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PACMIRS AIR TRANSLATIONS NO 8

OPERATING INSTRUCTIONS ON THE KI 84 /FRANK/ JAPANESE FIGHTER PLANE

(Doc 1578 - Sections 1 to 6)

SUMMARY

This is a translation of six sets of mimeographed instructions on the KI 84.

The first and longest is a 48-page pilot's guide to the plane. It gives detailed instructions on how to fly the plane, and how to operate its controls and other apparatus, under varying conditions.

The pilot's guide is followed by four leaflets of one to two pages each. They contain miscellaneous instructions and data, such as the prevention of excessive oil temperature, keeping the switch panel dry and precautions in handling the controls, as well as the plane's operational radius when carrying special equipment.

The final item is an 11-page manual prescribing a number of additional rules and regulations to be observed in operating the plane.

These instructions originated from different agencies. All six sets appeared in 1944. With one exception, they were labeled as reprints issued by AKENO air units.

Pages 1 through 48

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COMPLETE TRANSLATION

(TN: Additional sections of this document are being translated on lower priorities. Certain performance data tables in Section 1 below have already appeared in ADVATIS Translation 92. They are included in this report for the convenience of the reader.)

OPERATING INSTRUCTIONS ON THE KI 84 /FRANK/ JAPANESE FIGHTER PLANE

TABLE OF CONTENTS

Section 1. PILOT'S HANDBOOK FOR KI 84 (Provisional Draft)

Army Air Examination Department
Reproduced by AKEEO Army Air School
1 Jun 1944

INTRODUCTION

1. To obtain the best performance possible, every part of the airplane was built with precision workmanship.

Because this plane must frequently be operated under rigorous conditions requiring skill, the pilot must have an intimate knowledge of its construction, performance, and maintenance. Above all, he must have an adequate knowledge of its characteristics.

By skillful piloting and completely efficient control, the pilot should realize the full performance potentialities of the plane, and at the same time protect and preserve it.

2. A serious and common error is for trainees to believe that merely learning how to fly qualifies them as pilots. Only after construction, performance and maintenance have been mastered does excellent piloting result. Therefore, in training for this plane, which is comparatively easy to pilot, it is essential to emphasize to the trainees the importance of techniques both in the air and on the ground.

I. METHODS OF HANDLING

A. Controls

1. Adjustment of Rudder Bar Position

a. To shorten the distance to the rudder bar position, turn the pedal adjustment, located at the center of the rudder bar, to the right.

b. To lengthen the distance, turn the pedal adjustment to the left.

c. The full travel of adjustment, from front to rear, is 60mm. One rotation of the adjustment wheel produces a travel of 16 mm.

2. Flap Control

a. At take-off, lower the flaps to 15° open, by releasing flap lock and moving the control 15° from "full close".

b. In landing, lower flaps to 30° open, by releasing flap lock and moving the control to 30° from "full close".

c. To raise flaps to "close" position, release the lock and move the control to "close".

d. In shifting the flaps from 15° open to 30° open, or vice versa, the control must be moved quickly to the desired position, since in this operation the flaps close for a moment and the plane loses considerable altitude.

e. Limitation on speed with flaps set:

(1) At 15° - under 270 km/hr

(2) At 30° - under 250 km/hr

f. On the following occasions, whether on the ground or in flight, manipulate the control as described in previous paragraphs and operate the hand pump:

(1) When the engine stops

(2) When trouble occurs in the engine hydraulic pump

g. In flight, operate the hand pump. To lower flaps 30°, operate the hand pump 60 times (both forward and return).

h. When operating the flap control, carefully check the flap lock by pulling the handle once. If the flap lock is not secure, the flaps may close. This is especially dangerous at low altitudes. Therefore, make certain that the flap control is secure.

i. When the flaps open, the stick moves forward considerably.

3. Method of Operating Trim Tabs

a. When the plane is tail-heavy, turn the trim-tab control to the left.

b. When the plane is nose-heavy, turn the trim-tab control to the right.

c. One turn of the trim-tab control moves the tab approximately 2.5°.

d. The following table gives the general standards in trim-tab control.

	WEIGHT (Kg)	CENTER OF GRAVITY (%)	STANDARD TAB ANGLE USED
Take-Off	3,300-3,400 3767 3,900-4,000	25.4-26.1 26.6 28.4-29.0	0° Lower 2° Lower 3°-4°
Landing		Above 25.0 Below 24.0	Raise 5° Raise 12°
Cruise			Set so that level flight is possible without using hands.
Combat			Lower if possible to 5°.

e. Perform the trim-tab operation swiftly, using the palm of the hand against the control wheel.

B. Power Equipment

1. Engine Operation

Refer to the second part of this handbook - Piloting Methods.

2. Propeller Operation

a. Turn on the power supply switch.

b. Turn on the propeller switch.

c. To set the propeller at constant pitch, either high or low, throw the propeller control switch to "high" or "low" pitch position respectively.

d. In employing constant speed, set the propeller control at "constant speed", and place the propeller lever (propeller governor control) at the necessary rpm.

e. The change-over from "constant speed" to fixed pitch", and vice versa, is best accomplished by shifting the propeller-control switch accordingly.

f. To stop a change in pitch, open the propeller switch on the propeller control panel.

g. When operation at constant speed is not possible because of damage (propeller lever no longer controls rpm), the necessary rpm must be obtained by means of the propeller control.

h. Should the electric drive cease because of a failure in the wiring system, the pitch position of the propeller will immediately become fixed.

i. Poor mixture conditions in the engine will frequently cause hunting. It is essential to take precautions in regulating the mixture.

j. When the engine stops and it becomes necessary to glide, it is best to throw the propeller control into "high pitch" and glide with the propeller pitch at extreme "high".

3. Fuel Valve Operation and Use of Fuel Tanks

a. The five-way changeover valve is switched to any of the following positions; fuselage tank, port wing tanks and starboard wing tanks or to port and starboard wing tanks in combination

b. Except when it becomes necessary to cool the fuel, the fuel-cooler fourway valve is closed.

c. To use the wing and fuselage tanks, set the three-way valve at "wing and fuselage tanks". To use the jettisonable tanks, set the three-way valve at "auxiliary tank" (the center position). Do not use "closed" position during usual operation except in special cases.

d. Avoid sudden or jerky movements when operating the changeover valve. The changeover valve should be operated smoothly. Under operating conditions, the position of the handle should coincide with the indicator needle at each given position on the dial.

e. After entering the plane, it is absolutely essential to test the operation and performance of each fuel valve.

f. Upon installation of the jettisonable tank, conduct a ground suction test and check performance.

g. When using fuselage and wing tanks during cruising, it is possible to continue operation four to five minutes after the fuel gauge

warning light has gone on. It is advisable to perform the changeover when the fuel pressure guage needle begins to fluctuate considerably.

h. Because the jettisonable tank is not equipped with fuel guages, it is necessary in using one to calculate the flying time roughly from the altitude, rpm and manifold pressure. When the fuel pressure guage begins to fluctuate, there is scarcely any fuel remaining. Therefore, lose no time in making the changeover.

i. When using maximum horsepower, the consumption of fuel is high. Therefore, carefully observe the fuel-pressure guage, and make the changeover while there is still a reserve of fuel in the tank.

j. Should the changeover not be made in time and the engine fail, immediately perform the changeover and operate the wobble pump.

k. Exercise care when using port and starboard tanks in combination, since frequently the fuel in one tank will be consumed more rapidly than in the other.

l. When the fuselage and/or the jettisonable tanks are filled to capacity, frequently some fuel will overflow from the wing tanks during flight. Therefore, it is necessary to change over to the wing tank which is overflowing, and use this fuel for several minutes.

m. In refueling, first fill the main wing tanks, then fill the leading edge tanks.

n. Utilizing fuel tanks according to the following instructions is advisable.

(1) Refueling equipment

Item		Order of Use 1	2
Tanks		Wing Tanks	Fuselage Tank
Valve Positions	5-way Valve	Port and Starboard Wing Tanks in Combination	
	3-Way Valve	Open (Outgoing Trip)	Open (Return Trip)

2. Jettisonable tank equipment

Item	Order of Use 1	2	3
Tanks	Jettisonable Tank	Wing Tanks	Fuselage Tank
Valve Positions 5-Way Valve	Port and Starboard Tanks in Combination	Port and Starboard Wing Tanks in Combination	Fuselage Tank
3-Way Valve	Auxiliary Tank	Open	Open

Remarks: During ground test run and take-off use the wing tank. However, during ground test run, it is necessary to conduct a suction check on the jettisonable tank.

4. Operation of Auxiliary Pressure Pump

a. Always place the auxiliary pressure changeover valve at "off" position.

b. When the fuel pressure decreases or the needle fluctuates, and the engine is not operating smoothly, it is possible that vapor lock has occurred. In this case, switch to "increase pressure".

5. Operation of Engine Priming Equipment

a. Place the selector switch on "inject".

b. Injection is carried out by means of the hand-primer pump.

c. Immediately after priming, close the selector switch.

d. Set the pump handle.

e. When using special winter grade fuels, first place the selector switch at "carburetor" position and then carry out the above instructions.

6. Operation of the Hand-Wobble Pump

When starting the engine, or during an emergency, operate the hand-wobble pump with full strokes. Avoid sudden swift movement; operate smoothly.

Should the flow of fuel fail during cruising because of damage to the fuel pump, operate the hand-wobble pump at the approximate rate of 15 strokes per minute. Should the failure occur while operating at military horsepower, pump at the rate of 50 strokes per minute. (A stroke includes both forward and return movements.)

7. Operation of Fuel Cooler

When there is a possibility of vapor lock, switch the fuel cooler 4-way valve to "open".

8. Operation of the Oil Cooler

a. The oil cooler should be controlled so as to keep the oil at the specified temperature.

b. The oil shutter can be switched to five different positions: full open, 3/4 open, 1/2 open, 1/4 open, full close.

c. During dives, cold weather or emergencies, if the shutter opening is too great, the oil temperature will drop excessively and the viscosity of the oil at the center of the cooler will increase considerably. This will interrupt circulation. On the other hand, if the temperature rises, the difference in oil temperature at inlet and outlet decreases. When cruising with a less than normal oil temperature, allow the shutter to remain less than half open. At this position the difference in oil temperatures is approximately 15° C. The shutter should be approximately three-fourths open during climbs at normal or military horsepower, regardless of atmospheric temperature. This will produce a difference of approximately 30° C between inlet and outlet temperature.

9. Operation of Dust Filter

When the dust filter is needed because of sand and dust, place control lever on "dust filter".

b. When the dust filter is in use, the air-intake volume decreases, thus decreasing the manifold pressure.

10. Carburetor Air Heater

a. When there is a possibility of the carburetor freezing, switch the control lever to "heater".

b. When the carburetor heater is in operation, the manifold pressure falls.

11. Operation of Jettisonable Tank

a. Pull the control handle to drop tank.

b. Drop tank at an onspeed less than 350 km/hr.

C. Hydraulic Pump Equipment

1. Hand Hydraulic Pump Operation

a. Use the hand pump under the following conditions:

(1) Ground check

(2) When engine stops

(3) When the engine hydraulic pump fails

b. The first ten strokes in the operation of the hand pump are extremely easy. It seems as though there is hardly any reaction. As the hydraulic pressure builds up, the action becomes more difficult.

It is necessary to build up an extremely high pressure when retracting the landing gear and lowering the wing flaps. During these operations, the resistance increases proportionately with the increase in air speed. This requires a greater hydraulic pressure. Therefore, to perform these operations, reduce air speed as much as possible. In this way, less pressure is required.

Since the lowering of the wing flaps and the retracting of the landing gear take place at comparatively low altitudes, it is essential to give undivided attention to these functions so that control of the plane will not be lost.

c. The following table gives rough standards for operating the hydraulic hand pump.

	Speed (Km/Hr)	No of Strokes (Approximate) of Hand Pump
Extending Landing Gear	300	20
Retracting Landing Gear	250	80
Lowering Flaps to 30°	250	40
Raising Flaps to 15°	250	30

2. Two-Way By-Pass Valve

a. When engine speed is less than 1,220 rpm, the two-way by-pass valve should be at "open".

b. When engine speed is more than 1,200 rpm, this valve should be at "closed".

c. Should the pressure at the engine hydraulic pump outlet increase above a specified point when the engine is operating at low speed, the pump will overheat, and a breakdown of the pump drive shaft is likely. To avoid this, open the two-way by-pass valve.

d. When the engine stops, make sure that the two-way by-pass valve is open.

e. During cruising, it is best to leave the valve open, unless it is necessary to close it.

3. Performance of the Hydraulic Oil System

a. When the hydraulic system is in perfect condition, the pressure gauge will register as follows.

(1) When the two-way by-pass valve is closed, the indicator needle gradually moves away from zero (toward increased pressure) to 65 kg/cm^2 and suddenly falls to zero. The regulator valve clicks.

(2) When the landing gear, wing flap and cowl flaps are set in operation by means of their controls, the pressure increases, indicating the required pressure for some period of time. When the operation is completed, the indicator needle rises to 65 kg/cm^2 and suddenly falls to zero. The regulator valve clicks.

(3) When the hydraulic system is not being used, the needle indicator is always at zero.

b. When the hydraulic system is in imperfect condition, the indicator needle displays the following characteristics.

(1) The pressure relief valve is continually in motion. Under these conditions, if necessary, flight should be made with the two-way by-pass valve at "open". Do this only when operating the hydraulic system.

(2) Even when the various controls are put into operation, they do not always work perfectly. When this occurs, the pressure relief action is premature. The ensuing unsatisfactory pressure regulation requires use of the hand pump.

(3) When the various controls are not operated, the pressure rises and is not regulated. Under such conditions, open the two-way by-pass valve, and close it only when necessary.

(4) When the various controls do not respond perfectly, and the pressure is being regulated to 65 kg/cm^2, the indications are that the hydraulic system is operating normally but that the landing gear, wing and cowl flaps are not operating smoothly.

c. During cruising, it is necessary to observe the hydraulic pressure gauge in the same manner as the other instruments.

D. Landing Gear

1. Operation of Landing Gear and Tail-Wheel Indicator Lights

a. Turn on switch No 4 on the electric switch panel.

b. Depending upon the degree of light or darkness, use the switches marked "day" and "night" respectively.

2. Operation of Landing Gear and Tail Wheel

a. Retracting the landing gear

(1) When the cam which sets the landing gear control handle at "retract" is disengaged, the green light goes off.

(2) When the landing gear is completely up, the indicator lights turn red, and the landing gear mechanical indicators are retracted.

(3) When the engine stops or the hydraulic pump breaks down, operate the hand pump until the indicator lights turn red.

(4) When the landing gear fails to retract fully into the wheel wells, either because of friction at the well or because of an unsatisfactory hydraulic system, operate the hand pump or reextend the landing gear. At the same time, reduce air speed as much as possible before retracting the landing gear again.

(5) Retraction of landing gear should be undertaken at an airspeed of less than 250 km/hr. When air speed is high resistance increases, and it is difficult to get the wheels up.

b. Extending the landing gear

(1) Set the landing gear control handle at "down", with the trip lock to the inside. This prevents the handle from shifting back.

(2) When the landing gear is completely down, the indicator lights turn green, and the yellow part of the mechanical indicator rises above the wing surface.

(3) When the engine stops or the hydraulic pump breaks down, operate the hand pump until the green light goes on.

(4) During flight, the landing gear sometimes will not extend even when the hand pump is operated, because of a breakdown in the hydraulic system. In this case, place the control handle at "down", and rock the plane from left to right. The weight of the wheels alone should cause the landing gear to extend.

(5) Extend the landing gear at an air speed less than 350 km/hr.

c. Precautions

(1) When raising and lowering the landing gear, it is essential to place the control handle cam in the different positions accurately.

(2) When the landing gear and tail-wheel signal indicator lights are red or green, it signifies the completion of the retracting or extending operation. At any other time during the operation, the indicator lights are off.

(3) When landing under conditions in which the landing gear and tail wheel have not fully retracted or extended, a warning signal sounds as soon as the landing flap reaches the 30° open position.

(4) When the cable is slack and the cam is locked prior to lowering the landing gear, the landing gear will not extend even though the hydraulic pressure increases. Therefore, pull the cable and release the cam. At this point, the landing gear will descend of its own weight if the plane is rocked several times.

3. Brake Adjustment

Brakes must be adjusted at once when:

a. They take effect too suddenly and grab.

b. They do not take hold.

c. They are not equalized, or only one takes hold.

d. The brake shoes do not retract properly from the brake drum, or do not retract at all, and the brakes lock.

When the brakes are properly adjusted, they will keep the plane from moving on a runway (grass) with an engine speed as high as 2,600 - 2,900 rpm.

E. Instruments

1. Pitot Electric Heater

When there is a possibility of the pitot tube icing up, turn on the pitot electric heater switch.

2. Air Speed Indicator Drainage Device

During flight through rain or snow, or when water or sand enters the pitot tube, operate the air speed indicator drainage device.

3. Artificial Horizon

a. Operational procedure

When the valve is turned on, the artificial horizon will become settled within a few minutes. In order for the valve to operate fully, the changeover from "on" to "off" should be repeated fairly frequently.

b. Procedure for stopping

The artificial horizon will cease operating within a few moments after it is turned off /caged/.

c. During landing, take-off, taxiing, combat and other intensive operations, the artificial horizon must be caged.

d. The setting of the valve on "off" and "on" must be exact. It is not advisable to set it in between.

e. Because the life of an indicator is the gyro, avoid vibration, shock and dust accumulation.

4. Fuel Gauge

a. Switch from wing tanks to fuselage tank and vice versa by means of the selector switch.

b. The fuselage tank indicator is calibrated from 0 to 190 liters, and the wing tanks from 0 to 130 liters.

c. When the amount remaining in each tank is less than ten liters, a red light on the fuel gauge goes on.

d. Only the indicated positions on the selector switch will effect the drawing of fuel from the tanks. Therefore, it is necessary to place the switch accurately on the indicated positions.

e. When not in use, the selector switch should be in the "off" position.

5. Oil Temperature Gauge

a. Oil temperature is taken at engine inlet and outlet.

b. When the instrument switch on the switch panel is turned off, the needle will register 90° C.

c. Note that the oil temperature gauge will register approximately 4° to 5° C higher when operating at low engine speed.

6. Cylinder Temperature Gauge

a. The No 1 temperature gauge shows temperature of the fourth cylinder in the front row.

b. The No 2 temperature gauge shows temperature of the fourth cylinder in the rear row.

F. Firing and Bombing

1. HO 103 /Type 1 Fixed 12.7 Modified Browning Type/

a. Charging

(1) Turn on each switch controlling the electrically driven hydraulic charging system.

(2) Pull out the fuselage gun valve handle as far as possible, and release. The handle will then return by itself in two or three seconds. If it does not return, turn the handle 90°. It should then return. If it still does not, then push the handle.

(3) Push the button on the end of the control lever. Then the control lever will return to place with a click.

(4) Preparations for firing are then complete, except for repeating the operation in paragraph (1).

(5) Procedure to be followed when the electrical system fails

(a) Turn off the electrical system

(b) Pull out charging-valve handle. It will not return.

(c) Turn this handle 90° to the right and push.

(d) Push the button.

(e) Turn the handle 90° to the left.

(f) Repeat steps (b) and (c).

b. Firing

(1) Turn on the firing switch.

(2) Release the safety on the control lever. Push the button. The button makes dual contact.

(3) Even though the hydraulic system fails during firing, it is possible to continue firing if the electrical system is perfect.

(4) When the charging system breaks down or the guns jam because of damage, pull the charging valve.

2. HO 5 [20 mm Fixed Wing Gun, Record Type]

a. Charging

(1) Turn on firing and charging switches

(2) Pull the wing gun changing-valve handle twice. Note the impact.

(3) When the electrical system fails, the procedure is the same as in the case of HO 103. However, there is no necessity to push the handle.

b. Firing

(1) The procedure in firing is the same as with HO 103, except that it is done by means of the handle and the handle makes a single contact.

(2) When the charging system breaks down or the guns jam because of damage, pull the charging valve.

3. Reflector Sight

a. Turn on the firing switch.

b. In order to adjust the reflected light, turn the lower button to the right for "increase light" and to the left for "decrease".

c. To exchange the bulb, press the button on the lower left side, open and replace.

d. To adjust the anti-glare plate, press the button on the left side and raise or lower.

4. Bombing

a. Turn on the bomb control switch. The indicator light will go on.

b. Press the dual contact button on the throttle lever. At contact 1 the safety lock is released, and at contact 2 the bombs are dropped. When

the bombs have dropped, the indicator light goes off.

5. Gun Camera

a. Turn on the counter button and set the needle at 50. The green indicator light goes on and preparations for photographing are now complete.

b. Procedure for taking pictures is the same as that for firing wing guns.

c. The green indicator light goes off during the picture taking. The counter turns, and the needle indicates the amount of film remaining.

d. When all of the film has been exposed, the needle in the counter points to zero, and the green light goes off.

G. Electrical Equipment

1. Cockpit Light

a. Turn on the No 4 illumination switch

b. Turn the rheostat, which is at the end section of the light control, to the right to increase illumination, or to the left to decrease.

c. To adjust the light, lossen the flexible coupling.

2. Portable Lights

a. Turn on No 4 illumination switch.

b. Operate the lights with the switch at hand.

3. Ultraviolet Light

a. Turn on the No 4 illumination switch.

b. Turn on the No 4 power-supply switch on the ultraviolet light control panel.

c. Push the button on this panel for two or three seconds. Repeat if the ultraviolet light does not light.

4. Landing lights

a. Turn on No 3 landing-light switch

b. Turn off landing lights while on the ground. If left on, the landing light covering will burn. Further, if the engine is stopped, the storage battery will be exhausted.

5. Identification Lights

a. Turn the identification light switch to "bright" or "dim". "Bright" is approximately three times stronger than "dim".

b. To blink the identification lights for signalling purposes, press the signal button switch.

c. The light is always "on". When the button is pressed, the light goes off.

H. Communication Equipment

1. Operation of HI 3 Radio

a. Insert the transmitter-receiver plug in the junction box.

b. Turn on the radio switch.

c. Set the remote control unit handle at "CW" or "Voice".

d. Push in the telegraphic key, which is at the end of the lever controlling voice transmission, and leave in this position.

e. Transmit the message with this key.

f. When changing the frequency, switch the remote control unit to "change".

I. Cockpit Equipment

1. Operation of Cockpit Canopy

a. To open or close the canopy, turn the handle, pulling it toward the inside of the fuselage.

b. When finished turning, lock the handle at the desired notch.

c. The canopy must be kept open when visibility is poor -- during landing, take-off, taxiing, rainy weather or night operations.

d. For emergency opening, raise the emergency release handle 90°. The handle is released after it passes above the pilot's head.

2. Oxygen Intake

a. Loosen the upper knob controlling the valve.

b. Loosen the knob on the automatic regulator valve.

c. To use the electric heater, turn on the heater switches, located in the rear section of the junction box and in the switch panel.

3. Cockpit Ventilation Equipment

Set at half open or full open, according to degree of ventilation desired.

II. PILOTING METHODS

A. Starting, Ground Test Runs and Stopping

1. Preparation for Starting

a. Make certain the ignition switch is off.

b. Check the landing gear and wing flaps, and open the by-pass valve.

c. Check the performance of the control equipment and cockpit canopy.

d. After checking the performance of the fuel changeover valve, switch the valve to the tank which is to be used.

e. Open the cowl flap and oil-cooler shutter, except in cold weather.

f. Turn on the following switches: switch panel, power supply, instruments, propeller, starting.

g. Advance the throttle 10%.

h. Set the pitch lever at "high".

i. Set the automatic mixture control at "normal".

j. Move the 1st - 2nd speed blower control all the way, and after checking the performance of each, put at 1st speed position.

k. Place the emergency stopping lever at full rich position.

l. Set the boost override control at "normal".

m. Prime the engine.

(1) When the air temperature is less than 5° C and the engine is cold, prime the engine three or four strokes while the propeller is turned by hand.

(2) When the air temperature is above 5° C, use the acceleration pump instead of priming, slowly opening and closing the throttle, and at the same time having the propeller turned by hand.

n. The ground crew will turn the propeller approximately ten times. To supply oil to the nose of the engine, the ground crew will operate the pump approximately 400 times (TN: pre-oiling).

2. Starting

a. Inertia starter

(1) The ground crew will turn the inertia starter, and at the signal "contact", the clutch will be engaged.

(2) Wait until the propeller makes a half turn. Then press on the starter button, throw the ignition switch on "both" and wait for starting.

(3) When the engine starts, immediately check the oil pressure gauge. If the oil pressure does not rise within 20 to 30 seconds, stop the engine at once.

(4) After the engine starts, turn off the starting switch.

b. Starting truck

(1) Wait until the propeller turns several times. Then press the starter button (TN: Pencilled notation indicates the operation to be unnecessary). Place the ignition switch on "both", and await starting.

(2) Remaining procedure is the same as in c and d of paragraph 1 [Preparation for Starting].

c. Precautions

(1) When starting the engine with the inertia starter, turn a

sufficient number of times (80 to 100 per minute). If the inertia starter is not turned sufficiently, the engine will not start.

(2) Prevention of backfiring

The secret of starting lies in the carburetor. When the mixture control is not opened wide enough or is opened too wide, the engine will backfire. In operating the mixture control during starting, it is essential to open slowly and close quickly.

(3) After starting, check whether firing is regular by observing the manifold-pressure gauge. That is, if the needle moves in the direction of "0", firing is irregular. If the needle is stable or is moving toward "minus", firing is regular.

3. Starting Operation

a. Warm-up

(1) Check the fuel, methanol and oil pressures, and other items.

(2) Place the pitch lever at "low".

(3) Open the throttle gradually and regulate for warm-up speed.

(4) Continue warm-up operation until the oil temperature at inlet is above 40° C.

(5) After starting, keep strictly to the following schedule of engine speeds, which will lengthen the life of the engine considerably:

500 - 600 rpm	- About 1 minute (imperative)
800 - 1,000 rpm	- Approximately 3 minutes
1,200 - 1,300 rpm	- Until oil temperature at inlet is 40° C.

b. Check period

(1) Compression check

(a) Place blower control at 1st speed.

(b) Check methanol pressure.

(c) Open the throttle to +250 mm (military). Check for engine smoothness, and at the same time check the manifold pressure. This should be carried out within 30 seconds.

(d) When it is especially necessary, push the boost override control gear, open the throttle and check on whether the manifold pressure is at +400 mm (take-off).

(e) Methanol begins to flow at a manifold pressure of +125 mm. At military horsepower, it will consume approximately 150 liters. When methanol is not injected and the manifold pressure is increased above +125 mm, the cylinders will overheat. If the engine is kept running when the methanol is exhausted, the methanol pump will burn out. Therefore, care must be exercised.

(2) Ignition system check

When the manifold pressure is -100 mm to ±0 mm and the engine speed is 2,000 - 2,300 rpm, turn the magneto switch to "left" and to "right" from "both". The differences between the engine speeds at "left" and at "right", and that at "both", must be less than 30 to 40 rpm.

(3) Acceleration

After a sufficient warm-up, accelerate the engine.

(4) Check blower changeover (when necessary).

(a) Do not go into 2d speed on the ground except when checking changeover.

(b) Before repeating the changeover operation, allow approximately a one-minute interval.

(c) When carrying out the changeover, the blower control must not be stopped enroute, but must be shifted quickly either to 1st or 2d speed position.

(d) The changeover must be conducted at an engine speed under 2,200 rpm and a manifold pressure less than ±0.

(e) The changeover must be conducted with the oil temperature between 45° and 75° C, and carried out in less than 3 seconds.

(5) Propeller check

(a) Check the propeller control for change from high to low pitch and reverse.

(b) Place the propeller control at constant speed, and operate the pitch lever to check governor performance.

(6) Hydraulic system check

Advance the engine speed above 1,200 rpm, close the by-pass valve and check performance of wing and cowl flaps.

(7) The following table shows what the instrument readings should be during the ground test run and during flight, if the condition of the engine and parts essential to its operation is satisfactory.

ITEM	CONDITIONS	INSTRUMENT READING
Oil Pressure Changeover to 2d Speed	More than 1,500 rpm Maximum Standard Minimum	 12.0 kg/cm² 11.0 kg/cm² 10.0 kg/cm²
Fuel Pressure	Maximum Standard Minimum	0.35 kg/cm² 0.30 kg/cm² 0.25 kg/cm²
Methanol Pressure	Maximum Standard Minimum	0.9 kg/cm² 0.8 kg/cm² 0.8 kg/cm²
Oil Temperature (At Inlet)	Permissible Maximum 30-Minute Maximum Cruising Permissible Minimum	85° C 60°-70° C 40° C
Cylinder Temperature	Permissible Maximum 30-Minute Maximum Cruising Permissible Minimum	230° C 200° C 70° C
Rpm and Manifold Pressure	Take-off and in Emergency (one minute) Military (less than 30 minutes) Normal (longtime operation) Cruise Permissible maximum	2,900 rpm +400 2,900 rpm +250 2,600 rpm +100 1,800 - 2,000 rpm -100 to -200 3,200 rpm -200

(8) Precautions

(a) Vibration occurs in this engine at 1,400 - 1,600 rpm.

(b) High-pressure tests must be conducted in as short a time as possible.

(c) Cylinder temperature during the ground test run is generally under 200° C.

(d) On the ground, the temperature of the rear cylinder row is higher than that of the front row.

c. /Miscellaneous Table on Starting Operation/

Instruction	Conditions	Suggested Procedure
Before starting, turn propeller by hand.		Approximately 10 times
Before starting, supply oil to the nose.		Approximately 400 times
Warm-up		1. 500 - 600 rpm for 1 min 2. 800 - 1,000 rpm for 3 min 3. 1,200 - 1,300 rpm
Oil Pressure Main Oil Pressure	More than 1,500 rpm Maximum Standard Minimum 500 - 700 rpm	 8.0 kg/cm^2 7.0 kg/cm^2 5.0 kg/cm^2 2.5 kg/cm^2

4. Stopping

a. Following is the procedure for stopping the engine.

(1) Cool the engine until the cylinder temperature is less than 130° C. Never stop the engine when the cylinder temperature is above 130° C.

(2) Close the throttle, press the emergency stopping lever all the way down and stop the engine.

(3) After the engine has stopped and the remaining mixture has been ignited, turn off the ignition switch and the power-supply switch.

(4) After stopping the engine, allow the cowl flaps to remain full open. Except in special circumstances, never stop the engine by shutting the fuel valve.

b. To be ready for the next flight or an emergency mission, the following steps must be taken after the engine is stopped.

(1) Set the pitch lever at "high".

(2) Set the emergency stop lever at "full rich".

(3) Close the by-pass valve.

(4) Turn the fuel valve to the full tanks.

(5) After flight, set the elevator tab at "0".

B. Taxiing

1. Before beginning to taxi, the pilot must make the following checks and adjustments, to simplify control at take-off and to avoid errors.

a. Adjust cowl flaps and oil cooler shutter as specified (normally "full open").

b. Check the radio.

c. Check oxygen-mask equipment.

d. Adjust elevator tabs as specified.

e. Set the tail wheel at "free".

f. If necessary, turn on dust filter.

2. Exercise great care when taxiing because the forward field of vision is poor.

3. Check brake performance during taxiing.

4. When taking off with a jettisonable tank, select the runway carefully, since the space between the tank and the ground is small.

C. Take-off

1. After facing the plane in the take-off direction, carry out the following steps:

a. Adjust the cowl flaps as specified (full open except in winter, when flaps should be half open).

b. Adjust the pitch lever to 2,900 rpm.

c. Fix tail wheel.

d. If necessary, pull the boost override control gear.

e. If necessary, adjust wing flaps to 15° open.

2. Gradually open the throttle and, as speed increases, continue to open until the manifold pressure reaches +250 mm (if necessary, +400 mm). This operation must not be carried out too swiftly.

3. When gaining momentum, raise the tail section and increase speed.

4. Because there is a large amount of engine torque, keep in a straight line by pressing the right pedal down sufficiently.

5. When a speed of 150 km/hr is reached, slowly pull back the stick and take off.

6. After take-off, do not pull up too quickly, but hold the nose down slightly. When a speed of 250 km/hr is reached, retract the landing gear.

7. Care must be exercised when retracting the landing gear, because there is a tendency, when extending the left hand to grasp the control, to lift the right leg and incline the body to the left side.

8. The landing gear should be retracted after the wheels have been stopped by brake action. Unless the wheels are braked, friction will cause the rubber to burn.

9. When extending the landing gear, allow for sufficient altitude. Moreover, do not extend unless the speed is over 250 km/hr. Avoid retracting the landing gear at low speeds because the plane will lose considerable altitude.

10. When taking off after a long warm-up at low speed, or after taxiing for some time, it is advisable to advance the throttle first. This cleans oil from the spark plugs, increases the flow of fuel and eliminates air bubbles in the fuel system.

11. The following table indicates take-off performance of this plane (no wind).

	RUNWAY			GRASS		
Take-Off Period	approx 15 sec	approx 15.5 sec	approx 15 sec	approx 16 sec	approx 16 sec	approx 16 sec
Take-Off Distance	approx 360 m	approx 310 m	approx 320 m	approx 450 m	approx 390 m	approx 420 m
Indicated Air Speed	approx 150 km/hr	approx 140 km/hr	approx 150 km/hr	approx 150 km/hr	approx 140 km/hr	approx 150 km/hr
Manifold Pressure	+250	+250	+350	+250	+250	+350
RPM	2,900	2,900	2,900	2,900	2,900	2,900
Wing Flaps	0	15°	0	0	15°	0

12. Since a poor adjustment of the pitch control frequently produces an over-speed rpm, watch the tachometer carefully after leaving the ground.

D. Landing

1. When landing, the following procedure must be observed:

a. Extend landing gear.

b. Lower wing flaps.

When the flaps are lowered 20°, the plane will nose down considerably. Therefore, use the tabs accordingly.

c. Set the blower control at 1st speed.

d. Set the propeller pitch lever at 2,900 rpm.

e. Set the automatic mixture control at "normal".

f. Close the cowl flaps.

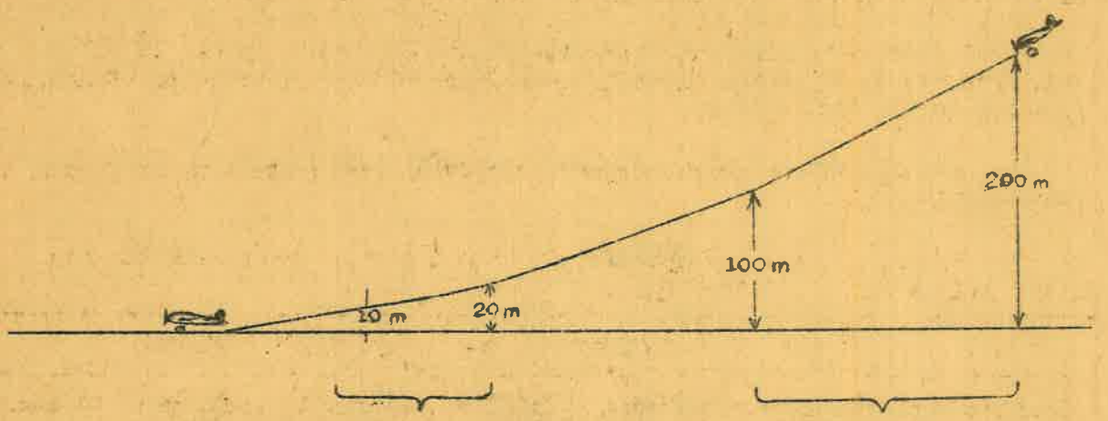
When descending at engine idling speed, the cylinder temperature drops. When necessary to increase cylinder temperature, momentarily advance throttle before landing.

g. Adjustment of the oil-cooler shutter

The oil temperature must not fall below 50° C.

2. When landing, the fourth turn should be carried out at a height above 300 meters.

3. The following diagram gives data on descent and contact with the ground.



V= 135-140 km/hr	V= 130-170 km/hr	V= 200 km/hr
N= 1,000-1,200 rpm	N= 1,400 rpm	N= 1,700 rpm
B= -450 mm Hg	B= -400 to -450 mm Hg	B= -350 to -400 mm Hg

When contact is made with the ground, close the throttle quickly.

4. This plane has good stall characteristics, and is extremely stable when flying at low speed. Further, operation of the wing flaps is quite effective, and makes landing very easy.

5. Because the ground effect at the time of contact is considerable, it is necessary to pull back on the stick.

6. To shorten the taxiing distance, pull the stick all the way back. If necessary, apply the brakes.

7. Having landed, taxied and come to rest, free the tail wheel, open the cowl flaps and close the wing flaps.

8. Precautions when making a second approach

a. Make up your mind quickly while there is still sufficient altitude. A second approach at low altitude is dangerous.

b. When the decision for a second approach is made, take the following steps in this order:

(1) Open the throttle wide.

(2) Should it be necessary to maintain altitude and speed, retract the landing gear.

(3) Set the tabs at 0°.

(4) Close the wing flap at a height above 200 meters and at a speed of more than 230 km/hr.

(5) During landing, the trim tabs are adjusted for the required amount of tail lift. It is dangerous to raise the wing flaps first, for the tail lift will be too great.

9. Precautions in Landing

a. Exercise care in extending landing gear and lowering wing flaps, since the resistance to each is extremely great and produces unstable conditions. Handle the controls carefully. Strictly avoid sudden movement of the controls, and take sufficient care to prevent stalling.

b. When landing, the throttle should be barely open. If a low approach is made with the throttle opened too wide, the field of vision will be reduced.

c. In contacting the ground, carefully avoid stalling or coming in with one wing low.

10. Following is a table indicating the landing performance of this plane with a full load (no wind).

	RUNWAY		GRASS	
Taxiing Period	approx 17 sec	approx 53 sec	approx 15 sec	approx 33 sec
Taxiing Distance	approx 390 m	approx 910 m	approx 370 m	approx 600 m
Landing Speed	approx 135-140 km/hr	approx 135-140 km/hr	approx 135-140 km/hr	approx 135-140 km/hr
Flaps	full open	full open	full open	full open
Brakes	used	not used	used	not used

E. Level Flight

1. Cruising

a. The manifold pressure is reduced under cruising conditions.

b. Set engine speed at "cruising" rpm.

c. Set manifold pressure at "cruising".

d. Set automatic mixture control at "cruising".

e. Close cowl flaps.

f. Adjust the oil-cooler shutter. When the cylinder temperature is high, open the shutter one fourth to one half. When the cylinder temperature is low, set the shutter between one-fourth open and full close.

g. If necessary, adjust the mixture by means of the emergency-stop lever.

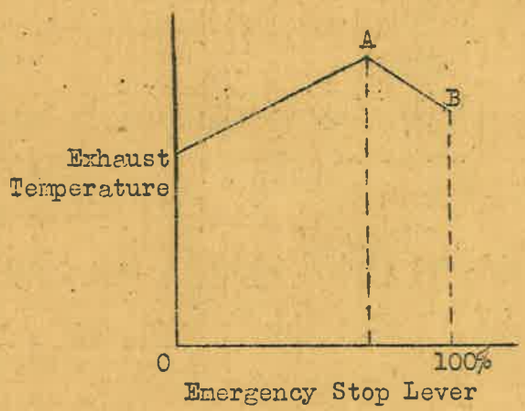
h. Trim the tabs as required so that flight may be controlled without resort to the rudder.

i. When cruising in 1st speed at an altitude less than 5,000 meters, and fully loaded, including jettisonable tank, the engine speed should be 1,900 to 2,000 rpm, and the manifold pressure -150 mm. If above 5,000 meters, use 2d speed. The engine speed should then be 2,200 rpm, and the manifold pressure -200 mm.

j. The propeller of this plane operates within a tolerance of approximately ±25 rpm during cruising.

k. Method of using the emergency-stop lever by regulating the exhaust temperature

When using the emergency-stop lever, there are ordinarily changes in the exhaust temperature, as shown in the diagram which follows. That is to say, when the emergency stop lever is used in conjunction with a fixed power output (constant engine speed and constant manifold pressure), the exhaust temperature rises to point A, which is its maximum. With further application of the emergency stop lever, the temperature reverses and drops off. When it reaches point B, it finally brings about improper operating conditions and causes hunting. Therefore, in this method, A is generally used as the desired point. If it is particularly necessary to obtain the minimum fuel consumption rate, place the emergency stop lever between points A and B. Generally this method is practical only at an engine speed less than 2,300 rpm and a manifold pressure less than 100 mm.



When the engine speed and manifold pressure are fixed, the maximum exhaust temperature varies with the altitude. An altitude difference of 1,000 meters will produce a difference in temperature of 10° to 20°. As altitude is increased, the maximum value for exhaust temperature will decrease. When the engine speed and manifold pressure are high, the maximum exhaust temperature will be higher than when the engine speed and manifold pressure are low. Further, the necessity for using the mixture control lever is increased. The following table illustrates this.

Altitude	3,000	2,000	1,000	3,000	2,000	1,000
RPM	1,900	1,900	1,900	2,000	2,000	2,000
Manifold Pressure	-150	-150	-100	-100	-100	-100
Speed	321	320	315	348	445	340
Exhaust Temperature	700	715	735	710	730	750
Mixture Control Lever	4.0	3.7	3.3	4.2	3.8	3.5
Oil Temperature ° Inlet outlet	62° 78°	64° 80°	65° 80°	62° 78°	64° 80°	65° 80°
Oil Cooler Shutter Opening	1/4	1/4	1/4	1/4	1/4	1/4

Precautions:

(1) Even when the altitude, engine speed, and manifold pressure are constant, the maximum exhaust temperature will differ

according to the fuselage, engine, instruments and atmospheric temperature.

(2) At maximum exhaust temperature, the mixture will vary with sudden changes in atmospheric conditions, causing the engine to backfire.

1. During cruising, it is necessary to take precautions when the carburetor is likely to ice up. If the carburetor ices up, the available mixture is less, the cylinder temperature drops and the engine tends to hunt.

In extreme cases, the engine stops, or the area around the throttle will not function smoothly.

Since icing is apt to occur between atmospheric temperatures of -10° C to +15° C, momentarily open the throttle at such times when necessary, and let the warm air into the carburetor by means of the carburetor air-heat control.

n. Following is a table showing cruising data and fuel consumption of this plane in formation:

	1st Formation			2d Formation			3d Formation		
Pilot	Major	Sgt	Sgt	Major	M/Sgt	2d Lt	Capt	1st Lt	W O
Altitude	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Rpm	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900
Manifold Pressure	-150	-145	-150	-150	-160	-150	-150	-140	-160
Speed	315	323	330	320	328	325	323	315	320
Temperature	±0	± 0	±0	±0	±0	±0	±0	±0	±0
Cylinder 1 Temperature 2	155 120	115 105	120 120	130 120	130 120	100 100	105 100	100 110	120 115
Exhaust Temperature	690	710		680	660	720	680	670	710
Mixture Control	43	37	43	40	44	40	40	36	40
Oil Inlet Temperature Outlet	63 81	64 27	60 78	60 80	70 90	60 75	63 78	62 78	62 75
Oil Pressure	7.1	7.4	7.5	7.3	7.4	7.2	6.8	7.6	6.5
Fuel Pressure	.31	.30	.34	.34	.30	.33	.32	.31	.30
Methanol Pressure	.80	.98	.90	1.00	.70	1.00	.80	.90	.90
Second Speed	11.0	10.0	9.0	10.0	10.0	10.0	9.0	10.5	9.0
Fuel Remaining (Liters)	314	295	310	303	305	310	307	207	306
Fuel Consumption (Liters)	383	402	387	394	392	387	390	400	391
Fuel Consumption rate (Liters/Hr)	152.4	160.8	154.0	157.6	156.8	154.8	156.0	160.0	156.4
Average Fuel Consumption Rate (Liters/Hr)						156.62			

Remarks:

(1) Flight Range: round trip from MITO to AKENO - 850 Km

(2) Time of take-off and landing:

	Take-Off	Landing
1st formation	0829	1059
2d formation	0830	1101
3d formation	0831	1103

(3) The amount of fuel consumed is the total consumed during flight plus the fuel consumed during ground test run, taxiing, climbing and descending.

(4) Hourly fuel consumption rate and the over-all average are obtained by dividing the fuel consumed in the air (take-off to landing) by the total hours.

n. The following table gives cruising range characteristics obtained in the performance of one of these planes.

Altitude	1,000		3,000		4,000		7,000	
Rpm	1,900	2,000	1,900	2,000	1,900	2,000	1,900	2,200
Manifold Pressure	-150 -100	-150 -100	-150 -100	-150 -100	-150 -100	-150 -100	-200 -150	-200 -150
Fuel Consumption (Liters)	132 146	141 155	138 151	152 168	144 158	160 174	142 156	160 174
Indicated Air Speed	338-318 348-330	346-332 358-347	340-321 350-332	351-332 359-348	340-325 349-330	351-334 357-346	297-277 309-288	315-291 327-303
True Air Speed	355-334 366-347	364-349 376-365	395-373 406-385	408-385 417-405	415-398 427-405	430-408 437-424	428-396 445-415	455-420 472-437
Flight Range	1,680 1,570	1,620 1,530	1,670 1,610	1,615 1,510	1,695 1,585	1,575 1,480	1,590 1,520	1,500 1,435
Flight Time	4 hr, 51 min 4 hr, 24 min	4 hr, 33 min 4 hr, 8 min	4 hr, 28 min 4 hr, 4 min	4 hr, 4 min 3 hr, 34 min	4 hr, 10 min 3 hr, 48 min	3 hr, 45 min 3 hr, 27 min	3 hr, 52 min 3 hr, 32 min	3 hr, 26 min 3 hr, 11 min
Remarks	Low Blower		Low Blower		Low Blower		High Blower	

Remarks:

The cruising range is a computed value calculated on the basis of full fuel capacity, with no allowance made for consumption during ground run, climb and descent, or for fuel remaining in the tanks. These fuel items amount to:

For 1,000 meters - 28 liters
For 3,000 meters - 54 liters
For 4,000 meters - 69 liters
For 7,000 meters - 118 liters

When the plane is equipped with a 200-liter jettisonable tank, the indicated air speed of the plane will drop approximately 25 km/hr from the figures given in the table.

When the plane is equipped with two 50-kg bombs, the indicated air speed will drop approximately 15 km/hr from the figures given in the table.

o. Following are the stalling speeds when the plane is fully equipped:

Altitude	Stalling Speed (Km/Hr)	Wing Flaps (Degrees)	Landing Gear	Elevator Tabs	Elevator Tabs (No of Turns)
2,000	165	0	Retracted	0	1200 [sic]
2,000	149	15	Retracted	0	1100 [sic]
2,000	139	30	Retracted	+2	1000 [sic]
2,000	168	0	Extended	0	1200 [sic]
2,000	163	15	Extended	+2	1100 [sic]
2,000	138	30	Extended	+4	1000 [sic]

2. Following is a table of standard maximum speeds during level flight:

Altitude	Indicated Air Speed	True Air Speed	Rpm	Manifold Pressure	Summary
1,000	518	544	2,900	+250	Low Blower
2,000	512	565	2,900	+250	Low Blower
3,000	505	586	2,900	+250	Low Blower
3,370	502	594	2,900	+250	Low Blower High Boost
4,000	488	591	2,900	+185	High Blower
4,900	452	584	2,900	+ 95	High Blower
5,000	454	586	2,900	+250	High Blower High Boost
6,000	448	610	2,900		High Blower
6,550	444	624	2,900		
7,000	426	615	2,900	+200	
8,000	388	594	2,900	+ 95	
9,000	350	569	2,900	+ 40	

Remarks:

Operate the mixture-control lever so that the exhaust temperature will be 680-700° C at low blower and 650-670° C at high blower, and the cylinder temperature 200° C.

F. Climbing and High-Altitude Flight

1. Full-Power Climb

a. Set the automatic mixture control at "normal".

b. Open the throttle to manifold pressure at military horsepower.

c. Adjust the cowl flaps so that the cylinder temperature does not exceed 230° C. Ordinarily the flaps will be fully opened.

d. Climbing speed up to 5,000 meters is 260 km/hr. For each additional 1,000 meters up to 9,000, there is a decrease of 10 km/hr. Thus at 9,000 meters, the climbing speed will be 220 km/hr. However, climbing speed exercises a great effect upon cylinder and oil temperature. Therefore it is necessary to maintain climbing speed in order to prevent too great a rise in oil and cylinder temperatures.

e. Do not use boost override lever.

f. Set the emergency stop lever at "full close". If too much fuel flows in proportion to the climb, the engine will vibrate. When this occurs, adjust the lever accordingly.

g. Changeover from low to high blower should be made at an altitude where the low-blower manifold pressure is +80 mm (approximately 3500 meters). The engine speed should be decreased to 2,600 rpm.

h. The following table shows climb performance for this plane.

Altitude	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000
Climbing Time (min : sec)	1:09	2:28	3:34	4:56	6:26	8:00	9:48	12:28	15:34
Rate of Climb (meters/sec)	14.4	14.3	12.8	11.7	11.0	10.0	8.3	6.3	3.8
Indicated Air Speed in Climb	260	260	260	260	260	250	240	230	220
Manifold Pressure	+250	+250	+190	+250	+250	+200	+100	0	+80
RPM	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900

Ceiling is (TN: figure missing from document).

i. Fuel consumption of this plane when operating at military horsepower is 500 to 550 liters per hour.

2. Normal Climb

a. When it is not essential to climb under full power, it is advisable to climb with engine speed at 2,600 rpm and manifold pressure at +100 mm.

b. In normal operation, change from low to high blower is made as follows.

(1) The changeover altitude should be 4,000 meters (manifold pressure should be approximately +30).

(2) Close throttle to approximately 60%.

(3) Shift from low to high blower. Readjust manifold pressure.

c. Following is a table on climb at normal engine operation.

Altitude	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
Rpm	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600
Manifold Pressure	+100	+100	+100	+30	+100	+100	+20	+100	+180	+310
Speed (km/hr)	260	260	260	260	260	245	240	225	210	200
Exhaust Temperature	720	710	740	750	690	690	680	660	630	560
Cylinder Temperature 1	210	160	160	170	170	180	180	170	160	145
Cylinder Temperature 2	130	140	130	130	130	135	125	120	115	100
Oil Temperature Inlet	52	58	60	62	65	67	70	70	71	72
Oil Temperature Outlet	85	85	88	90	90	92	98	95	95	96
Oil Pressure	7.8	7.5	7.3	7.2	7.2	7.0	6.9	6.8	6.5	6.0
Fuel Pressure	.36	.34	.32	.30	.30	.29	.29	.29	.29	.28
High-blower Pressure	21.0	21.0	21.0	21.0	11.0	11.0	11.0	11.0	11.0	11.0
Remarks										

Period of climb to 5,000 meters is approximately 8 minutes, 7 seconds; to 8,000 meters, approximately 15 minutes, 48 seconds. When fully equipped, the absolute ceiling is 9,400 meters.

d. When the oil pressure decreases during a climb lower the engine speed to some extent if conditions permit. Leveling off will also increase the oil pressure.

G. Special Maneuvers

1. This plane will perform acrobatic maneuvers with ease. It is free of maneuverability defects.

2. Don't execute maneuvers involving sharp turns. Snap rolls and spins are harmful to the fuselage.

3. Never fly upside down. Inverted flights reduce the oil pressure to zero.

4. In pulling out of a dive at high speed, the force of acceleration must be less than 4 g.

5. In executing special maneuvers, it is necessary to maintain speed and altitude, always keeping in mind the special characteristics of the plane.

6. To save wear and tear on the engine, flight drill should be performed at an engine speed of 2,600 rpm.

7. The elevator trim tabs are left at cruising position except when diving (vertically).

8. The spin characteristics are good. The plane will not go into an inadvertent spin. When the plane has been put into a spin, neutralize the various control surfaces.

9. Execute loops with starting speed at 400 km/hr, engine speed at 2,600 rpm, manifold pressure at +100 mm.

10. Procedure for executing an oblique loop is the same as that for a loop.

11. An Immelman turn is executed with a starting speed of approximately 400 km/hr, engine speed at 2,600 rpm and manifold pressure at +200 mm. The altitude attained by an Immelman is 800 meters.

12. Execute the chandelle by climbing at an initial speed of 350 km/hr and an angle of 80°. Open the throttle until manifold pressure reaches +100 mm. When the speed reaches between 150 and 160 km/hr, follow standard procedure to complete maneuver.

13. To perform a split-S (half slow roll), set the pitch lever at 2,600 rpm. During level flight, speed should be 270 km/hr. Carry out the standard procedure. Loss in altitude will be approximately 900 meters, and speed upon regaining level flight will be approximately 400 km/hr.

How the stick is held during inverted flight, and in pulling out of the dive, has a considerable effect upon the loss in altitude and speed.

14. To perform a split-S (half snap roll), set the pitch lever at 2,600 rpm. The speed should be 250 to 300 km/hr. Press on the right (or left) rudder bar sufficiently; at the same time, pull back and to the right (or left) as far as necessary. Head the nose down. Do not fly in inverted position. Loss in altitude will be approximately 650 meters (800 meters), and speed upon regaining level flight will be approximately 350 (400) km/hr.

15. The slow roll is executed at 2,600 rpm from an initial speed of 320 km/hr. Standard procedure applies.

16. Sharp turns should be executed with engine speed at 2,600 to 2,900 rpm, manifold pressure at +100 to +250 mm and initial speed 380 to 400 km/hr. When turning left, the plane tends to nose downward because of torque. When turning right, the plane will tend to nose upward.

The speed maintained during the turn will vary according to the angle of bank and the weight of the plane.

Altitude	700 - 800 meters			
Turn	180°		360°	
Direction	Left	Right	Left	Right
Time of Turn (Seconds)	9.15	8.55	17.05	20.0
Turning Radius (Meters)	Approx 270	Approx 260	Approx 260	Approx 260

Remarks:

Rpm set at 2,900, manifold pressure ±250. (TN: For another example of negative manifold pressure, see table on page 36.)

17. The first phase of a chandelle must be executed slowly, with full force of acceleration not exceeding 3 g. When the pull-out is executed too swiftly, an extreme loss of speed results and the maneuver will not achieve as high an altitude as anticipated. However, this loss can easily be overcome. Using an engine speed of 2,900 rpm and maximum manifold pressure, climb swiftly to regain the lost altitude.

18. In executing a dive, do not over control the elevator trim tabs. The extent to which the stick is pushed forward is in direct proportion to the speed and in inverse proportion to the diving angle. Even though the controls become heavy, the elevator trim tabs should not be lowered over 5° except when necessary. When executing dives, allow a sufficient margin of altitude, and successively increase the speed of the dives. After becoming accustomed to speed, extend to the permissible speed limit. An example of diving follows:

a. On entering the dive, altitude is 5,000 meters, rpm 2,900 and manifold pressure -100. At a speed of 350 km/hr, execute a half roll, put the nose down at an angle of 60° and lower the elevator tabs 5°.

b. During the dive, open the throttle until manifold pressure is +250 mm.

c. On pulling out of the dive, altitude will be 1,300 meters, manifold pressure +250 mm and speed 750 km/hr.

19. Precautions

a. Do not exceed the permissible rpm limits except when there is a breakdown of the propeller.

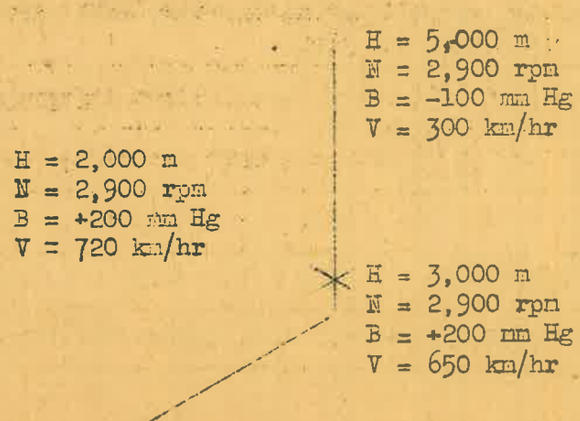
b. At the time of pull-out, close the throttle about half way.

c. The pilot must check the elevator trim-tabs on entering the plane.

d. Should the plane vibrate during a dive, close the throttle and slowly reopen.

20. Vertical dives should be executed with the same care and procedure as regular diving. However, extra care is necessary, because the increase in speed when pulling out of a vertical dive is extremely great, and the loss of altitude is considerable.

An example of a vertical dive follows:



a. Entering dive

(1) Altitude - 5,000 m

(2) Engine speed - 2,900 rpm

(3) Manifold pressure - 100 mm Hg

(4) Air speed - 300 km/hr

b. When diving with a manifold pressure of +200 mm, altitude will be 3,000 m, and air speed 650 km/hr.

c. When pulling out of the dive, the force of acceleration will be approximately 3.5 g, loss in altitude approximately 1,000 m. Maximum speed attained will be 720 km/hr. Consequently, vertical dives must be executed only when there is sufficient altitude.

H. Formation Flight

Inertia is an important factor, especially when flying in formation. It is necessary to have a full grasp of the initial movements /of a maneuver/, to correct one's own movements speedily and to follow the formation leader.

I. Night Flight

1. Night flight in this plane should be undertaken only after becoming familiar with daylight operation.

2. The following precautions must be observed when taking off:

a. Guard against the plane's tendency to incline left.

b. Engine speed and manifold pressure should be conservative. Use military horsepower, because of the greater taxiing distance needed.

c. It is advantageous to set the wing flaps at 15°.

d. Use an adequate take-off area, allowing a margin of safety.

3. Either the Sperry simple landing lights or front spotlights will facilitate landing.

4. For night flying by pilots of medium ability, this plane will require an airfield with a runway 1,200 meters long and at least 100 meters wide.

5. Equipment for night flying is as follows:

a. The plane is equipped with guide lights at an angle of 4° 30' (declination).

b. The height of the horizontal light is three meters.

c. Other equipment and procedure for night flying is the same as that of other planes.

J. Flight Restrictions

Table on Flight Restrictions

Item	Diving	Acceleration	Wing Flaps		Landing Gear			Engine RPM
			15°	30°	Retracted	Extended		
Restrictions	Less than 750 km/hr	Less than 5 g	Less than 270 km/hr	Less than 250 km/hr	Less than 250 km/hr	Less than 250 km/hr	Sharp turns (such as snap rolls and spins) and inverted flight are prohibited.	3,200 rpm However, boost should be under -200 mm, and this rpm should not be maintained for over 30 seconds.

K. Combat

1. Try to exploit to the maximum the excellent combat qualities of this plane.

2. Use maximum horsepower during combat.

3. It is advisable to select an altitude less than 8,000 meters for combat.

4. During combat cruising, operate in low blower at 2,300 rpm and -50 mm manifold pressure. In high blower, operate at 2,500 rpm and -100 mm manifold pressure.

5. During combat, keep the cockpit canopy closed. But be on guard against /attacks from/ the rear, because the field of vision in this direction is not good when the canopy is closed.

6. Since searching for the enemy is hampered by having to look through the glass canopy, keep the canopy open at such times.

L. Firing

1. Precautions to be Observed When Firing

a. The ring sight is 150 to 300 km /sic/, and differs from former types.

b. Advancing for the attack requires caution. It is necessary to sight accurately in the initial onslaught.

c. In an attack, stability is an indispensable factor.

d. If one wing gun jams while firing, it is impossible to continue sighting.

2. The basic procedure for firing is roughly the same as for the Type 2 Fighter.

M. Bombing

1. This plane is best suited for dive bombing.

2. Because the bombing method for this plane is extremely easy and the rate of direct hits is high, it is possible after practicing several times to

develop confidence in one's ability to obtain hits.

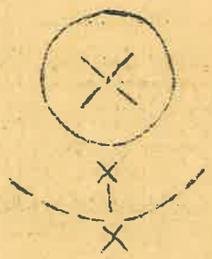
3. Following is an example of a dive-bombing attack by this plane:

a. Dive

Execute the dive from an altitude of 1,500 meters, at an airspeed of approximately 200 km/hr and an angle of approximately 55°.

b. Sighting

Employing the ring sight used in machine gun firing, sight the target just within the 300 km [sic] ring, as shown in the diagram.



c. Bomb release

Release bombs while diving at a speed of 550 km/hr and an altitude of 600 meters.

d. Recovery

When the bombs are away, pull out of the dive quickly. The loss of altitude in pulling up will be approximately 200 to 300 meters.

N. Precautions in Tropical Areas and During Extreme Heat

1. In tropical areas and during extreme heat, the temperature of the fuel in the tank rises. If the temperature continues to rise, it will produce vapor lock, the engine will not operate smoothly and, in extreme cases, will stop altogether. Moreover, should the fuel temperature rise even more, vapor lock may occur even after take-off.

2. The following precautions should be taken to avoid vapor lock.

a. Keep the plane out of the sun as much as possible, and in particular cover the surfaces over the fuel tanks.

b. When there is a possibility of vapor lock, use the fuel cooler.

c. When climbing, use the fuel cooler. When fuel pressure drops off, build up the pressure with the fuel pump.

d. If necessary, open and close the throttle rapidly before take-off to check whether or not a vapor lock condition exists. The hand pump may be used to increase flow of fuel in the fuel system.

e. Watch fuel pressure carefully, and at the same time, avoid violent manipulation of the throttle as much as possible. Lose no opportunity to use the hand fuel pump.

3. In tropical areas and during extreme heat, it is necessary to prevent

not only vapor lock conditions but a[ssive rise in cylinder and oil temperatures. For this reason, keep a[round test run and taxiing down to a minimum. Cylinder temperature not affects the mixture-control lever operation but also has a great effect [n climbing speed and oil temperature. Therefore, when the cylinder tempera[is too high, it is advisable to climb at a speed slightly greater th[the ideal climbing speed. An increase in cylinder temperature will affect [e durability of the ignition wiring considerably.

4. Following is an example of operation in a tropical area:

ALTITUDE [Meters]	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
Atmospheric Temperature	+30°	+26°	+21°	+14°	+8°	+3°	-3°	-11°	-18°	-27°
Rpm	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Manifold Pressure	+250	+230	+130	+250	+245	+140	+40	-60	-160	-250
Airspeed (km/hr)	270	280	290	280	270	260	250	240	220	200
Cylinder Temperature 1	140°	150°	150°	160°	175°	180°	195°	195°	195°	200°
Cylinder Temperature 2	190°	195°	195°	200°	190°	200°	205°	200°	205°	225°
Exhaust Temperature	655°	670°	655°	620°	640°	640°	640°	640°	620°	610°
Mixture Control Lever [%]	0	0	0	25	28	38	38	53	73	95
Oil Temperature Inlet	57°	60°	63°	66°	68°	69°	71°	73°	77°	84°
Oil Temperature Outlet	88°	88°	90°	93°	95°	95°	98°	102°	105°	110°
Oil Pressure	7.2	7.1	6.8	6.5	6.3	6.2	6.1	5.8	5.8	5.5
Fuel Pressure	.31	.29	.28	.27	.32	.34	.33	.33	.35	.37
Fuel Temperature with cooler Inlet	41°	40°	37°	36°	36°	35°	34°	33°	32°	30°
Fuel Temperature with cooler Outlet	36°	35°	33°	31°	29°	27°	25°	22°	13°	11°

Remarks:

a. Fuel cooler in use before take-off.

b. At 4,000 meters, fuel pressure is 0.27. If it appears that it will drop further, build up more pressure.

c. At take-off, the temperature at the surface [of the fuel] was +32° C. The plane was allowed to remain in the direct rays of the sun for approximately five hours prior to take-off.

C. Precautions for Cold Areas

1. The operational limits of cold-resistant lubricating oils in cold weather areas are as follows:

Classification Lubricating Oil (Inlet)	Recommended Temperature
Warm-Up	Up to 20° C
Permissible Maximum	60° C
30-Minute Maximum	40° C
Long-Time Operation	
Permissible Minimum	20° C

2. Starting

a. Although oil will not maintain heat when temperature is around -15° C, the engine will start readily with four or five injections of the primer.

b. In temperatures from -15° C to -30° C, lubricating oil will maintain /sic/ heat, and the engine will start readily with five to six injections. However, it is necessary to continue using the primer after starting until the engine speed becomes stabilized. Engine speed cannot be maintained by throttle-controlled acceleration.

3. Instructions for starting a cold engine and for ground test operation are as follows:

a. Starting preparations

(1) Turn the propeller by hand at least ten times.

(2) At the same time the propeller is being turned, use the injector pump to build the oil pressure to 2 to 3 kg/cm^2. If the oil pressure does not increase, take off the outlet section of the injector pump and withdraw the air.

(3) Confirm the rise in oil pressure, turn the propeller by hand and at the same time prime the engine four to five times. In addition, increase fuel pressure from 0.3 to 0.4 with the hand pump. However, in temperatures less than -30° C, prime the engine until the fuel pressure in the carburetor float chamber is 0.3 to 0.4 kg/cm^2. At this point, close the three-way valve. After starting, open the valve.

(4) Open the throttle 3.0 to 3.5 on the graduated scale.

b. Starting

(1) Prime once more before starting. In addition, set the primer for another injection.

(2) When the inertia starter is turning sufficiently, turn on the ignition switch, at the ignition signal, and press the booster switch.

(3) When the engine starts, carry out the injection which was previously prepared for, and continue slowly until the engine speed has become stabilized. Four to five injections are usually needed. When fuel conditions are to be stabilized

by control of the throttle, exercise care to prevent the engine from stalling or backfiring.

c. Ground test run

(1) If oil pressure does not rise within 30 seconds after starting, stop the engine and investigate.

(2) After starting, when engine operation becomes stabilized, carry out the usual warm-up and performance-check procedures. The time necessary for warm-up when the oil does not maintain heat is approximately 15 to 20 minutes. When the oil maintains heat, the time will be approximately 10 to 15 minutes.

4. When the temperature is less than -30° C, drain the oil.

P. Emergency Landing

1. When the engine fails, loss in altitude is considerable. Thus care is called for in estimating distance. This is particularly true when the landing gear is extended.

2. When the engine fails and it is necessary to make an emergency landing, it is advisable to estimate the distance to the center of the airfield and then to contact the ground there. This is necessary because one is apt to underestimate distances.

3. When making an emergency landing outside of an airfield, lower the wing flaps without extending the landing gear, and open the cockpit canopy.

G 11 49 P — Can — Alt. — gear + flaps —

Section 2. PRECAUTIONS IN HANDLING KI 84

Flight Section Training Department
1 Jun 1944

Accidents have recently occurred from excessive rise in oil temperature in the KI 84 engine. They continue to occur, especially in the 12th Air Brigade. Therefore, observe the following instructions carefully.

1. Exercise the utmost care in operating the oil shutter (front shutter open, rear shutter closed).

Carefully observe the oil temperature at inlet and outlet. The difference should be 20° C to 25° C. When the difference in the two temperatures is slight, adjust the shutter opening.

When the shutter opening is too small, the difference in temperatures decreases as a result of the cooling deficiency.

On the other hand, when the opening is too large, a difference between the two temperatures no longer appears. This is because the oil in the cooler is overcooled, its viscosity increases and oil from the engine then circulates directly to the tank without passing through the cooler. This, in turn, increases the inlet temperature, thus eliminating the difference between inlet and outlet temperatures.

When there is no difference between inlet and outlet temperatures as a result of overcooling, regulate the oil temperature as follows:

a. Close the shutter and travel at low manifold pressure for a short period of time.

b. After the oil-cooler temperature has risen, open the shutter.

Since the shutter opening must be adjusted for altitude, particularly during high altitude flight, never fail to readjust the opening when approaching the ground.

2. Avoid the use of different types of oil, especially M60 (a reprocessed oil). When an oil is reprocessed, its specifications are lowered; in particular, its temperature will rise excessively, making it impossible to control by means of the shutter. Always use IMTABA, Pennsylvania or Texaco lubricants.

3. Close attention must be given to the oil temperature gauge, keeping in mind the special characteristics of this engine. If the inlet oil temperature exceeds 70° C, do not take off.

Section 3. PRECAUTIONS IN HANDLING KI 84

Army Air Headquarters
Reprinted by AKENO Army Air Force
Jul 1944

1. When mooring KI 84 outdoors, cover the switch panel in the cockpit with waterproof material. If this is not done, rain water soaking through the gap between the right fuselage gun and cowling will drip on to the switch panel, and the performance of switches around the volt-ammeter will be impaired.

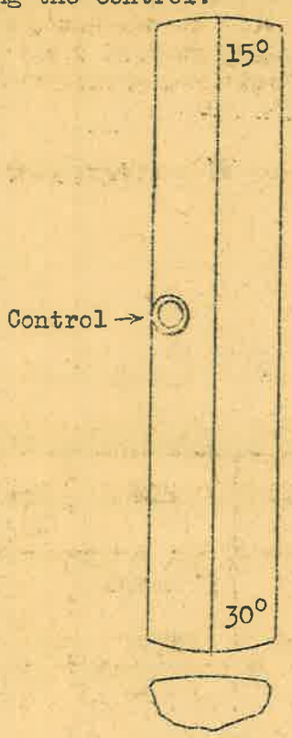
2. If ground test engine speed conforms with the following table, safe flight can be expected.

Propeller Blade Type	Manifold Pressure	RPM	Propeller Diameter	Propeller Angle
No 3 Design	+250 mm ± 0 mm	2750-2800 2450	3 m	30°
No 5 Design	+250 mm ± 0 mm	2800-2900 2500	3.1 m	26°

Section 4. PRECAUTIONS IN HANDLING KI 84 (Planes No 577 and Above)

Army Air Examination Department
Reprinted by AKENO Army Flying Unit
14 Aug 1944

1. The following is a sketch of the wing flap control housing. Instructions for operating the control.



Landing Gear Warning
Signal Switch

a. To lower flaps to 15°, push control to forward position.

b. To lower flaps to 30°, push control to rear position. However, the control knob has a two-position lock. Push down to first position and then move to rear position.

2. The windows are constructed sufficiently large to facilitate installation of the cockpit floor boards.

3. The tail-wheel lock control lever has been changed to a position behind the landing-gear valve.

Section 5. KI 84 OPERATIONAL RADIUS WHEN CARRYING SPECIAL EQUIPMENT

Army Air Examination Department
Reprinted by AKENO Army Air Force
16 Aug 1944

I. RESULTS OF EXPERIMENTAL FLIGHT SHOWING POSSIBLE ATTACK RANGE

Special Equipment	Amount	Operational Radius
100-kg Bomb Jettisonable Tank	1 1	550 km
250-kg Bomb Jettisonable Tank	1 1	500 km
100-kg Bomb	2	350 km
250-kg Bomb	2	250 km

II. PRINCIPAL EXPERIMENTAL FLIGHT DATA

1. The time taken to assemble was estimated to be ten minutes.

2. The attack altitude was 4,500 m, the manifold pressure -100 mm, the engine speed 2,100 rpm.

3. Combat air speed was used within a 100-km radius of the target. The manifold pressure was +100 mm and the engine speed 2,400 rpm.

4. The fuel reserve was 100 liters.

5. In the experiment involving the use of two 250-kg bombs, the leading edge tanks were not used.

6. If the airfield is sufficiently large, the leading edge tanks may be utilized. The operational radius will then be 320 km.

Section 6.. SUPPLEMENTARY INSTRUCTIONS ON OPERATION OF KI 84

AKENO Army Air School Apr 1944

These instructions are based upon statistics on accidents occurring between Nov 1943 and Mar 1944

I. COCKPIT PROCEDURE

Cockpit procedure is clearly indicated in the maintenance manual. It is essential that these procedures be followed;

A. Switch Panel

1. Power Supply

Upon entering the cockpit, the pilot must switch on the power supply. Upon completion of flight, the pilot must turn this switch off.

2. Flaps

Always at "on"

3. Propeller

Always at "on"

4. Instruments

Always at "on"

B. Various Control Handles

After completion of flight the following procedure must be observed:

1. Throttle to "full closed"

2. Pitch control to "high"

3. Mixture control to "full rich"

4. Cowl flaps to "full open" (neutral)

II. GROUND TEST RUN

In conducting the ground test prior to flight, the pilot must carry out the following procedure:

A. Propeller Control

1: Changing of High and Low Pitch

Upon completion of warm-up, make the change-over at less than 1500 rpm. (Make certain the voltmeter reads 28 volts, then switch to amperage. The ammeter will register eight to nine amperes). Rpm will drop approximately 500.

2. Checking Governor Performance

Shift to maximum high pitch at less than 2000 rpm and note change in revolutions per minute.

B. Attention to Instruments

If constant attention is not paid to the instruments, satisfactory operation cannot be obtained. Therefore, the following points must be carefully observed:

1. Oil Pressure

Make certain that the oil pressure is 7.5 to 8 kg/cm^2

2. Methanol Pressure

Make certain that this pressure is 0.8 to 1.0 kg/cm^2

3. Exhaust Temperature

Exhaust temperature is highest at approximately $\pm$ 0 to 100 mm of Hg (manifold pressure). Contrary to expectation, it decreases at + 250 mm of Hg.

4. Manifold Pressure Gauge

Although it must be checked with the tachometer, it is especially essential that the manifold pressure gauge does not oscillate.

5. Voltmeter

Make certain that the voltmeter reads 28 volts.

6. Tachometer

When checking the performance of the governor, advance the throttle rapidly. The tachometer fluctuation must be less than $\pm$ 170 rpm.

III. FLIGHT DRILL

When the above mentioned procedure is put into practice no great strain is placed upon the engine. However, it is also necessary to take the following precautions. These precautions are grouped according to the various flight instruction courses.

A. Take-Off and Landing

1. Proper adjustment of the brake is essential.

2. Before take-off, the spark plugs will be cleaned by advancing engine rpm as far as possible without allowing the brakes to slip.

3. Instrument Readings at Take-Off

Cylinder temperature -70° C to 180° C (Landing temperature - above 70° C)

Oil temperature (inlet) -50° to 70° C

4. Oil Shutter

Winter – ½ open)
) standard
Summer – ½ to 3/4 open)

5. Watch the tachometer carefully. When rpm is excessive, change the propeller control to high pitch in order to restrict rpm.

6. Retracting the Landing Gear

When the landing gear does not retract properly, work the selection valve two or three times and simultaneously pump the hand pump, thus increasing the oil pressure.

7. Extending the Landing Gear

When the landing gear does not extend properly, carry out the above procedure, simultaneously rock the plane to left and right and extend the landing gear. Leave selector valve in down position.

8. When the flaps are lowered 30°, watch the warning signal carefully. If the warning signal is on, it indicates that the landing gear or tail wheel has not extended properly, and communication with the ground is necessary.

B. <u>During Flight</u>

1. Oil Temperature (inlet and outlet)

a. Determine whether or not the difference between oil temperature at inlet and outlet is 20° C. The oil temperature at inlet is the standard.

b. When there is no difference between the inlet and outlet temperature, close the oil shutter. Manifold pressure and rpm will fall. Continue flight in this manner for one or two minutes, then reopen the shutter to one-fourth open.

2. Cylinder Temperature

Switch on 1 and 2 (TN: Cylinder temperature gauges showing front and rear row). For flight, set at row indicating higher temperature.

3. Exhaust Temperature

Exhaust temperature should be 750° C or under, and the needle must not oscillate. It is advisable to use this maximum temperature during cruising periods.

4. Propeller Control

During flight it is necessary to bear in mind the relation of the propeller control to manifold pressure and rpm.

a. Set the pitch lever and advance the throttle. If rpm increases, the governor high pitch circuit is not functioning. Throw the propeller control switch to high pitch position, and when the desired rpm is attained, shift to constant speed. At

this point blade rotation will occur. The speed will be constant and the pitch angle will balance the manifold pressure.

b. Set the pitch lever and retard the throttle. If rpm decreases, the governor low pitch circuit is not functioning. Move the propeller control switch to low pitch. When the desired rpm is attained, shift to constant speed. At this point, the pitch angle is at a low position which conforms to the manifold pressure, and is constant.

c. In case of accidents such as mentioned in the preceding two paragraphs, should the circuit break occur between the relay and the propeller, the propeller control ceases to operate altogether.

d. When a break occurs in the high pitch circuit, but the low pitch circuit remains intact, the pitch angle decreases with the manifold pressure. It is impossible to return to high pitch even though operating the high pitch of the propeller control. Should the break occur in the low pitch circuit, the opposite condition results.

C. Special Maneuvers

1. Diving

It is necessary not to exceed 2900 rpm. Approved momentary high speed is 3200 rpm.

2. Sharp Turns and Loops

If the magnitude of accelerations exceeds 3 g, increase the fuel pressure to 0.35-0.4 kg/cm^2; if below 3 g, satisfactory operation is possible when fuel pressure is reduced to 0.25 kg/cm^2.

3. Continuous Climb

Oil pressure should be over 5 kg/cm^2. The oil temperature at inlet should be below 85° C. Methanol pressure should be 0.9 to 1.0 kg/cm^2. Exhaust temperature should be constant and below 750° C.

4. High Altitude Flight

The oil pressure should be above 5 kg/cm^2.

IV. [CIRCUMSTANCES WHEN] FLIGHT SHOULD BE CANCELLED

1. When voltage does not exceed 20 volts.

2. When governor and high and low pitch circuits are not functioning properly.

3. When methanol pressure does not rise.

4. When there is no difference between oil inlet and outlet temperatures.

V. [CIRCUMSTANCES WHEN] THE OIL FILTER MUST BE CHECKED

1. When engine rpm is excessive.

2. When cylinder temperature reaches 200° C and beyond.

3. When there is rapid fluctuation (especially when the oil temperature and cylinder temperature rise and fluctuate).

4. When the oil pressure drops and the oil inlet temperature exceeds 85° C.

VI. CRITICAL DAMAGE TO ENGINE

Excessive rpm, and irregular combustion, known as detonation, must be carefully guarded against in twin row radial engines.

A. Detonation

1. Detonation is irregular combustion with local and intense burning speed. It results from using too lean a fuel mixture and/or too low an octane value.

2. Because of the carburetors, impellers and manifolds in present-day use, gasoline diffusion is poor.

3. Frequency of detonation tends to increase with the number of cylinders. Although the basic reason is uneven distribution of fuel in the cylinders, this tendency is increased considerably by improper handling and maintenance.

4. Detonation is frequently caused by overtightening the methanol injection pump lever, or by improper adjustment of the mixture control.

5. The following are symptoms of detonation.

a. Rpm and exhaust temperature [sic] drop off.

b. The manifold gauge fluctuates and engine vibration occurs.

c. Cylinder temperature rises.

d. When vibration occurs at high manifold pressure, it is possible that detonation is occurring.

6. Detonation invariably brings internal engine damage:

a. Burning of pistons

b. Burning of the pistons produces piston seizure

c. The waste metal resulting from piston seizure brings a drop in oil pressure. This in turn causes general damage to the internal parts of the engine.

B. Excessive Revolutions Per Minute

1. An electrically-controlled constant speed propeller does not require much attention when its operation and adjustments

are satisfactory. If the change of pitch were not adjusted to the changes in horsepower, and the speeds were drastically increased, excessive rpm would be unavoidable.

2. The weakness of present-day engines lies entirely in the KERUMETTO crankshaft bearings. When rpm is excessive, the bearings are destroyed in an instant because of overheating and insufficient oil supply to the bearing retainer. Since the bearings in this engine are still undergoing research, and no definite solution is as yet available, it is especially necessary to be careful.

3. Causes of Excessive Rpm

a. When the propeller and electric power supply switches are not "on" or when the power supply is less than 20 volts.

b. When there is a short in the high pitch circuit.

c. When the governor is improperly adjusted.

d. When the pitch control gear mechanism is not satisfactory.

e. When the pitch lever operation is not satisfactory.

4. Engine Damage Arising from Excessive Rpm.

a. Crankshaft bearings are destroyed.

b. The peripheral speed of the cam becomes excessive, and the tappets are dislocated. This interrupts the distributor order.

c. The valve movement, which is controlled by the tension of the valve spring, does not conform to the piston stroke, and the piston head strikes the valve. The valve stems are bent or broken off, and at the same time the interior parts of the engine are damaged.

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