin can be easily compensated for by a very slight adjustment of the elevator-flap.

5. The rudder-flap is controlled by turning the handle on the right of the control pedestal when that handle is in its in-position. This rudder-flap is useful principally for single-engine operation. Three or four turns of the handle will balance the unequal thrust and enable the pilot to fly with feet off the rudder with one engine dead.

6. The aileron-flap is controlled by pulling this same (rudder-flap) handle out, approximately 1/2 inch and turning it right or left to make the airplane right or left wing heavy. This aileron-flap is useful for relieving wing heaviness caused by use of gas from one wing tank. It is also useful for single-engine flight to relieve the wing heaviness of the dead-engine wing.

10. Landing Gear

1. The retracting mechanism for the landing gear is on the left side of the co-pilot's seat and it can be operated easily by the co-pilot. It can, however, also be operated very quickly by the pilot. This mechanism consists of the following:

(a) A valve with a lever handle on a segment having three positions.

(b) A pump handle which is pumped up and down with the valve in either the up or the down position.

2. When the valve is in mid-position, the pump handle can not be operated.

3. The pump forces oil into the retracting cylinder which pulls the gear up into place when the valve is in the up-position. After the wheels have been fully retracted the pump can no longer be moved because pressure has been built up in the line between the pump and the cylinder.

4. 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 nacelle.

5. For extending the wheels the sequence of operations is as follows:

(a) Put valve in down-position.

(b) Pump the handle until it can no longer be pumped or moved.

(c) Return valve to neutral, thus locking the landing gear in its down position. If valve is not returned to neutral, pressure will not be held against the retracting piston holding the gear down.

6. Allowing the landing gear to drop of itself when the pump handle is placed in the down position is not recommended because of the danger that the pilot will forget to pump pressure on the piston and to lock the valve in neutral. The warning lights and horn may give no indication of this danger. Bouncing on the ground may, in this case, throw the upper truss back past dead center so that the load would come directly on the retracting cylinder. If valve lever is not in neutral there is a possibility that the gear will slowly fold up.

7. The light signals operate as follows:

(a) When the valve handle is not it its neutral off-position the single red light marked "valve" is on. This is to insure that the valve is in its off-position during landing and also to insure that during cruising flight the wheels will not drop out of their nacelles owing to possible leakage of the oil through the pump.

(b) The red light on the wheel signal box is on at all times when the wheels are not firmly against their stop in the extended position.

(c) The green light is on only when the wheels are firmly against this stop.

(d) When both lights are on this indicates that one wheel has come down firmly against its stop and the other has not yet reached its stop.

8. If anything should happen to the landing gear to make it stick in any position other than fully locked open, the valve can be reversed and the operations done over. The system is so designed that the wheels will come down in case anything goes wrong with the retracting mechanism. They may come down rather slowly but after they are down the pump should be used to build up pressure in the cylinder holding them against their stops.

9. The horn signal operates whenever the throttles are closed with the wheels retracted.

10. There is a hand operated globe valve at the upper end of each retracting strut in the nacelle. If these valves are closed when the gear is fully extended the gear will be held in that position and pressure may be relieved in the rest of the system. Whenever these globe valves are used a tag should be attached to the throttles so that the pilot, before taking off, will know that he cannot retract the landing gear. The globe valves must be safetied in the open position when the gear is to be operated.

11. In case of an emergency landing in rough ground where there would normally be danger of nosing over, the airplane can be landed with the wheels retracted to lessen the danger of a crash. Such a landing will result in damaging the propeller blades and probably also, if the landing is very rough, the pillow blocks which support the axles without any shock-absorbing medium.

P. Dump Valves

1. Dump valves on the two main (right and left) tanks allow gas to flow out in an emergency when load must be decreased for increasing single-engine climb and ceiling. The flow from the dump valves is 120 gallons per minute, or 720 pounds per minute decrease in airplane weight. An immediate effect is noticed in climbing on one engine. The valves are opened with a single hard pull on the dump valve opening handle. This pull has to be hard enough to break the stop wire. It will require ordinarily 40 to 60 pounds pull to break the wire. The opening handle can be released immediately and will go back into place but will leave the dump valves open. The gas tank gauges should be watched if it is desired to dump but a limited quantity. The dump valve closing handle, located to the right of the opening handle can be pulled when the desired amount of gas has been dumped.

2. The following specific steps may be taken in opening and closing the dump valves:

(a) Pull handle marked "open" until it reaches an apparent stop which will be caused by taking up of the slack in the cable.

(b) Increase force of pull to break safety wire and pass actuating lever beyond its dead center. Handle will then come to a second stop which will open the valve. Total pull is approximately 6 inches.

(c) Replace handle to its original position. The valve will remain open until the "close" handle is pulled.

(d) When sufficient gas has been dumped as indicated on fuel gauge, pull handle marked "close" until it reaches its first apparent stop, then farther over dead center, to the second stop, a total distance of some 6 inches.

9. In dumping gas after single engine failure, the amount to be dumped can be determined by the distance remaining to be flown. If the dead engine is still idling and the gas is not turned off, it will suck a considerable quantity of gas. In this case 100 gallons per hour should be allowed for 120 miles per hour airspeed. For a 60 mile flight with no wind 50 gallons would be needed plus 35% reserve. All but 70 gallons can then be dumped. The gas runs from the dump valves (of the main tanks only) at the rate of approximately 120 gallons per minute. The gas gauge can be watched and the dump valve closing chain pulled when the gauge shows that 70 gallons remain.

The ceiling on one engine goes up several thousand feet when the usual amount of gas for this condition is dumped. Rate-of-climb increases markedly and, most important of all, power required to maintain flight decreases very appreciably so that the good engine can be throttled to or nearly to normal operating limits.

10. There are a number of other items such as the propeller pitch being in low, landing gear being up, wing flaps being up, etc. which are important to single engine operation. See Section II.

Q. MISCELLANEOUS ITEMS

Divide into navigation and emergency hatches

1. The Hatch in the roof of the pilot's cabin opens in the following manner.

(a) Unsnap belt holding folded windshield.

(b) Open the two latches holding the two navigators' doors. This will allow the two doors to swing down.

(c) Raise the windshield through the opening and set supporting pins in sockets on roof of fuselage.

(d) Do not mistake the red emergency exit hatch handles for navigator's door handles. The emergency exit handles if released will allow the entire door to carry away. This might strike and damage the fin and rudder. Emergency exits are provided both in pilot's compartment and in rear of cabin. Both have doors that are carried away when release handles are opened.

2. 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 on the rear wall of the baggage compartment. The cables may be attached to fittings in the wing structure which are accessible through hinged doors in the lower surface of each outer wing panel, and to a bolt in the jury tail skid.

3. Door Locks all operate with the same key with the exception of the lavatory door which has a special key.

4. Synchronizer lights assist the pilot in synchronizing the engines, an important feature for passenger comfort. When right engine is turning faster than the left the order of lighting of the three lamps will be to the right and vice versa. When the lighting of the lamps does not rotate the engines are synchronized. Out

5. Heating and Ventilation are thermostatically controlled and are ordinarily not to be adjusted by the pilots in flight. In case heat is not needed the steam valve on the companionway wall can be shut off to eliminate all heat

from the system. The damper control can be changed from automatic thermostatic operation and operated manually by turning the arrow, beside the steam valve, to the down-position. Sliding it to the right or left will then increase or decrease the amount of air passing through the steam radiator and into the duct along the floor of the cabin.

The cold air ducts along the wall can be operated individually by each passenger, except that in extremely cold weather the cold air supply to the upper ducts may be shut off entirely by a damper located in the passageway alongside the mail compartment.

SECTION III

LOADING AND ITS EFFECT UPON STABILITY

A. Stability and Center-of-Gravity Location

1. Longitudinal stability as distinct from longitudinal balance or trim is the inherent tendency of the airplane to return to its trimmed angle of flight after being disturbed in pitch. If the airplane is trimmed to fly hands-off at some airspeed (say 160 m.p.h.), and a gust noses it down until the airspeed rises to 170, or if some of the passengers move to new seat locations so that the airspeed rises in the same manner and then these passengers move back to their old seat locations the airplane will slowly nose up toward its original flight angle and airspeed. It will usually nose up farther than the original trimmed speed, then oscillate down again, gradually damping out (in case there has been no permanent change in center-of-gravity) at the original trimmed speed. ?

2. The more tail heavy the airplane is loaded the less pronounced will be this tendency to return to any given trimmed air speed.

3. In every airplane there is a point of rearward center-of-gravity movement at which the airplane becomes neutrally stable longitudinally. It will then cease to return to its trimmed airspeed but will remain at any new flight condition induced by some disturbing cause.

4. Beyond this rearward center-of-gravity location the airplane becomes unstable, tending to depart from a trimmed state and failing to return.

5. An airplane can be trimmed for any airspeed regardless of whether it is stable or unstable, longitudinally, the only difference being that if it is unstable it will not return to its trimmed flight path when disturbed, and if it is stable it will.

6. It will be clearly recognized that any change in loading during flight, such as passengers moving or gas being used up, will cause a change in the airspeed or trimmed angle but will not necessarily affect stability. The DC-1 is stable longitudinally in any loaded condition authorized in the table, Figure IX

7. If an extremely heavy load is put in the rearmost compartment, the airplane may not then be stable, but such an extreme condition of loading is unauthorized by the chart and is not allowed by the Department of Commerce.

8. For any condition of loading in which the center-of-gravity is farther forward than the rearward limit, longitudinal stability will be very positive and distinctly noticeable to the pilot.

9. The only disturbing effect of extreme forward positions of the center-of-gravity is that eventually it becomes difficult to get the tail down on landing; but even when the airplane is loaded in such an extreme nose-heavy condition, it can, with a light load, be safely landed in a tail-high position.

450

B. Limits of Loading

1. The most tail-heavy load authorized on the DC-1 consists of 9 ~~or~~ 10 passengers in the rearmost seats and 1000 pounds in the rear baggage compartment with 400 pounds in the forward mail compartment.

950

2. The two passengers in the second seats are almost directly over the center-of-gravity and their presence or absence will not affect this center-of-gravity location.

2 in forward two seats 1000 520

3. The most nose-heavy loading authorized is with no passengers, 75 pounds in the forward mail compartment and 25 pounds in the rearward baggage compartment. ~~The same nose-heavy load is obtained when there are no passengers, if 370 pounds is placed in the forward compartment and 130 pounds in the rear compartment.~~

4. The loading chart, Figure IX , gives intermediate loads for this condition. A familiarity with this chart will assist the pilot materially in understanding how his airplane must be loaded in order to maintain its positive stability.

5. An example will illustrate how simply this chart may be used. Take the case of eight passengers and 750 pounds of cargo (baggage and mail and express). The front compartment load should be 590 pounds while the remainder must be in the rear compartment.

between the limits of 590 & 520

AERONAUTICS BRANCH - DEP'T OF COMMERCE

LOADING SCHEDULE

DOUGLAS DC-1 SERIAL 1137 NC-223 Y

EMPTY WEIGHT 11,749 LBS. - GROSS WEIGHT 17,500 LBS.
MAX. PAY LOAD IS 3540 LBS. WITH 262 GALS. OF FUEL.
MAX. PAY LOAD IS 2051 LBS. WITH 510 GALS. OF FUEL.

PASSENGERS	NONE	TWO	FOUR	SIX	EIGHT	TEN	TWELVE
MAXIMUM CARGO	2000	1800	1600	1500	1400	1400	1500
MAXIMUM FUEL	510 GAL.	495	470	432	392	335	262

IN CASE OF NO CARGO FOR PASSENGER LOAD UP TO AND INCLUDING SIX, 150 LBS. BALLAST MUST BE CARRIED IN REAR COMPARTMENT.

DISTRIBUTION OF CARGO TO FRONT COMPARTMENT.
(REMAINDER OF LOAD TO BE PLACED IN REAR 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	0	60	130	210	280	350	420	490	570	640	710	790	860	940	1000	1000	1000	1000	1000	1000
		MINIMUM	0	0	0	0	0	10	80	150	220	300	370	440	510	580	650	720	790	850	920	1000
	1 OR 2	MAXIMUM	0	30	110	180	250	330	400	470	550	620	690	770	840	910	990	1000	1000	1000		
		MINIMUM	0	0	0	20	90	160	230	330	370	440	510	580	650	720	790	860	930	1000		
	3 OR 4	MAXIMUM	0	50	120	190	270	340	410	490	560	640	710	790	860	930	1000	1000				
		MINIMUM	0	0	60	130	210	280	340	410	480	550	620	690	760	830	900	970				
	5 OR 6	MAXIMUM	30	100	170	250	320	390	460	540	610	690	760	830	900	980	1000					
		MINIMUM	0	70	140	210	280	350	420	490	560	630	700	770	840	910	980					
	7 OR 8	MAXIMUM	100	190	260	330	400	480	550	620	690	770	840	910	990	1000						
		MINIMUM	40	110	180	250	320	390	460	530	600	670	740	810	880	950						
	9 OR 10	MAXIMUM	100	200	300	400	500	600	670	750	820	890	970	1000	1000	1000						
		MINIMUM	40	110	180	250	320	390	460	530	600	670	740	810	880	950						
	11 OR 12	MAXIMUM	100	200	300	400	500	600	700	800	900	1000	1000	1000	1000	1000	1000					
		MINIMUM	0	70	140	210	280	350	420	490	560	630	700	770	840	910	980					

APPROVED - R. D. Bedinger
DEP'T OF COMMERCE INSPECTOR.

BAKER - 10-24-33

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SECTION IV

PERFORMANCE OF THE DOUGLAS AIRLINER (MODEL DC-1)

A. Efficient Climbing Methods for Transport Operation

1. There are a number of very divergent ways to operate the DC-1 during the climb. One may climb (a) very steeply, too steeply, in fact, for the best climbing rate, (b) at exactly the correct airspeeds to give the maximum altitude in the shortest time, or (c) at a very flat angle and a low rate of ascent in an effort to cover the greatest possible distance while one is climbing. All of these manners of climbing may be carried out at either high or low pitch of the propellers. They may be done at either full power or at any desired power condition.

2. These combinations make up an infinite variety of possibilities, each pilot usually preferring a different method of climbing. The analysis, however, of the climbing abilities of the DC-1 shows that, weather and terrain permitting, the most economical and most useful technique of climbing for a given schedule of over 200 miles is that obtained with the following set of conditions:

(a) Shift to high pitch soon after take-off.

(b) Use recommended climbing airspeeds which will give minimum point-to-point time. Up to 8,000 feet use 140 miles per hour indicated airspeed. Above 8,000 the indicated airspeed can be gradually decreased to 130 at 10,000, 120 at 15,000, etc.

(c) Climb at 75% power, which will be obtained at full-throttle at approximately 5,000 feet in high pitch at 140 miles per hour. Above 6,000 feet the power drops off, as shown in Figure X1 , to 50% at approximately 16,000 feet.

(d) Below 5,000 feet, 75% power climb will be determined by throttling to hold supercharger pressure to 34.5 inches.

(c) Climb steadily, weather permitting, up to optimum cruising altitude as determined from Figures XII, and XV

3. Although it is commonly thought that 75% power full throttle climbs are too hard on the engines, the engine manufacturer recommends these 75% power climbs even though slightly less power is to be used in cruising, for the following reasons:

(a) Engine wear and economy are functions of time-of-operation at a given power, so that, within certain limits, operation at higher power for a short time is to be preferred to operating for a much longer time at a slightly lower power output.

(b) The sooner the high density lower altitudes with their greater danger of over-stressing operation are left behind, and the sooner the airplane reaches optimum cruising altitudes where the engines are safer from over-supercharging, the better. They are also safer then from over-leaning of the mixture, and from overheating of cylinders.

If there is no need for optimum cruising speed on a given flight because of tail winds, easy schedules, or departure ahead of time, the climbing as well as the cruising power-conditions may be decreased. Even under these conditions, however, the general method of climbing given above, with proper modifications for power, will be found to give the most satisfactory results.

4. Maximum rate-of-climb with full power is obtained with the propellers in low pitch and at the airspeeds shown in the chart and table, Figure X At altitudes below critical, the engines must be limited in throttle-opening to prevent over-supercharging. The supercharger (manifold) pressure gauge will be the guide during this part of full-throttle climb if such a climb at low altitudes is ever needed. A supercharger pressure of 34.5 inches of Mercury is the limit which will allow full rated power of the engines at these altitudes.

5. For take-off and emergency operations or for single-engine climb in the event of an engine failure at low altitudes, excess power beyond the rated power may be used by operating at over-supercharging pressures up to the limits prescribed for such emergencies in Figure III. See also Section IV, C.

B. Efficient Cruising Methods for Transport Operation

1. The DC-1 is designed and its propellers are adjusted for a new method of cruising. This new method consists in controlling the cruising power by altitude instead of by throttle-opening. It is much more accurate than the old methods. It is also very much more efficient because the desired percentage power output is applied at an air density allowing the minimum drag and hence the maximum speed for this power. The reason the speed is really a maximum for this power is that the operation is conducted at the maximum possible altitude at which the airplane can be flown level at this power. It is full throttle operation and the altitude is called optimum cruising altitude. In a sense this is "sub-stratosphere flying" even though it is at but 14,000 feet.

2. Now for each percentage power (such for instance as 75% cruising, or 70% cruising) there is a different optimum cruising altitude. This altitude also varies somewhat with the temperature as can be seen from Figure XII. The principal problem has been the setting of the propeller in such a manner that the required cruising engine revolutions would occur at exactly the altitude where the required supercharger pressure would be obtained at full throttle. This would be ideally and perfectly achieved for all cruising powers only with a propellor which could be varied in flight to any desired pitch within the cruising range. Such a propeller is not yet ready for use, and so a compromise high pitch determination was made such that the three variables, engine revolutions, supercharger pressure, and altitude, coincide to give the required percentage power at full throttle with all of the safeguarding engine limits respected and very nearly the desired engine revolutions at 70% power optimum cruising altitude.

3. With highly supercharged engines which may easily permit dangerous over supercharging, with controllable propellers which may be left in low pitch when leveling out thus permitting over-reving, with engines which are to be operated most efficiently at full throttle, and a delicate adjustment of mixture control, the margin between over-strain or over-heating on the one hand, and failure to obtain the cruising performance desired on the other is a narrow one and will justify considerable time spent in an effort to perfect the understanding and technique of the new system.

4. The chart showing Power, Engine Revolutions, and supercharger Manifold Pressure as functions of cruising velocity and altitude, Figure XV , is useful for the pilot during flight, at least until he has acquired a complete familiarity with this operating technique. As can be seen from this chart 70% power, for instance, can be obtained not only at full throttle optimum cruising altitude (15,200 ft.) but also at lower altitudes (take 6000 ft. for instance) throttled to the supercharger manifold pressure (29.7") and engine revolutions (1695 r.p.m.) corresponding to the altitude and power lines (70%) chosen. It will be noted at once, however, that this lowering of cruising altitude, even though at constant power, is paid for in lessened cruising speed (-13.5 m.p.h.). It will also be noted with a reference to Figures V and VI that the indicated airspeed rises while the true airspeed is decreasing. Herein lies the reason for the popular fallacy that the higher one flies the slower one flies, - herein and also because hitherto the pilot has been unable to determine his power and has not realized that his power usually dropped off rapidly with altitude, even though his engine revolutions were maintained by continued opening of the throttles.

5. Temperature has a very pronounced effect upon both drag (or resistance) of an airplane, and therefore upon power-required (and velocity), and upon engine power-available at any altitude or any throttle opening. There are a number of ways in which one may take this into account. The simplest way is to correct the pressure altitude, if the temperature does not happen to be exactly "standard" for the altitude at which the airplane is flying. This correction is done graphically on the charts by simply following the proper temperature line (ice-warning indicator temperatures will be satisfactory for this purpose) down to the altimeter reading (pressure altitude), and at this intersection following the horizontal line, which then constitutes your corrected density-altitude, over to the velocity, engine revolutions, supercharger manifold pressures and percentages of power which you wish to read.

6. Temperature also has a pronounced effect upon the airspeed indicator, causing it to read approximately 1% lower for each 10 degrees Fahrenheit temperature increase at constant pressure-altitude.

7. If maximum velocity at a 75% power cruising condition is desired, it will be obtained at 14000 feet altitude and this velocity will be 200 m.p.h. If this velocity is not needed for the scheduled operation it would be desirable to climb to a higher optimum cruising altitude where the economy of operation would be improved. If one climbed to 16,200 feet one would cruise full throttle at 193 m.p.h. at 65% power. If there is a tail wind or a lax schedule which permits very much slower cruising it will not be possible to utilize optimum cruising altitude because the passengers cannot stand such high altitudes. Thus it will be necessary to partially close the throttles in addition to "throttling with altitude."

8. Fuel consumption does not increase for a given power output by flying higher at full throttle. In other words, specific fuel consumption is independent of altitude. It may even be possible that such full throttle optimum cruising altitude operation could be carried out with leaner mixtures and consequently lower specific consumption than low altitude flying at the same power. Care will be required, however, to prevent detonation or over-leaning of the mixture, especially in cold weather when the thermo couples may not indicate too high cylinder head temperatures.

9. Fuel used per mile will be definitely lowered for a given power output by flying at optimum cruising altitudes because the velocity increase at constant power gives more miles per horsepower hour and consequently more miles per gallon, and more miles per overhaul dollar.

C. Efficient and Safe Single-Engine Operation

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 the other engine, dead) is very critical to

1. Airspeed
2. Yaw (sideslip or skid)
3. Altitude
4. Cylinder temperatures
5. Mixture control
6. Supercharger pressure
7. Engine revolutions
8. The state of the other engine
9. Load
10. Propeller pitch, landing gear, wing flaps, etc.

1. Airspeed during single-engine climb is most critical of all. If airspeed is allowed to get too high, (10 miles per hour above the recommended indicated airspeed) it will be discovered that, with full load or nearly full load, the airplane will require much greater power and engine revolutions in order to maintain the climb desired than if climb is made at the correct airspeeds. At or near single-engine ceiling, even two or three miles per hour indicated airspeed above the correct airspeed will give a rate-of-descent instead of a rate-of-climb.

It is very desirable in the event of engine failure to operate the remaining engine at as low an excess power output as is absolutely necessary to maintain safe flight. Thus, although one may have to exceed the cruising limits of Figure III, and even have to operate near to the emergency limits, it will be found possible by accurately observing all of the optimum flight conditions specified, to maintain altitude with the single engine operating at approximately 80% power.

If engine failure occurs at such a point that a gradual slight rate-of-descent is permissible, so gradual even, that in 100 miles the airplane could lose 4000 feet, the operating engine can be throttled even more. Excessive engine wear may thus be entirely obviated and the probability of the remaining engine failing, reduced to the cruising minimum. The airspeed for such an operation at a slight rate-of-descent should be the same as for single-engine climb.

If the airspeed drops to below the recommended value for single-engine climb, rate-of-climb may momentarily rise (from the zoom or change from kinetic to potential energy.) As soon, however, as the airspeed is held steady at the lower value it will be found that rate-of-climb has been decreased or perhaps even a rate-of-decent will ensue. In order to get back to the correct airspeed for minimum power climb or for minimum power maintenance of level flight, a further loss will be necessary while the airplane is nosed over (however slightly) to pick up the required increase in airspeed.

For single-engine operation, either climbing or minimum power flight, use

(a) 95 m.p.h. indicated airspeed up to 4000'

(b) 100 m.p.h. indicated airspeed between 4000 and 8000.

(c) 95 m.p.h. indicated airspeed above 8000'.

2. Yaw is important near single-engine ceiling (or if desiring to throttle to minimum power to maintain any altitude), because it induces a loss due to increase in drag and increase in lift. It is often present because the dead-engine side of the airplane is kept higher than the operating-engine side, under the erroneous belief that single-engine operation or control is improved in this manner. Power required for single-engine flight is a minimum when the airplane is level laterally and flying straight. There will be a very slight yaw under these conditions but it will be barely noticeable.

For control, prior to the adjustment of the rudder-flap to relieve the single-engine rudder load, it may be found to slightly lighten the unbalanced force if one momentarily raises the dead-engine wing. But this is really unnecessary and it increases the loss due to yaw.

3. The altitude at which engine failure occurs will determine the best method of operating the remaining engine. If it occurs at or above 8000 feet the operating engine may be readily opened full throttle (low pitch of course) and the supercharger pressure will not give any cause to worry because of the low density at these altitudes. More than the full rated power of the engines can be taken out at or slightly above 8000 feet because the propellers are in low pitch and "low pitch climbing critical altitude" occurs slightly above "high pitch level flight critical altitude." For this reason, and also because the over-reving of the engine in this condition increases the engine wear, the engine should be throttled slightly to minimum power for the level flight or the slight descent necessary to complete the flight.

At lower altitudes supercharger pressure will be the principal limit. While a supercharger pressure of ~~37.8~~ 36.8 may be allowed momentarily with 87 octane fuel and low cylinder temperature, detonation, high cylinder temperatures, and loss of power will probably ensue unless the supercharger pressure is reduced very soon. For long flights on one engine at low altitude, very great attention must be paid to power-control, to over-supercharging, over-reving, over-leaning the mixture, and detonation or over-heating. No attempt should be made to climb rapidly with excess power near sea level because this condition of low altitude single engine operation is by all odds the most hazardous one the pilot has to meet from the point of view of engine operation.

4. Cylinder temperatures are the pilot's ultimate guide in guarding the engine from damaging operating conditions during single engine flight. If over-supercharging is carried too far, the thermocouples will very soon carry the story to the cylinder temperature indicators, with a rise approaching the emergency limit of 580 degrees. If over-leaning of the mixture occurs the temperature rises immediately and very rapidly. If detonation occurs the temperature rises and the power drops off.

Two cautions are necessary with regard to the cylinder temperature guide:

(1) The thermocouple measures the temperature of but one cylinder (usually but not always the hottest).

(2) If the thermocouple wires have a loose or broken connection one may over-lean or over-supercharge to the damaging point without proper temperature warning.

5. Mixture control is of primary importance in single-engine operation because if full rich mixture is used, both excessive fuel consumption (100 gal. per hour) may result and, at the same time, maximum power will not be available because power drops off with over-rich mixtures. If the mixture control is leaned out to maximum power, as indicated by maximum r.p.m.) for any throttle setting and attitude of flight, then there is considerable danger of detonation or over-heating. The margin between over-rich and over-lean mixture is so narrow on single engine operation that the proper operation of the mixture control may present one of the pilot's most serious problems. One will not, of course, be concerned about excessive fuel consumption if one engine has failed because the protection of the other engine is of such supreme importance in such an emergency. It is, however, a matter of some concern to get the necessary power which may not be obtainable without leaning out.

For take-off it is better to have a too-rich rather than a too-lean mixture because the temperatures rise very rapidly while the pilot is busy with other things, and in case of engine failure on take-off with too-lean mixtures, the remaining engine may rise to damaging temperatures almost before the pilot can half-circle the field for a landing.

The mixture control will be found to have a serious lag which affects the operation in the following manner: The usual method of leaning out the mixture is to watch the tachometers and gradually lean out as the engine revolutions increase. When a point is reached beyond which no further increases are noticed in the tachometer indications, or where the engine revolutions begin to fall off, the mixture control is moved slightly toward the rich side. This method is unsatisfactory for the DC-1 engines because it will be found that occasionally after a few minutes if one richens the mixture slightly, engine revolutions will be gained, showing that the mixture was actually on the too-lean side of maximum power. High cylinder temperatures and detonation will then result even on 87 octane fuel. Until there is developed a better guide for mixture control it is safer to lean-out the mixture very slowly while watching carefully the cylinder temperatures and to stop when temperatures show an appreciable rise.

6. Supercharger manifold pressure of ~~37.8~~ 36.8 inches is allowed with 87 octane fuel for short periods of single engine operation if detonation or overheating do not ensue. Supercharger pressure should be kept down to the minimum required to maintain flight in order to reduce the engine loads and temperatures. It is possible to maintain altitude on one engine at a supercharger pressure of 34.5 inches, and this should be the aim as soon as possible after an engine failure.

7. The engine revolution emergency limit is 2050 r.p.m. This limit will be reached only in single-engine low pitch climb. Single-engine operation would not be possible in high pitch because the engine revolutions would be too low to permit the power output required to maintain flight or climb.

8. The state of the "dead" engine has a bearing upon the drag of the airplane and hence the power-required of the operating engine. If the propeller is stopped on the dead engine the drag is very considerably reduced and the climb, ceiling, and speed considerably improved for the other engine. The power required for flight with one completely stopped propeller is considerably less than when the dead engine is idling.

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9. Load has a very appreciable effect on single-engine climb, ceiling, and minimum power required, as can be seen from the maximum climb chart. The dumping of 1000 pounds of gas increases the single engine ceiling two thousand feet.

10. Propeller Pitch must, of course, be low pitch for single-engine operation. The landing gear must be kept retracted until just before landing. The wing flaps must not be lowered until immediately before landing, because the single engine will not maintain altitude with flaps and landing gear down.

SECTION V

STANDARD PERFORMANCE CHARTS

1. The following charts have been made not from theoretical data but from actual flight tests with full load and standard equipment on the DC-1. They are in accordance with the engine manufacturer's recommendations regarding cruising performance and the limitations upon engine power. The climbs and descents from each cruising altitude have been included in the determination of average block-to-block speeds. The limitations upon rate-of-climb and rate-of-descent required for passenger comfort have been taken into account and no such limitation has been exceeded. The technique of flying in order to obtain these ideal performances is as follows: The take-off is made with low pitch and the wheels retracted immediately after leaving the ground. When all obstructions are safely cleared the propellers are changed to high pitch and the airplane set in a 75% power climb at the airspeed and manifold pressure indicated on the chart, Figure XI. This chart will give the desired percentage of power at each altitude during climb. The climb continues uninterruptedly in accordance with the table, to the proper altitude for cruising where a new set of conditions apply after levelling out.

2. If the altitude chosen for the cruising flight is optimum cruising altitude for that percentage of power the throttles will be fully open and the mixture controls adjusted to give safe operating temperatures and the minimum cruising consumption consistent with the cruising limitations. For 75% power this will be 14,000 feet, and for 62.5% power it will be 17,000 feet for standard temperature conditions.

3. If because of weather, icing danger, high counter-wind gradient, or because of passenger comfort, or for a very short flight it is deemed inadvisable to climb to the optimum cruising altitude a lower than optimum altitude is chosen where the control of power at the throttled condition necessary becomes slightly more complex. The engine revolutions and

supercharger manifold pressure for the desired power and altitude can be read from the chart, Figure XV. In case these variables do not all exactly agree, as they will not if temperature, load, or engine condition is non-standard or gauges get out of calibration, a compromise setting should be decided upon which favors the specified supercharger pressure.

4. At some distance before the terminal is reached, as indicated on the chart, a third stabilized flight-condition is called for. This will be a slight rate-of-descent with the maximum power which it is possible to use consistent with the engine revolution limitations for this descent. The rate-of-climb meter will naturally be a most useful guide during this part of the flight since it will be possible quickly to determine from it the desired rate-of-descent at the desired revolutions. When a greater range of propeller pitch is obtainable, this part of the flight will become much more important than it is at present because then it will be possible to utilize the full desired percentage power during the descent without turning up the engine too fast, and at an increase of 20 to 30 m.p.h. airspeed.

5. The charts have been constructed from average block-to-block speeds which include climbs at constant power and at specified climbing airspeeds, cruising performances at controlled power output at various altitudes, and descents at higher speeds and very flat angles. A study of the charts will show how high-altitude flying, in addition to its other advantages, shows for longer flights a considerable gain in speed. For short flights the loss of time used in climbing is not quite compensated by the gain in velocity with high altitude cruising. (See Figures XVI and XVII)

6. Altitude of take-off has an appreciable effect upon block-to-block speeds, decreasing the time required to climb up to the altitudes of faster cruising and thereby increasing the trip speeds. Altitude of landing has the opposite effect, decreasing the gain obtainable from the long fast descent.

7. The high altitude test flights which were made over 450 and 700 mile trips show that this airplane cannot be flown with a disregard of essential power-control information like former transport airplanes, without falling into one or both of two dangers; namely, failure to obtain the economical high cruising block-to-block speeds, and excessive wear or damage to the engines. Sixty miles per hour has been added to speeds at the expense of the necessity for careful control. The trip charts and power control charts were constructed as a protection for the pilot from the danger of damaging the new equipment through misunderstanding of its correct operation, and from having a large discrepancy between test performance and operation performance, heretofore the invariable rule when new equipment arrives. This discrepancy is not necessary. It arises occasionally on steamship companies when new high powered high performance turbine vessels are turned over to able sea captains who are better navigators or executives than they are engineers of the category required for very late type of power plant operation.

8. The effect of wind-aloft upon the chart velocities can be seen at once by noting the counter wind gradient (or favorable wind gradient) between any two altitudes. Favorable wind gradient will, of course, always counsel higher altitudes. Counter wind gradient if not greater than the gain in airplane speed with cruising at higher altitudes, will also leave a net gain for the higher altitudes. Even if there is a slight loss of speed the other advantages and safeties of higher altitude cruising technique may lead to its choice.

9. For the usual method of operation on a scheduled flight the pilot can utilize the chart in a different manner. He will know from his wind-aloft reports and his long experience in covering this particular route, at just what time he would ordinarily arrive at his terminal if he flew in the usual manner and at the usual cruising-power. If his arrival there would normally be ahead of schedule he will then fly at a lower percentage power (with lower fuel consumption and lower engine

overhaul costs). He can readily determine from the chart at what speed he must fly in order to reach his destination on schedule time. This will determine the percentage of power to use. If he wishes to make this flight at optimum economy for the determined speed, he will climb to the altitude at which this percentage of power is obtained full-throttle. Here he will have to be guided, of course, by passenger comfort and also by weather conditions. Only considerable experience with the use of these charts will enable a pilot to reach the maximum speeds indicated. These speeds are ideal speeds obtainable under ideal conditions if the pilot has perfect familiarity with the use of charts. It will usually be possible under operating conditions to closely approximate these maximum performances.

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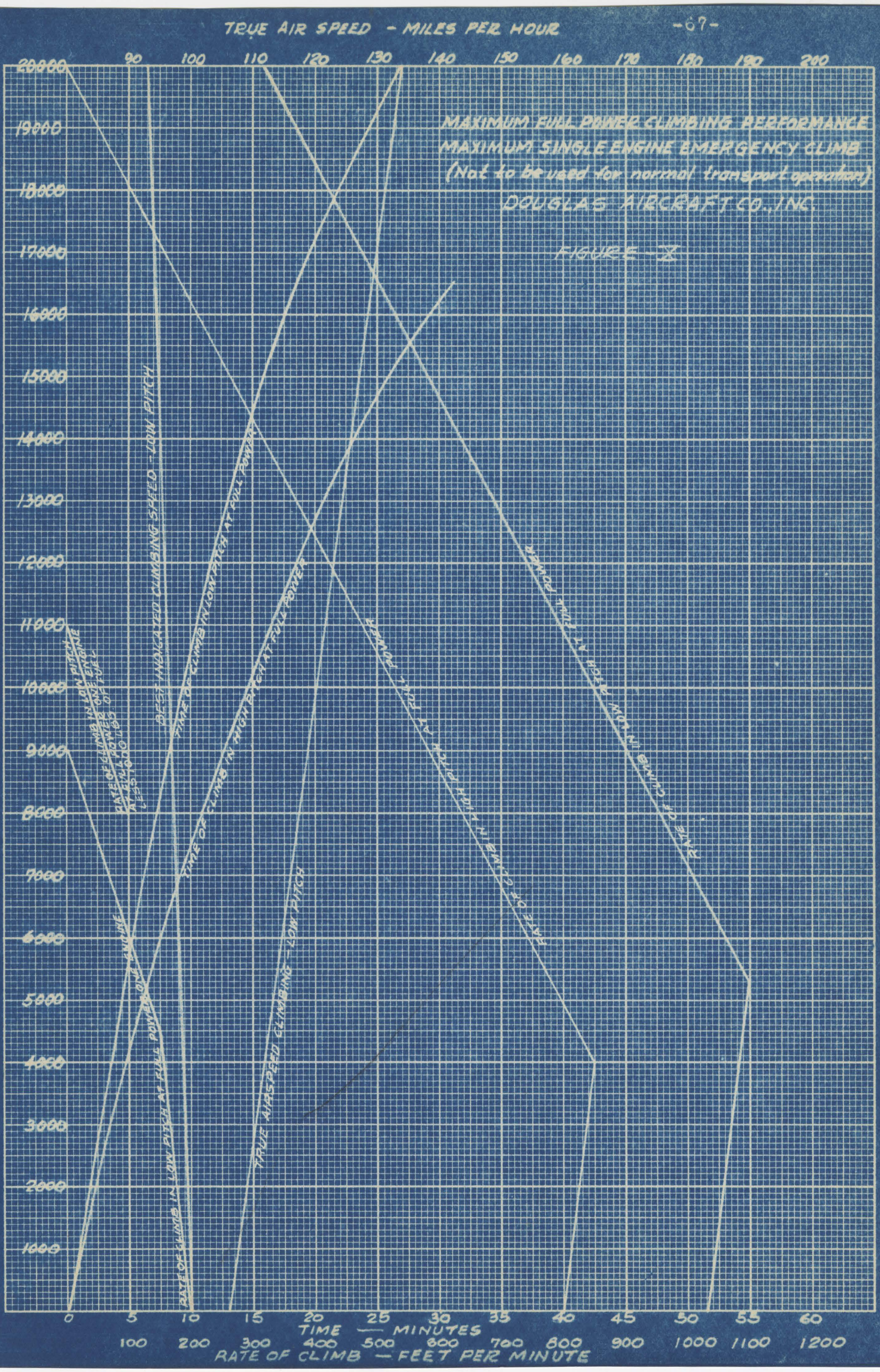

MAXIMUM FULL POWER CLIMBING PERFORMANCE
MAXIMUM SINGLE ENGINE EMERGENCY CLIMB
(Not to be used for normal transport operation)
DOUGLAS AIRCRAFT CO., INC.

FIGURE X

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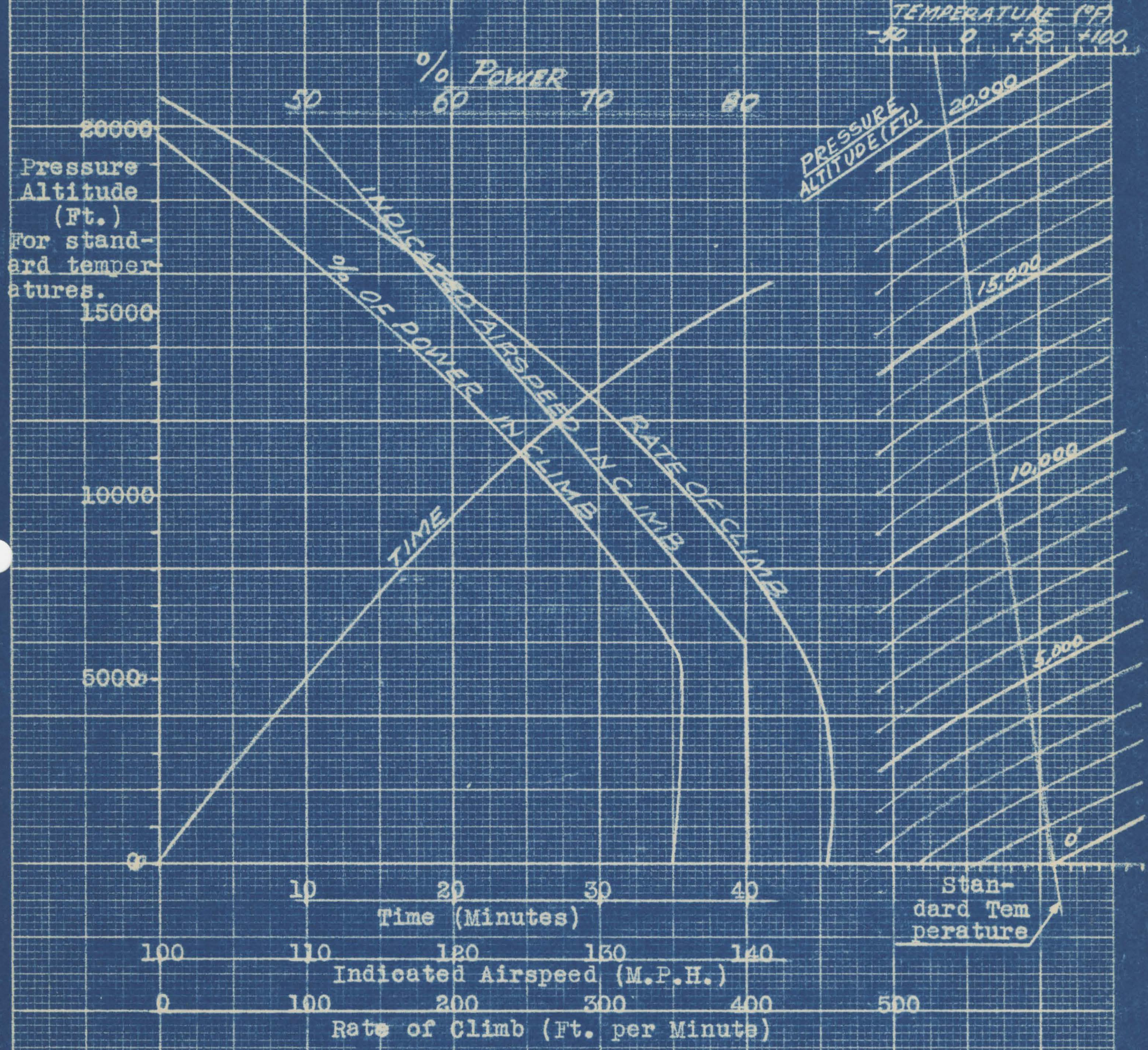
XI

[redacted] 68

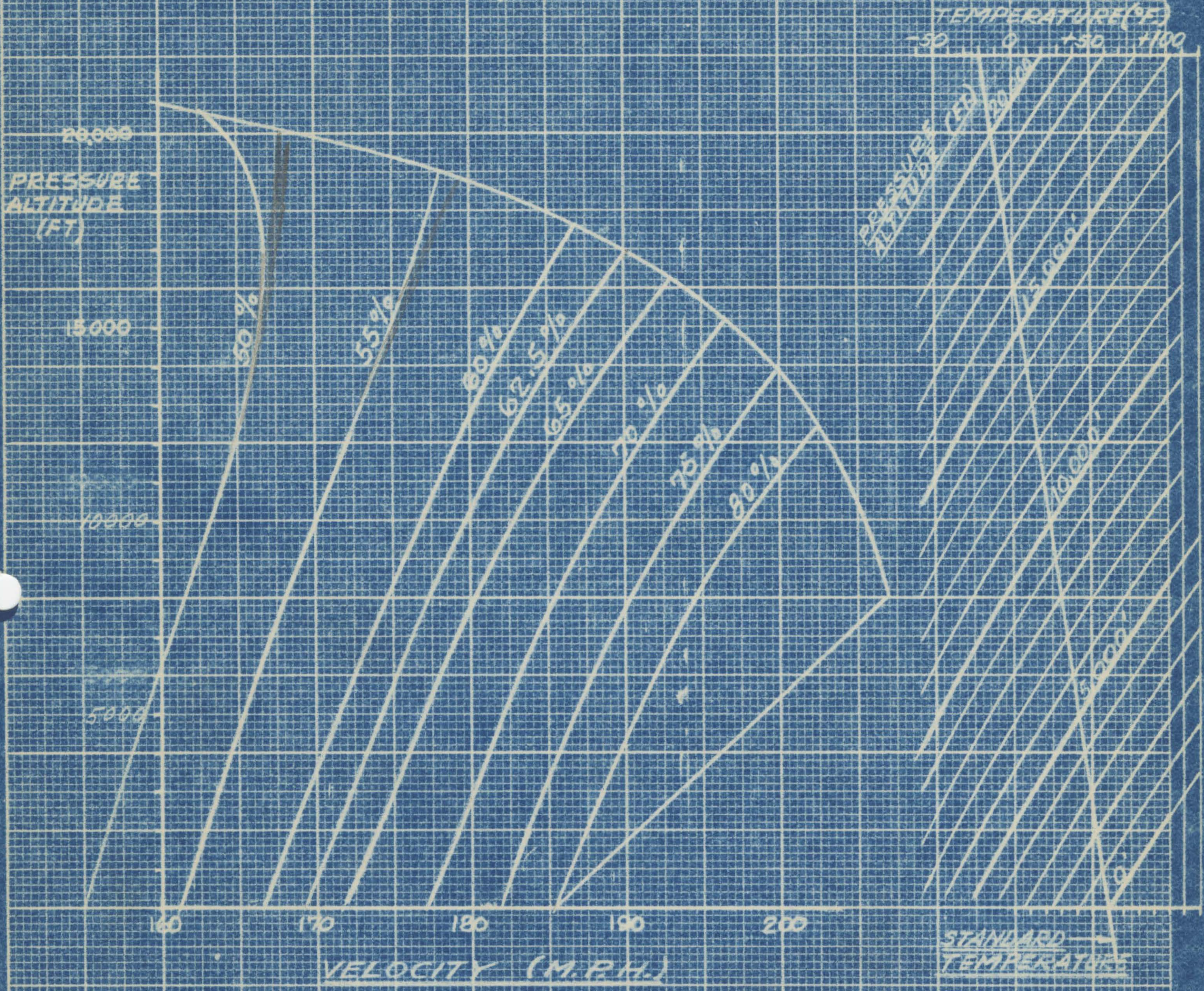
FIGURE XI



Douglas Airliner (DC-1) Recommended High Pitch, High Speed Climb, Indicated Airspeeds, Rates, And Climbing Power for Various Altitudes and Temperatures.

Hamilton Std. 3-bladed Controllable Pitch Propeller, 11' 6" Diam., Blade Design No. 6105, High Pitch Setting 34.5 deg. at 42 in.

FIGURE XII

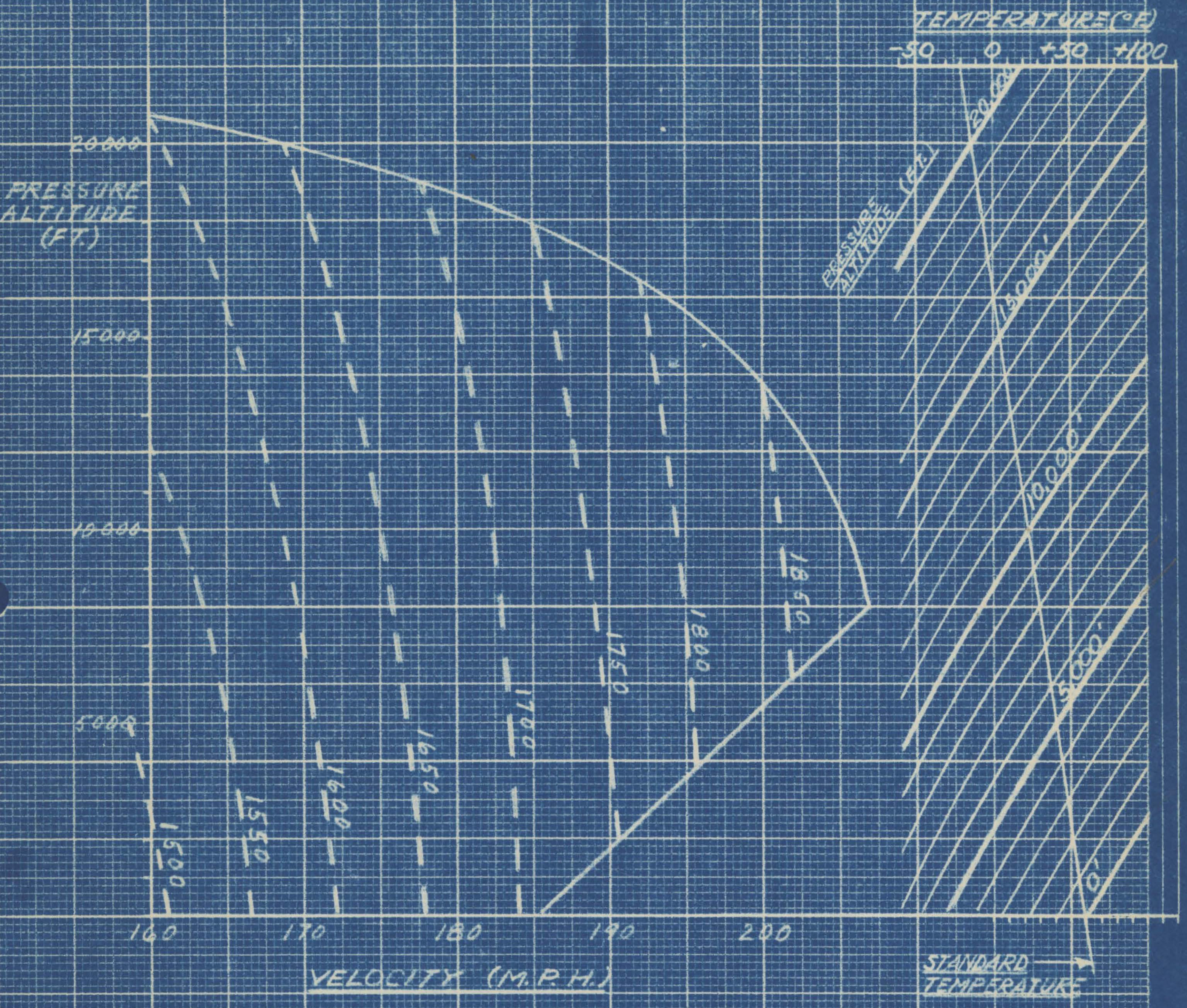


Douglas Airliner (DC-1) Velocity as a Function of Altitude and Percentage of Rated Engine Power.

Hamilton Standard Controllable Pitch Propeller, 11' 6" Diam., Design No. 6103, High Pitch Setting 34.5 deg. at 42 in.

To find velocity for any given percentage power, altitude and temperature, follow the temperature line down to the altitude and then horizontally to the power line.

FIGURE XIII

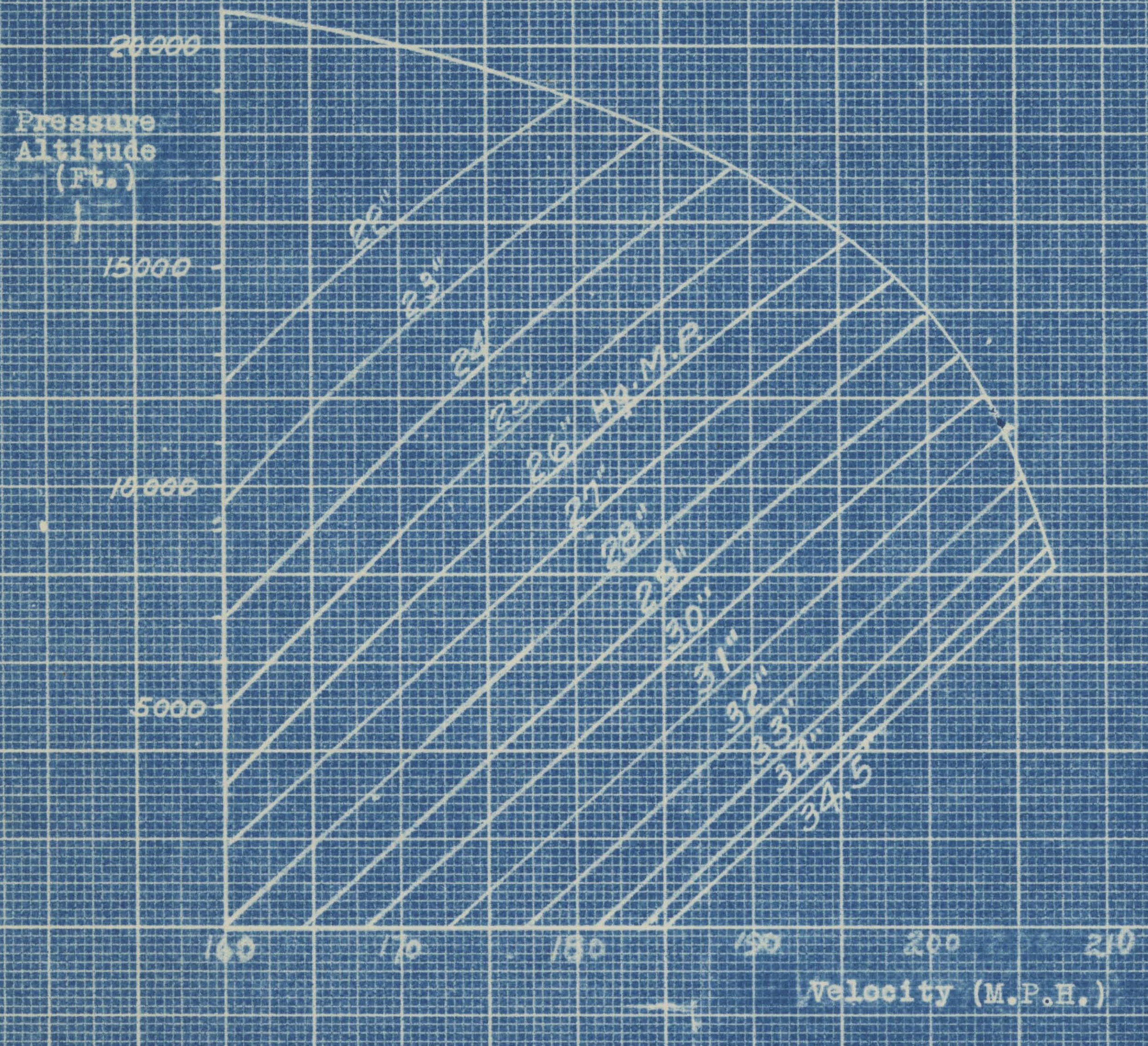


Douglas Airliner (DC-1) Velocity as a Function of Altitude and Engine Revolutions per Minute.

Hamilton Standard Controllable Pitch Propeller, 11' 6" Diam. Design No. 6103, High Pitch Setting 34.5 deg. at 42 in.

To find the velocity for any Altitude, engine revolutions and temperature: follow temperature line down to altitude and then horizontally to engine revolution line

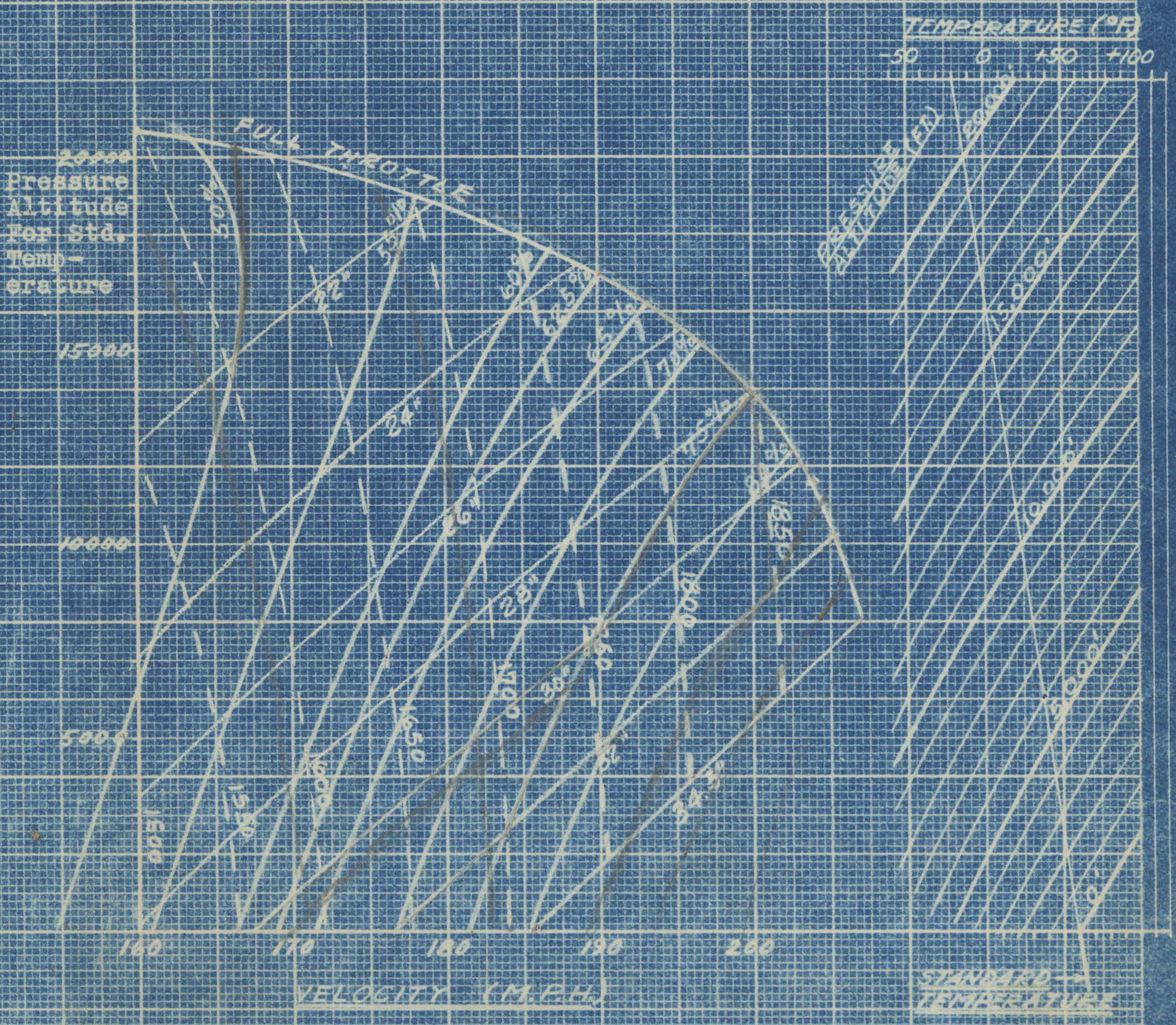
FIGURE XIV



Douglas Airliner (DC-1) Velocity as a Function of Altitude and Supercharger Manifold Pressure.

Hamilton Standard 3 Bladed Controllable Pitch Propeller, 11'6" Diam., Design No. 6103, High Pitch Setting 34.5 deg. @ 42".

FIGURE XV



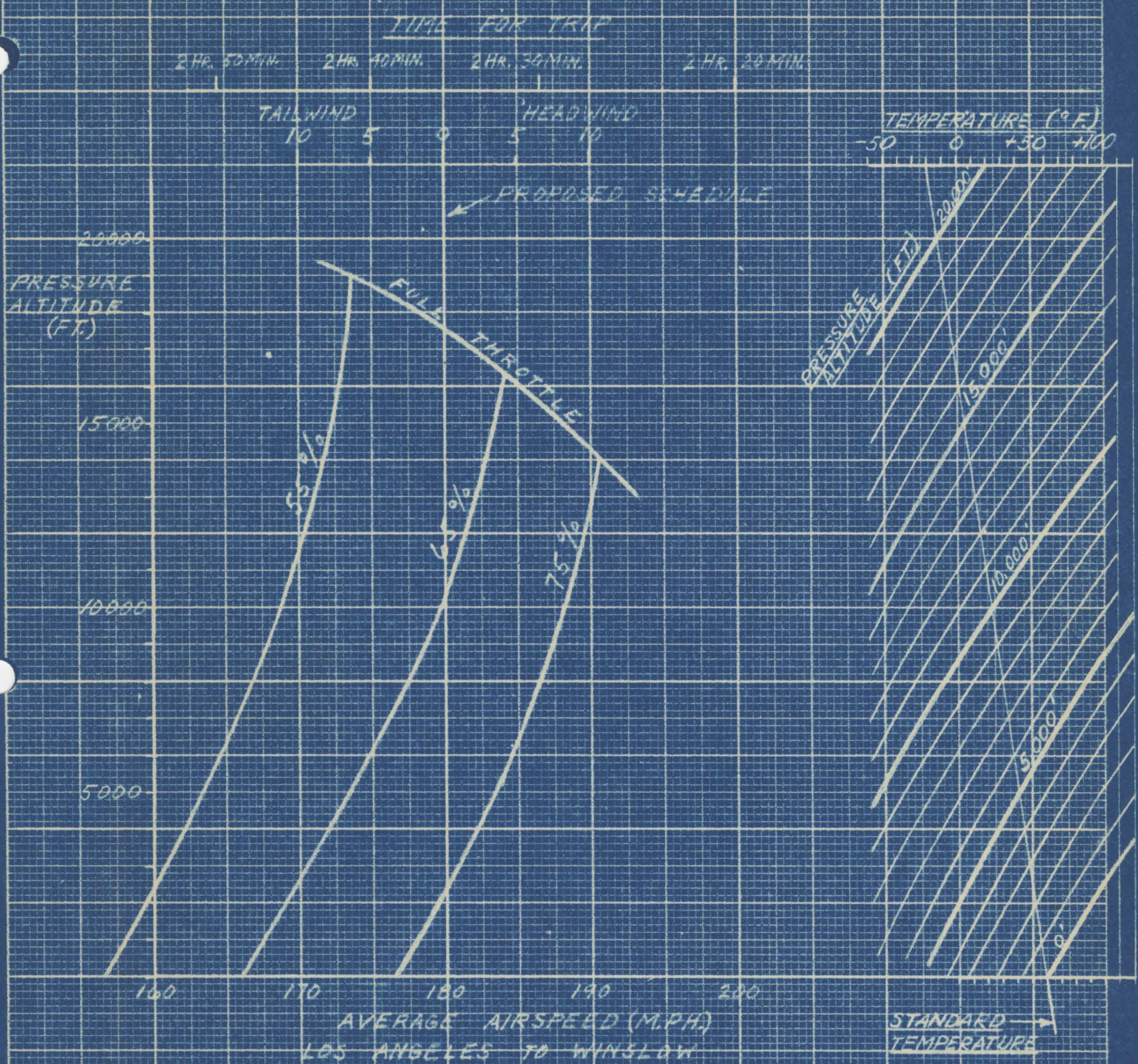
Douglas Airliner (DC-1) Engine Revolutions, Percent Power, and Supercharger Manifold Pressure, as Functions of Velocity and Altitude

Hamilton Standard 3-bladed Controllable Pitch Propeller, 11' 6" Diam., Blade Design No, 6103, High Pitch Setting 34.5 deg. at 42 in.

To use chart follow proper temperature line down to altitude and then horizontally to percent power, revolutions and velocity for any percent power.

Use left hand pressure altitude scale for supercharger manifold pressure and full throttle velocity.

FIGURE XVI

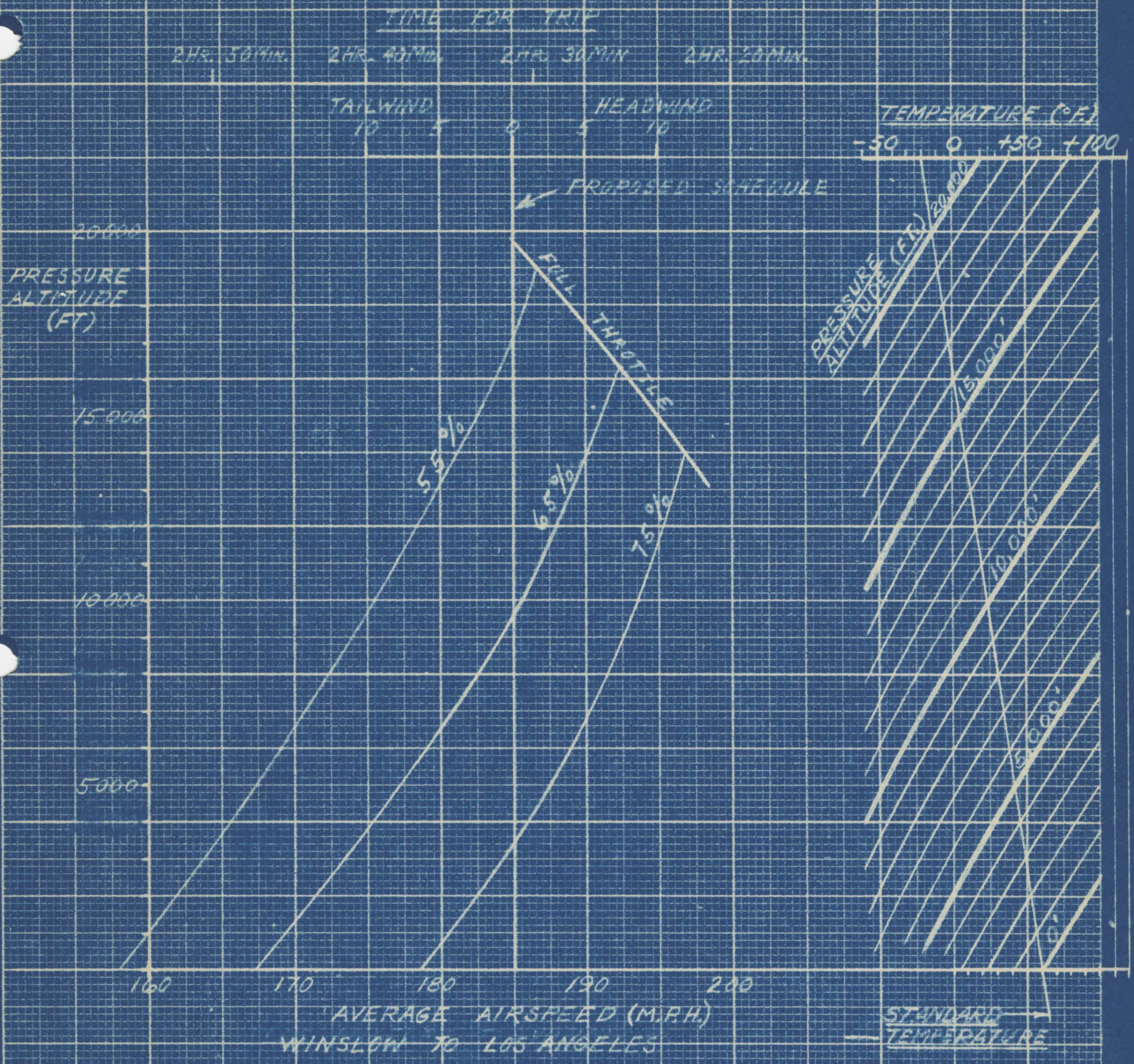


Douglas Airliner (DC-1) Average Trip Speed for "Los Angeles-Winslow" as a Function of Cruising Altitude, % Power, and Temperature.

Ham.-Std., 3 Bladed Prop. 11' 6" Diam. Blade Design No.6103, High Pitch Setting 34.5 deg. @ 42".

To find percent power for scheduled speed with zero wind follow proper temperature line down to altitude and horizontally to scheduled speed line, read percent power, add or subtract wind aloft from cruising speed.

FIGURE XVII



Douglas Airliner (DC -1) Average Trip Speed for"Winslow-Los Angeles" as a Function of Cruising Altitude, % Power,and Temperature.

Ham.-Std. 3 Bladed Cont. Prop. 11'-6" Diam. Blade Design No.6103, High Pitch Setting 34.5 deg.@ 42".

To find percent power for scheduled speed with zero wind follow proper temperature line down to altitude and horizontally to scheduled speed line,read percent power,add or subtract wind aloft from cruising speed.

SECTION VI

PASSENGER COMFORT

Certain considerations of passenger comfort apply to this airplane in a different manner than they do to most former airplanes. These are as follows:

A. Sound Level

1. With the sound insulation of the DC-1 it will be found that the factors which influence passenger strain are somewhat different than on noisier airplanes. The opening of the door at the front of the cabin will admit a very much higher sound-level than is present with the door closed. This will usually awaken sleeping passengers and annoy others and if possible it should be reduced to a minimum number of times during the trip. The noise-level in the pilots' compartment is very much higher than it is in the cabin, chiefly because the propeller tips, the principal cause of noise, are closer to the pilots' compartment.

2. With the sound-level in the cabin as low as it is, other disturbances than sound, such as low-frequency vibrations below the audible range, become very annoying and are often the cause of nervous strain. Any operation of the engines or the controls which reduces these other disturbances, such as smoothing out the engines or synchronizing them, will reduce the strain.

B. Synchronizing Engines

1. The beat of unsynchronized engines becomes very annoying because the general noise-level is so low. It is quite difficult to recognize the lack of synchronization in the pilots' compartment but it is very audible and annoying in the cabin. Until a satisfactory visual synchronizer is developed the pilots will find it highly important for passenger comfort to bend every effort toward keeping the engines synchronized by the beats during long flights.

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C. Drafts and Ventilation

1. When the door at the front of the cabin is open the cabin ventilation is completely upset. This is particularly true if the pilots' windows are even slightly open. Very often it will be found difficult to open or close the cabin door because of the air pressure on one side of it. When it is opened in this condition the blast of air on the front passenger is quite annoying. Doors should be tightly latched when closed.

D. Climbing

1. The DC-1 can be climbed at such a steep angle that, although it is not particularly noticeable to the pilots, it is uncomfortable to the passengers. The rate-of-climb limitation imposed by the operations department can be so easily exceeded on this airplane that especial care will be required to keep within the limits for passenger comfort. The ceiling of this airplane is over 25,000 feet with full load and the seemingly effortless climb at 17,000 feet may deceive the pilot into disregarding the maximum altitude which the average passenger can withstand.

E. Descent

1. On account of the extremely efficient design on this airplane the approach to a terminal field will be found at first very confusing in the matter of rate-of-descent and the pilot will have difficulty in adjusting to the great distance required to lose his altitude at the maximum allowable rate-of-descent. This slow rate-of-descent at high airspeed makes possible the great gain in block-to-block speeds indicated in the standard performance charts.

SECTION VII

THE AUTOMATIC PILOT

A. General Description

1. The automatic pilot, designed and built by the Sperry Gyroscope Company, provides automatic control of the rudder, ailerons and elevator maintaining the desired attitude of the airplane, directionally, laterally and longitudinally. In addition a control is provided for maintaining any constant altitude desired. The automatic pilot consists essentially of a directional gyro, horizontal gyro, air valves, balanced oil valves and hydraulic servo unit. The gyros and valves are operated by the vacuum pump on the left engine and an oil pump, for providing pressure to the servo unit is mounted on the right engine.

2. The two gyros, which are similar to the Sperry Directional Gyro and Horizon, are used to provide the datum lines from which the control surfaces are operated. If the airplane moves away from any one of these datum lines a difference in pressure occurs in the air valve. (The gyros hold their set attitude. The ports of the air valve are opened or closed by rotating away from or toward a knife edge plate which is fixed to the gyro.) The air valve operates a balanced oil valve which regulates the flow of oil to either side of the piston in the servo unit. The pistons being connected to the control cables operate the surfaces.

B. Detail Description

1. The control unit mounted in the upper center of the instrument board houses the gyros, air valves and the oil valves. Appearing on the face of this unit in addition to the indicators, of the gyros are a ball bank indicator, the gyro caging knobs, the control knobs and a vacuum gauge. Refer to the picture, Figure XVIII, PAGE 75.

2. The Directional Gyro is caged and set on compass headings by the knob under the ball bank. The lower card is fastened to the gyro and the upper card indicates the relation between the gyro and the controls.

3. The Horizon Gyro is caged by the knob to the right of the Directional Gyro caging knob. The Horizon indicates climb by the bar rising and dive by the bar lowering. Angular changes are shown in degrees. Banks are shown in degrees on the bottom of the black field behind the bar.

4. The top card on the Directional Gyro and the two pointers on the Horizon are position indicators of the automatic controls. These three indicators are manually positioned for any direction and attitude by rotating the three knobs marked "TURN", "BANK" and "CLIMB". These two instruments and the ball bank furnish the indication for direction and attitude in manual piloting as well as during automatic piloting.

5. Engaging and disengaging of the pilot is accomplished by moving the engaging lever, located on the left rear corner of the top of the control pedestal to either the on or off position. The automatic pilot can be over-powered in emergencies without disengaging. When the emergency is over and the controls have been released the automatic pilot will return the airplane to its original course and attitude.

6. An oil pressure of 120 pounds is required for correct operation of the servo unit. This pressure is maintained by an automatic pressure regulator. The pressure gauge is mounted on the left side of the instrument board. A vacuum of four to five inches of mercury is required.

C. Operation

1. Check the air vacuum and oil pressure. A vacuum of at least four inches of mercury and an oil pressure of 120 pounds is necessary.

2. Be sure that the Horizon has been uncaged at least three minutes (time required for the gyro to settle) and that the knob marked "LEVEL" is turned in the off direction as far as it will go.

3. Hold the airplane in level flight and in trim.

4. Set the Directional Gyro card on the heading desired and uncage (some pilots prefer a compass heading, others fly a zero course) and then with the knob marked "TURN" set the upper card to coincide.

5. Using the knob marked "BANK", set the indicator pointer on top of the Horizon to coincide with the pointer on top of the black field.

6. Set the pointer on the right side of the Horizon to coincide with the bar by turning the knob marked "CLIMB".

7. Move the engaging lever to the "ON" position slowly as far as it will go and the automatic pilot will take over the controls. While doing this keep the airplane under manual control until the automatic pilot synchronizes with your manual control. This is necessary to avoid a violent leveling out of the airplane in case you have let a wing down, climbed or turned off course between the times at which you set the automatic control indicators and engaged the pilot. It requires approximately twice the normal power on the manual controls to overpower the automatic pilot.

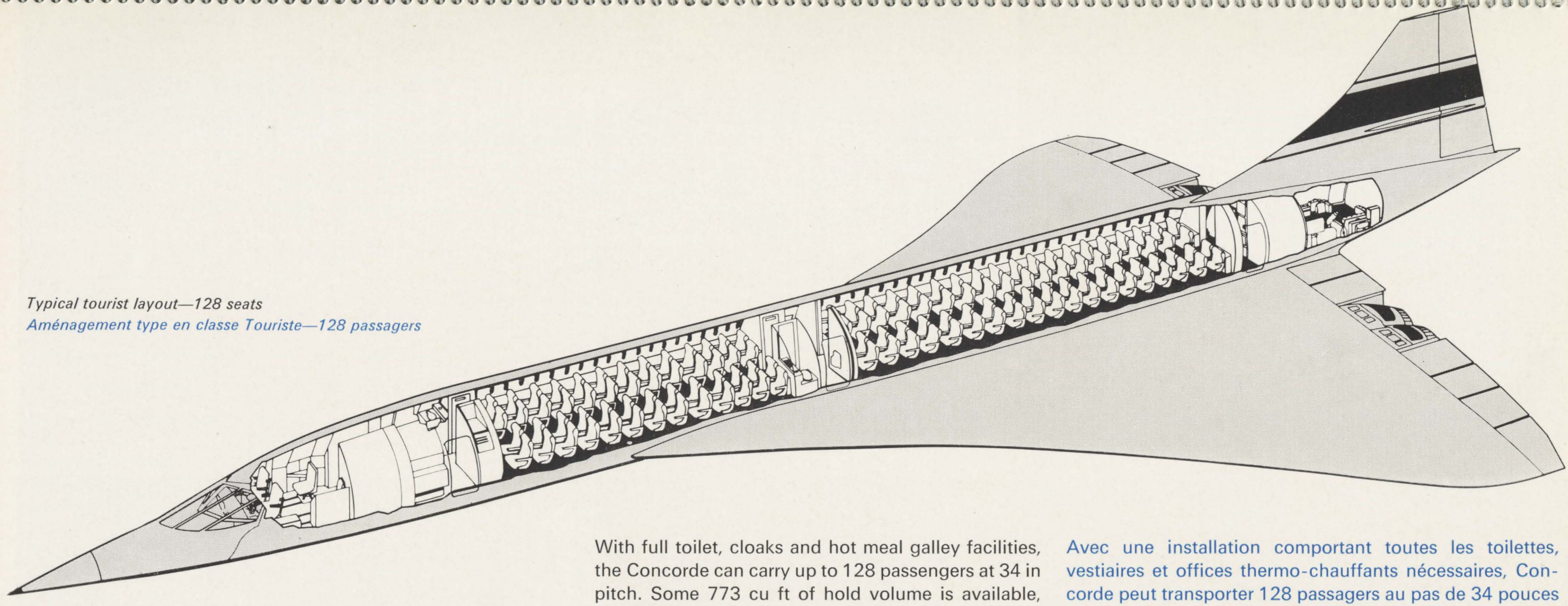
8. Turn the knob marked "LEVEL" in the "ON" direction as far as it will go. This will keep the airplane at the altitude the airplane is flying when the control is cut in. Before changing altitude release this control by turning the knob in the off direction.

9. Flat turns may be made for small directional changes by rotating the knob marked "TURN" in the appropriate direction. Correctly banked turns are made by rotating the knob marked "BANK" in the appropriate direction. (Any angle of bank up to 40 degrees is possible) and then rotating the "TURN" knob at a rate to keep the ball bank centered. Spiral climbs or dives can be easily made by turning the knob marked "CLIMB" in the appropriate direction.

10. The "CLIMB" knob is used for changes in altitude.

11. If the automatic pilot fails to control or acts sluggish, one or more of the following will probably be the cause:

(a) Engaging lever is not fully on.
(b) Oil supply is low.
(c) Oil pressure is too low.
(d) Vacuum is under 3 1/2" mercury.
(e) Gyros are still caged.



Typical tourist layout—128 seats

Aménagement type en classe Touriste—128 passagers

With full toilet, cloaks and hot meal galley facilities, the Concorde can carry up to 128 passengers at 34 in pitch. Some 773 cu ft of hold volume is available, sufficient for all passengers' baggage and in addition a substantial payload of mail.

The three doors on each side are classed as Type 1 emergency exits. The left forward and left mid-fuselage doors are designed for use as passenger doors and the rear left door as a service door. On the right side, the forward and mid-cabin doors are used for galley and cabin service, the rear door being required only as an emergency exit. In the event of an airport emergency it will be possible to evacuate a full complement of passengers within the 90 seconds specified by the airworthiness authorities. Satisfactory tests have already been carried out under realistic conditions in the full-scale Concorde mock-up.

Avec une installation comportant toutes les toilettes, vestiaires et offices thermo-chauffants nécessaires, Concorde peut transporter 128 passagers au pas de 34 pouces (0,86 cm). Un volume utilisable de quelque 22 m^3 est alors réservé aux bagages, et il est également possible d'emporter un important chargement de poste.

Les trois portes ouvrant de chaque côté de la cabine sont classées comme sorties de secours de type 1. Les portes avant gauche et centre gauche sont destinées aux passagers, la porte arrière gauche étant réservée au service. Sur le côté droit la porte avant et la porte centrale sont destinées au service hôtelier, la porte arrière servant uniquement d'issue de secours. En cas d'urgence, il sera possible d'évacuer tous les passagers dans le laps de temps de 90 minutes imposé par les règlements de sécurité. Les essais effectués dans des conditions réelles, en utilisant la maquette en vraie grandeur de Concorde, ont été très satisfaisants à ce sujet.