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TECHNICAL ORDER NO. 01-40NC-1

# PILOT'S FLIGHT OPERATING INSTRUCTIONS

## C-47 AIRPLANE



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Air Service Caravan Co., Inc.

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Figure 1 - Side View of Complete Airplane

SECTION IINTRODUCTION

1. This Technical Order is the Pilot's Handbook of Flight Operating Instructions for the Model C-47 Transport Airplane. Pilots and other personnel who are required to understand the operation of this airplane will read and be familiar with the information contained herein.

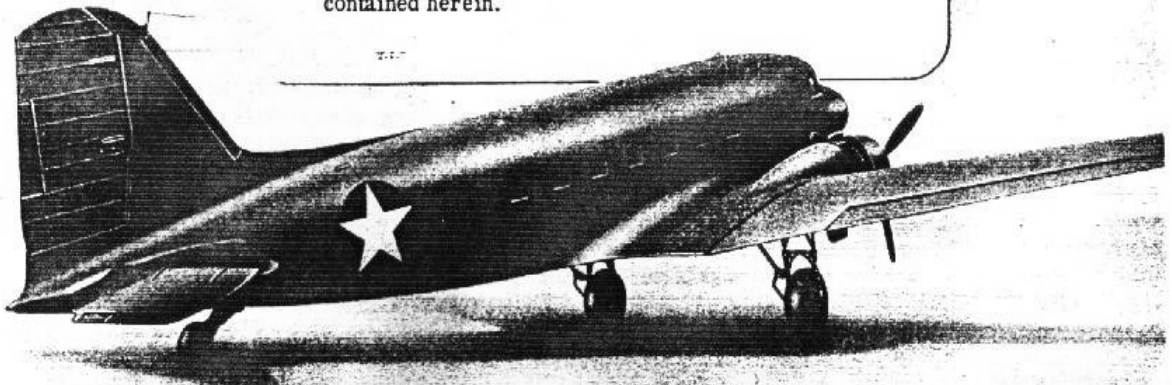


Figure 2 - Three-Quarter Rear View of Complete Airplane

SECTION IIDESCRIPTION1. Airplane.

a. General. - The C-47 Transport Airplane is a low-wing, bimotored monoplane of all metal construction. Its overall span is 95 feet, overall length 64 feet 5-1/2 inches and overall height (at rest) 17 feet. Provisions are made to accommodate a crew of three as follows: pilot, copilot and radio operator.

b. Wing. - The wing is full cantilever of monocoque stressed skin construction. It is made up of a center section of constant chord with the engine nacelles attached and a left and right tapered outer panel. Each outer panel consists of a main section, a detachable rear trailing edge section at the inboard end, and a detachable tip. The ailerons are of metal frame, fabric-covered construction. The right aileron only is equipped with a controllable trim tab. The hydraulically operated wing flaps are of the split trailing edge type of all-metal construction.

c. Empennage. - The horizontal and vertical stabilizers are of all-metal, multicellular construction, attached in fixed alignment to the fuselage. The rudder and elevators are of metal frame, fabric-covered construction, and are both statically and aerodynamically balanced. The rudder and each elevator is equipped with a trim tab controllable from the pilot's compartment.

d. Fuselage. - The fuselage is of semimonocoque construction and is divided into six compartments as follows: pilot's compartment, right-hand cargo and baggage compartment, left-hand cargo and baggage, radio operator's compartment, main cargo compartment, and lavatory. The pilot's compartment in the nose of the airplane contains equipment necessary for the pilot and copilot and is soundproofed and lined. The right-hand cargo and baggage compartment is located on the right-hand side of the fuselage just aft of the pilot's compartment and may be used as a cargo or baggage compartment or for storing one type B-3 life raft. The left-hand cargo and baggage compartment is located on the left-hand side of the airplane and extends from the bulkhead just aft of the pilot's entrance door to the forward wall of the main cargo compartment. It may also be used for storing cargo or baggage, or for carrying two type A-2 life rafts. The radio operator's compartment extends from the aft wall of the right-hand cargo and baggage compartment to the forward wall of the main cargo compartment. It contains provisions for the radio operator and includes all the necessary radio controls. The main cargo compartment extends from the bulkhead behind the radio operator's compartment and the left-hand cargo and baggage compartment to the forward wall of the lavatory in the tail of the airplane. Folding benches are installed along each side of the

compartment and provide accommodations for 28 passengers. In lieu of the passengers, 18 type M-60 liters may be carried, or the airplane may be loaded with cargo not exceeding a total weight of approximately 5,117 pounds. The lavatory compartment is just aft of the rear wall of the main cargo compartment and contains a chemical disposal type toilet and a wash basin.

e. Landing Gear. - The landing gear consists of two independent units, one mounted under each nacelle. The landing gear is hydraulically operated and is so arranged that it retracts up into the nacelles, leaving only the bottom of the wheel projecting. Each wheel is mounted on two oleo type shock absorber struts. Hydraulically operated Bendix 14 x 3 dual brakes, which are controlled by toe pressure on the rudder pedals, are installed on each wheel. A safety latch is installed which hooks the upper landing gear truss to the main spar when the gear is in the extended position. A red and a green light on the extreme right-hand side of the instrument panel and a horn in the pilot's compartment comprise the landing gear warning system. The tail wheel is not retractable and is mounted on an oleo pneumatic shock absorber strut at the rear of the fuselage. The tail wheel is capable of swiveling 360 degrees but may be locked in the trailing position for take-offs and landings by a control in the pilot's compartment.

f. Emergency Equipment and Exits. - Refer to figure 3 for emergency equipment and routes of egress.

## 2. Power Plant.

a. Engines. - This airplane is powered with two Pratt and Whitney R-1830-92 engines. Refer to section V for further description.

b. Propellers. - The propellers are of the Hamilton standard hydromatic quick feathering type with a diameter of 11 feet 6 inches.

### c. Fuel System.

(1) General. - The fuel system consists of four fuel tanks within the center wing section, two tank selector valves, two cross-feed valves, two wobble pumps, two fuel strainers, an engine-driven fuel pump mounted on each engine, and a primer in each nacelle. Each engine is supplied by a separate fuel system, that is, the right engine normally draws fuel from the right tanks and the left engine from the left tanks. However, both systems are connected by a cross-feed arrangement which permits both engines to be supplied by either tank or either fuel pump in case of emergency.

(2) Fuel Tanks. - The four fuel tanks within the center wing section hold 804 U.S. gallons (669.7 Imperial gallons) of fuel. All four tanks are independent. The two main (forward) tanks have a capacity of 202 U.S. gallons (168.26 Imperial gallons) each, and the two auxiliary (aft) tanks hold 200 U.S. gallons (166.6

Imperial gallons) each. It is recommended that 100-octane fuel in accordance with specification No. AN-9531 be used. Use of the fuel should be as follows:

(a) The left engine should normally use fuel from the left-hand tanks and the right engine from the right-hand tanks. This is extremely important for all take-offs and landings; however, at cruising altitudes, any one tank may be used to supply both engines.

(b) The auxiliary tanks should be filled first. The quantity of fuel in each system should be approximately the same.

(c) When running fuel tanks empty in flight, before switching to another tank, keep a close check on the fuel quantity gage and on the fuel pressure gage. It is advisable to switch to another tank as soon as the fuel pressure begins to drop, rather than waiting for the fuel pressure warning light to come on. If a tank is allowed to run dry to the extent that the engine slows down, the throttle should be closed on the engine before the tank selector valve is switched to prevent the engine from overspeeding.

(d) In all take-offs, fuel from the auxiliary tanks should be used. Upon reaching cruising altitude, switch to the main tanks. In landings, fuel from fullest tanks should be used.

### (3) Airplane Balance Change Caused by Fuel and Oil.

(a) The U.S. Civil Aeronautics authority states that during take-offs and landings, the center of gravity of this airplane shall not be forward of 11 percent of the mean aerodynamic chord, or aft of 28 percent of the mean aerodynamic chord. Let us consider these two balance limits to be fulcrums upon which the airplane balances; first on one, then the other. Suppose the airplane is so loaded with full fuel and oil that its center of gravity is directly over the nose heavy fulcrum. In this case, any removal of rear fuel would tend to make the nose tip down or the center of gravity to move forward of the front center of gravity limit. The front fuel practically coincides with the nose heavy fulcrum, so whether it is full or empty it has little effect on the balance in the nose heavy case. From the preceding diagram it is obvious that the critical loading for a nose-heavy condition is with full oil and no fuel. Full front fuel added would make practically no change in balance, as has been stated before, but additional rear fuel would tend to tip the tail down or move the airplane center of gravity rearward.

(b) Now assume the airplane to be so loaded with full fuel and oil that its center of gravity is directly over the tail-heavy fulcrum. Any consumption of oil or front fuel would cause the tail to tip down or the center of gravity to move aft of the rear limit. Rear fuel consumed causes the nose to tip downward. With



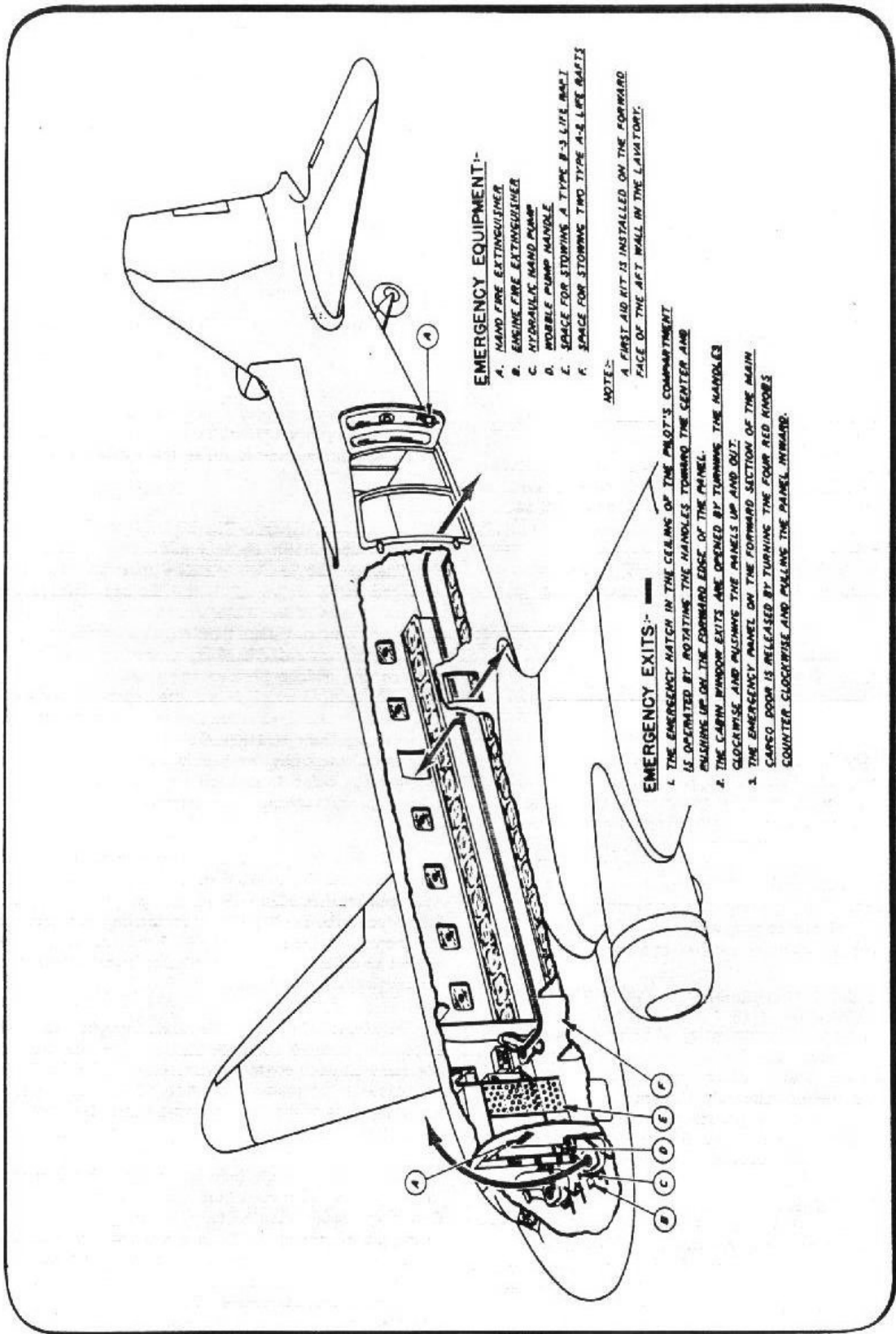


Figure 3 - Emergency Equipment and Exits

these facts in mind, it is clear that rear fuel in an airplane which tends to be tail heavy should always be emptied before drawing from the full front tanks in order to attain the greatest cargo and passenger loading.

(c) From fuel and use restrictions it is seen, that under normal loading conditions, a tendency toward nose-heaviness is anticipated. This gives rise to the restriction calling for use of fuel from front tanks first. In certain limited instances, however, wherein cargo is carried well aft and there is a definite trend toward tail-heaviness, it is considered permissible to reverse the usual procedure and consume fuel from the rear tanks first. This will alleviate the tail-heavy condition which would be accentuated if fuel were used from front tanks first.

(d) For emergency "LONG RANGE" operation, eight fuselage tanks, or less, depending on range required, may be installed in the cargo compartment. Take-offs and landings should be made on wing tanks; fuselage tank fuel should be used first, main fuel second, and auxiliary last for cruising conditions only. An eight-tank installation will increase the gross weight to an over-load condition of approximately 29,000 pounds. For the effect on speeds and load factors refer to figure 30.

This emergency overload gross weight of 29,000 pounds is for flight weight "ONLY" and the landing gross weight remains at 26,000 pounds for the C-47 airplane.

**Caution** The emergency long range over-loading condition of approximately 29,000 pounds should only be undertaken when it is anticipated that the intended mission will be of sufficient duration to use up at least 3,000 pounds of fuel prior to landing as the "LANDING GROSS WEIGHT" of the C-47 is 26,000 pounds. Over-loading of this airplane should not be undertaken if weather conditions are unsettled or turbulent weather is anticipated.

(4) Fuel Pressure Gages. - Fuel pressure gage readings are taken from a point adjacent to the fuel pressure warning switch installed in the pressure line at the carburetor. The fuel pressure gages and warning lights are located in the upper right-hand corner of the instrument panel. The normal operating fuel pressure is 14 to 16 pounds per square inch. The warning lights will go on should the fuel pressure drop below 12 (+1-0) pounds per square inch.

d. Oil System. - The oil system for one engine is independent of that for the other. Oil is carried in two tanks, one mounted in each nacelle, and each having a capacity of 29 U.S. gallons (24.2 Imperial gallons). Oil dilution equipment for winter starting is provided. Oil pressure and oil temperature gages are provided on the right-hand side of the instrument panel. The red warning lights on the instrument panel adjacent

to the oil pressure gages will go on if the oil pressure drops to 50 pounds per square inch. Manually operated shutters, controllable from the pilot's compartment, are provided on each oil cooler to allow for manual oil temperature regulation.

### 3. Equipment.

#### a. Hydraulic System.

(1) General. - An engine-driven pump on each engine supplies pressure to the hydraulic system. The hydraulic system is of the pressure accumulator type and normally operates at 825 to 875 pounds per square inch pressure. It incorporates a hand pump for auxiliary use when the engine-driven pump does not supply sufficient pressure or when it is inoperative. The hand pump will supply fluid under pressure to any of the units that derive their power from the main hydraulic system. Units operated hydraulically are the landing gear, wing flaps and cowl flaps.

(2) Landing Gear. - The landing gear consists of two independent units, one mounted under each nacelle. The landing gear is hydraulically operated and is so arranged that it retracts up into the nacelles leaving only the bottom of the wheels projecting. Each wheel is mounted on two oleo type shock absorber struts. Hydraulically operated brakes, controlled by toe pressure on the rudder pedals, are installed. A safety latch is installed which hooks the upper landing gear truss to the main spar when the gear is in the extended position. The operation of both units of the landing gear is controlled by one handle on the hydraulic control panel. Refer to section III, paragraph 2.b. for retraction and extension procedure.

(3) Wing Flaps. - The center wing panel and the outer wing panels, inboard of the ailerons, are fitted with split trailing edge type wing flaps. These are used for reducing the landing speed and landing run, and also for increasing the gliding angle. The flaps may be operated by either the pilot or copilot from a control on the hydraulic control panel.

(4) Cowl Flaps. - Hydraulically operated cowl flaps are provided for each engine. The operation of the flaps on each engine is controlled individually by two valves. The controls for the cowl flaps are mounted on the side of the fuselage adjacent to the copilot's seat.

(5) Engine Pump Selector Valve. - Each engine drives a high pressure pump which connects to the four-way engine selector valve. During normal operation, the valve control is in a vertical position and the left-hand engine supplies pressure to the main hydraulic system, and the right engine furnishes fluid to the automatic pilot system. The engine pump selector, however, provides a means whereby the right engine may supply pressure to the system.

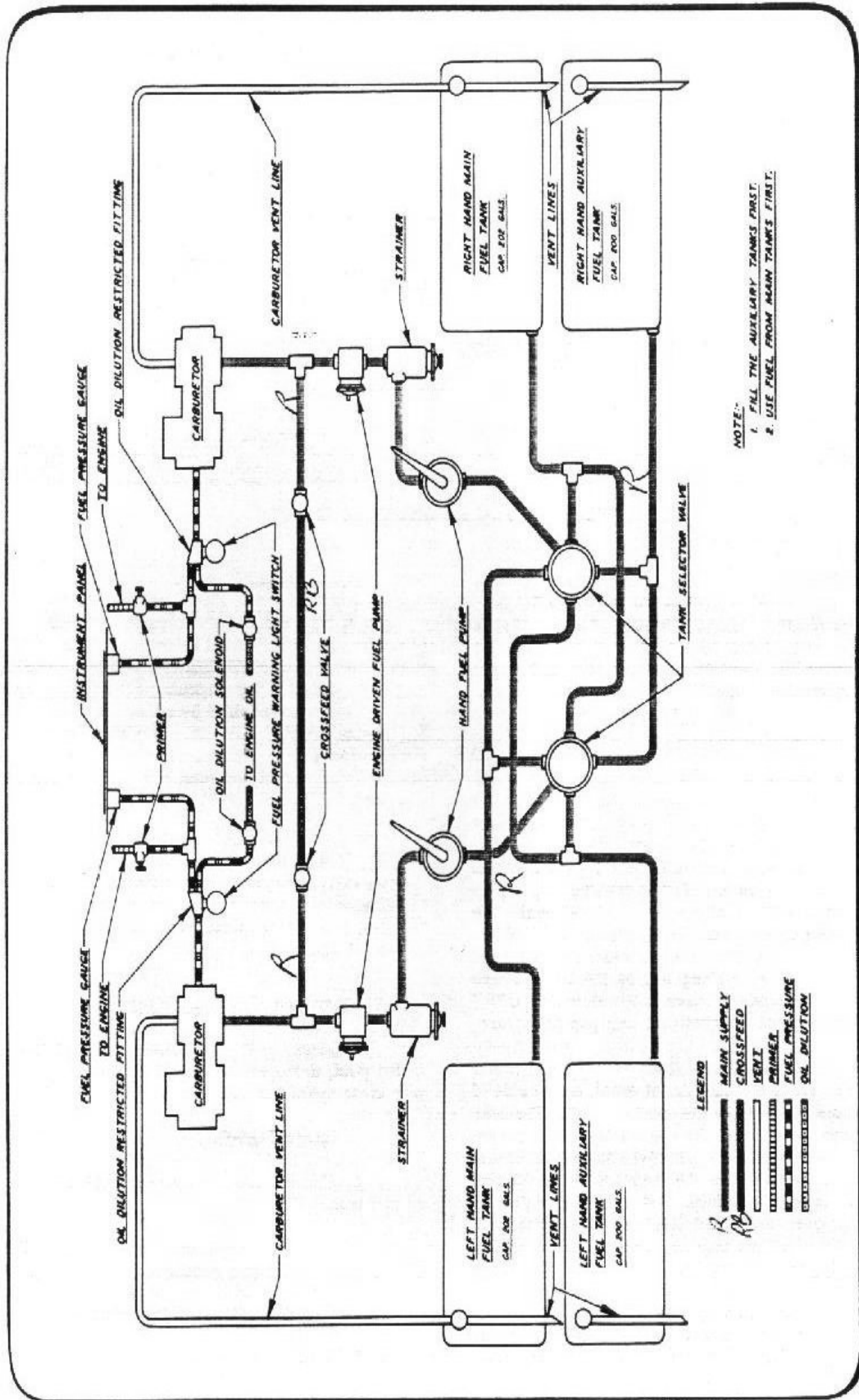


Figure 4 - Fuel System Diagram

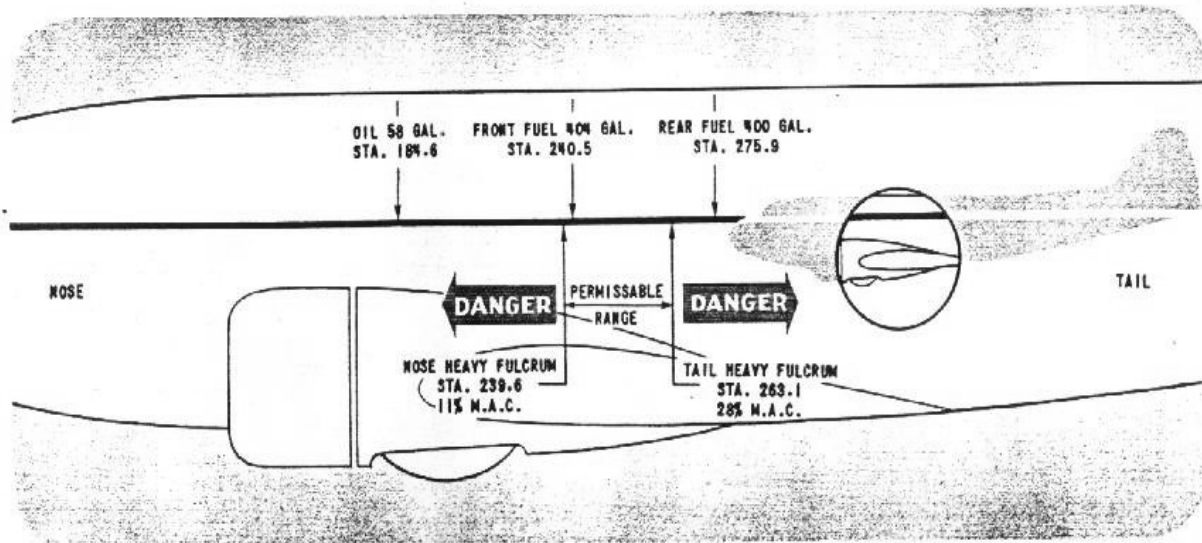


Figure 5 - Fuel and Oil Balance Chart

(6) Hydraulic Hand Pump. - A hydraulic hand pump is installed at the bottom of the hydraulic control panel. When a loss of pressure occurs, and it is desired to operate any of the units in the hydraulic system, move the selector valve for that unit to the desired position and operate the hand pump. The hand pump also may be used to build up pressure in the pressure accumulator.

(7) Shut-Off Valve. - The star-type control handle for the shut-off valve is located at approximately the center of the hydraulic control panel. Normally this control is wired in the "OFF" position, during which time the various hydraulic units may be operated with the hydraulic hand pump. If it is desired to pump up the pressure accumulator with the hand pump, the shut-off valve control must be turned to "ON." When pumping up the pressure accumulator with the hand pump, the pressure will register on the aft pressure gage. When the shut-off valve is wired in the "OFF" position, the gage will not indicate hand pump pressure.

(8) Pressure Gages. - Two pressure gages are located just aft of the instrument panel, on the side of the fuselage adjacent to the copilot's seat. The rear pressure gage indicates the amount of fluid pressure in the hydraulic lines, and in the pressure accumulator. The front gage indicates the pressure in the landing gear retracting strut down line and also registers hand pump pressure if the landing gear control is in the "DOWN" position and the hand pump is in operation. If the hydraulic system (rear) pressure gage reads less than 500 pounds with the wing flaps, landing gear and cowl flap in "NEUTRAL," the brakes off, and the engines running, the system is not functioning properly and an investigation should be made.

b. Flight Controls. - Conventional wheel, column and rudder pedal flight controls are provided for the pilot and the copilot.

#### c. Automatic Pilot.

(1) A type A-3 automatic pilot provides control of rudder, ailerons and elevators, maintaining directional, lateral and longitudinal stability required of an airplane in flight. The controls are operated by hydraulic pressure supplied by either the right or the left engine-driven hydraulic pump as determined by the position of the engine pump selector valve. Hydraulic pressure of between 110 and 120 pounds is required.

**NOTE:** As an added safety measure, servo relief valves are provided which allow for immediate emergency overpowering of the automatic pilot by applying about twice the normal force on the controls.

#### (2) Operation of Automatic Pilot.

(a) General. - Before attempting to use the automatic pilot, the operator should familiarize himself with these operation instructions.

#### (b) Before Take-Off.

1. Check vacuum on run-up; should be 3 inches to 5 inches Hg.
2. Check oil pressure; should be within 10 pounds of recommended pressure.
3. Uncage bank and climb gyro.
4. Set and uncage directional gyro.
5. On installations equipped for two-station remote control, check to see that the pilot's selector switch is turned "OFF."



6. Engage the automatic pilot and check operation by turning each control knob.

7. On installations equipped for two-station remote control, turn the pilot's selector switch to first the "1" position and then to the "2" position, and check remote control operation from each of the two stations. Return the pilot selector switch to "OFF."

8. Remove any air from hydraulic surface controls.

9. Disengage automatic pilot.

(c) After Take-Off.

1. Trim airplane "hands off."

2. See that speed control valves are open; set at (1) if best setting is not known.

3. Set rudder follow-up card to match directional gyro card by turning rudder knob.

4. Set aileron follow-up index to match bank index by turning aileron knob.

5. Set elevator follow-up index to match elevator alignment index by turning elevator knob.

**Caution** DO NOT ALIGN ELEVATOR FOLLOW-UP INDEX WITH HORIZON BAR AS RELATIVE MOVEMENT BETWEEN ELEVATOR ALIGNMENT INDEX AND HORIZON BAR IS IN OPPOSITE DIRECTIONS.

6. Engage automatic pilot by slowly moving the "ON-OFF" lever to the "ON" position. By holding the controls, the pilot can feel when the automatic pilot is flying the airplane.

7. To make course changes, rotate the rudder knob slowly and smoothly. If turning large amount, set in bank with aileron knob.

8. Set the desired fore-and-aft attitude by rotating the elevator knob.

**Caution** DO NOT ALLOW AIRPLANE TO GET TOO FAR OUT OF TRIM. DO NOT FORGET THAT AUTOMATIC PILOT CAN BE OVERPOWERED.

9. To transfer control of the airplane's heading to the No. 1 station (navigator) on installations equipped for two-station remote control, turn the pilot's selector switch to the "1" position. The navigator may then turn the airplane by rotating the knob on the navigator's turn control to right or left. The rate and direction of turn to be set in are shown by the markings on the front of the unit. To stop the turn, rotate the knob so as to return the pointer to "0."

To transfer control of the airplane's heading to the No. 2 station, turn the pilot's selector switch to the "2" position.

(d) Operating Limits. - The operating limit (from the vertical) for the bank and climb gyro is 50 degrees, and for the directional gyro is 55 degrees.

**Caution** DURING MANEUVERS WHICH WOULD EXCEED THE OPERATING LIMITS, OR WHEN THE ENGINES ARE NOT RUNNING, THE GYROS SHOULD BE CAGED. AT ALL OTHER TIMES THE GYROS SHOULD BE UNCAGED.

(e) Detailed Operating Instructions.

1. The Caging Mechanism.

a. To cage the directional gyro, gently push the caging knob in as far as it will go. To uncage, pull the knob straight out so as to avoid turning the directional gyro card away from the desired heading.

b. To cage the bank and climb gyro, rotate the caging knob clockwise as far as it will go, in order to have the caging knob pointer coincide with the white line above the word "CAGE." To uncage, rotate the caging knob counterclockwise as far as it will go, until the caging knob pointer coincides with the white line above the word "UNCAGED."

2. Speed Control Valve Setting.

a. When the automatic pilot is engaged, there may be an oscillation of one or more of the controls with the speed control valves wide open. The valve corresponding to the oscillating control should be slowly turned toward the closed position until oscillation ceases. After the valve has been closed enough to stop oscillating in a control, the knob for that control should be turned back and forth a small amount to be sure that control operation has not been cut off by closing the speed valve too far. Speed valve settings should not have to be changed, unless it is desired to alter the speed of control.

b. The numbers on the valve dials represent turns of the valve and may be used as a reference for returning the valve to a desired setting. When there is no oscillation present, speed control valves should be left wide open (toward "FAST" as far as they will go), unless reduced speed of control is desired. When proper adjustment is obtained for all three controls, the airplane should not yaw, pitch, or roll more than one degree (plus or minus). There should be no "hunting" of the airplane about any of its three axes. If the ailerons are oscillating, they will cause a yaw, even though they do not move enough to cause a wing to drop. Adjustment of the aileron speed control valve will usually correct this.

**Caution** TURNING ANY OF THE THREE SPEED CONTROL VALVES TO ITS OFF POSITION (TOWARD "SLOW" AS FAR AS IT WILL GO) LOCKS THE CORRESPONDING SURFACE CONTROL IN WHATEVER POSITION IT HAPPENS TO BE. THIS SHOULD BE AVOIDED.

### 3. Airplane Trimming Control.

a. Changes in flight attitude, power, altitude, and load shifts will affect the fore-and-aft trim of the airplane. This will cause the automatic pilot to operate the elevator against the out-of-trim condition so as to hold the airplane to the set-in attitude. Such conditions may result in an oscillation of the elevator control. The trim of the airplane can be checked by disengaging the automatic pilot for a few seconds and noting whether the airplane tends to nose up or down. A trim correction should then be made with the airplane's trimming tab or stabilizer.

b. In order that the human pilot will not have to apply a large force to the elevator to hold the airplane when the automatic pilot is disengaged, the airplane should be kept approximately in trim during automatic pilot operation.

### 4. Directional Control.

a. Directional control with the automatic pilot is taken from the directional gyro control unit, which is generally set to agree with the magnetic compass, and is rechecked for drift of the gyro at periodic intervals.

b. The average drift of a directional gyro should not be more than 3 degrees in 15 minutes. A drift of 5 degrees in 15 minutes is permissible on one heading, provided the average on the four cardinal headings does not exceed 3 degrees in 15 minutes.

c. Because the automatic pilot controls to the set heading, the gyro drift will result in a change in the heading of the airplane. When the airplane is only 2 or 3 degrees off the desired heading by magnetic compass, a small adjustment of the rudder knob will suffice to correct the heading. When there is an appreciable difference in reading between the compass and the directional gyro control unit, the automatic pilot should be disengaged for a moment while the gyro is being reset.

d. Whenever the rudder knob marked "RUD" is rotated, the rudder follow-up card is offset from the directional gyro card, producing a flat turn.

e. Banked turns may be made by setting in bank with the aileron knob; then, by continuous rotation of the rudder knob, apply enough rudder to keep the ball-bank indicator centered.

f. A convenient method of making turns is to cage the directional gyro and offset the card a few degrees, depending upon the rate of turn desired. Then immediately add the amount of bank necessary to cen-

ter the ball-bank indicator. In using this method no indication of the amount of turn is given, as the directional gyro is caged. To resume straight and level flight, uncage the directional gyro and level the airplane by rotating the aileron knob.

5. Lateral Control. - Lateral control with the automatic pilot is taken from the bank and climb gyro. The aileron knob marked "AIL" can be set for either level flight laterally or to the desired angle of bank as shown by the bank scale at the top of the dial.

6. Longitudinal Control. - Longitudinal control with the automatic pilot is also taken from the bank and climb gyro. The elevator knob marked "ELE" is rotated to obtain the desired fore-and-aft attitude airplane.

### (f) Maneuvers.

1. General. - With the exception of straight flight, which may be level, climbing, or descending, the only maneuvers that it should be necessary to perform with the automatic pilot are turns and spirals. Course changes for a few degrees may be made as flat turns, in which case it is only necessary to rotate the rudder knob slowly until the airplane reaches the desired heading.

2. Normal Turns. - By rotation of the aileron knob, place the airplane in approximately a 15-degree bank, as shown by the bank scale, and immediately rotate the rudder knob at such a rate as to center the ball-bank indicator. If the airplane tends to nose up or down slightly, this condition can be corrected with the elevator knob. As the desired heading is approached, rotation of the rudder knob should be stopped and the airplane leveled out by means of the aileron knob.

3. Spirals. - Spirals may be made in the same manner as turns, the airplane being nosed up or down by means of the elevator knob. A convenient method of making spirals is to cage the directional gyro, set in bank, and offset the rudder card a few degrees, depending upon the rate of turn necessary to center the ball-bank indicator. Control the rate of ascent or descent by adjusting the elevator knob. In using this method, no indication of the amount of turn is given as the directional gyro is caged. To resume straight and level flight, uncage the directional gyro, and level the airplane by rotating the aileron and elevator knobs.

(g) Manual Control. - When it is desired to resume manual control, move the engaging lever to the "OFF" position and take over the controls. Hydraulic surface control relief valves are provided as an added safety measure so that the human pilot can overpower the automatic pilot by applying about twice the normal force on the controls.

d. Electrical System. - The electrical installation is a single circuit, 12-volt grounded system, except where instrument deflections may occur. Two 85 ampere-hour batteries are installed in the fuselage and one type E-7 generator is installed on each engine. Charging of the batteries by either or both generators

is controlled by the generator main line switches, which are located in the main electrical junction box on the left-hand side of the airplane just aft of the pilot's entrance door. Two battery master switches are located on the left-hand electrical control panel in the pilot's compartment. A battery cart plug is located on the under surface of the fuselage just forward of the leading edge of the wing. The fuse panel is located in the main electrical junction box, and 100 percent replacement is provided. Spare light bulbs are carried in a box mounted on the upper right-hand side of the fuselage above the copilot's seat.

e. Communication Equipment. - The radio operator's compartment is located on the right-hand side of the fuselage between the right-hand cargo and baggage compartment and the forward wall of the main cargo compartment. The radio equipment installed in the airplane includes the following units:

Command Set - Type SCR-183 or Type SCR-274N

Liaison Set - Type SCR-187 or Type SCR-287

Radio Compass - Type SCR-269 or Type SCR-280

Marker Beacon Receptor - Type RC-39 or  
Type RC-43

Interphone Equipment - Type RC-36 or RC-45

f. Heating and Ventilating System. - The heating system is of the steam-heated air type. The right-hand engine exhaust collector ring incorporates a boiler where water is converted to steam by the heat of the engine exhaust gases. The steam is then passed into a radiator where it heats air brought in from the outside. The heated air is then circulated through ducts to the various compartments in the airplane. A desired interior temperature can be obtained by regulating the mixture of heated and outside temperature air. If desired, air at outside temperature only, may be circulated through the system in variable amounts.

g. Ice Eliminating Equipment.

(1) A propeller anti-icing system, consisting of a supply tank, a gear type pump, an electrical switch,

a rheostat, a slinger ring on each propeller, and the necessary lines from the tank to the propellers, is installed in the airplane. The supply tank has a capacity of approximately 4.2 U.S. gallons (3.5 Imperial gallons) of de-icing fluid, AAF Specification No. 3585.

(2) An alcohol type windshield anti-icer system is installed. The system consists of an alcohol supply tank containing 3 U.S. gallons (2.5 Imperial gallons), a hand supply pump, perforated tubing around the front outboard and side windshield panels, and the necessary connecting lines.

(3) Rubber de-icing shoes are provided for the leading edge of each outboard wing, the horizontal stabilizer, and the vertical stabilizer. The shoes are inflated by air pressure from the vacuum pumps mounted on each engine.

h. Fire Extinguishers. - The controls for the engine fire extinguishers are located under a door in the floor between the pilot's seats for a Lux CO<sub>2</sub> type fire extinguisher with outlets installed in each engine section. In case of fire during flight, set the selector valve to the engine on fire and pull the "RED" release handle.

**NOTE:** Once the "RED" engine fire extinguisher release handle is pulled, complete emptying of the CO<sub>2</sub> cylinder cannot be prevented. Do not move the selector valve after selecting engine and pulling release handle.

Two portable hand type one-quart Pyrene extinguishers are provided. One is installed in the main cargo compartment adjacent to the entrance door, and the other is installed on the aft bulkhead of the pilot's compartment, just above the pilot's seat.

i. Oxygen Equipment. - A high pressure oxygen system for the pilot, copilot, and the radio operator is installed. The system consists of an oxygen supply cylinder in the right forward cargo compartment, a pressure regulator and a high pressure gage mounted on the cylinder, a pressure gage on the instrument panel and outlets adjacent to the pilot's, copilot's, and the radio operator's stations.

## DON'T

## Use Oxygen Intelligently

## DO

- |   |   |
|---|---|
| <p>① Do Not Fail to Check All Oxygen Equipment Before Take-Off</p> <p>② Do Not Fail to Insure Full Cylinder Pressure and an Adequate Supply Oxygen for Your Mission</p> <p>③ Do Not Fail to Use Your Own Fitted Mask and Necessary Connecting Tubing</p> <p>④ Do Not Leave Your Walk-Around Bail-Out Oxygen Bottles in Your Locker. You May Need Them</p> <p>⑤ Do Not Waste Your Oxygen Supply by Excessive and Needless High Flows</p> <p>⑥ Do Not Take Liberties at High Altitude by Walking About the Aircraft Without Portable Oxygen Bottles, or by Not Turning on the Oxygen Supply in Time</p> | <p>① Use Oxygen Above 10,000 Feet on All Flights</p> <p>② Use Oxygen from the Ground Up, at Night, or on Rapid Ascents to High Altitude</p> <p>③ Breathe Normally</p> <p>④ Adjust Your Mask Carefully and Eliminate Leaks Before Take-Off</p> <p>⑤ Be Thoroughly Conversant with Your Oxygen Equipment and Reasons for its Use</p> <p>⑥ Report Faulty Function of Oxygen Equipment Promptly and Insure Correction</p> <p>⑦ Check Your Oxygen Equipment Frequently During Flight</p> |
|---|---|



j. Fuselage Equipment.(1) Seats.

(a) The pilot's and the copilot's seats are adjustable for height and for fore-and-aft movement.

(b) The radio operator's seat is of the swivel type and is provided with 90-degree rotation. The radio operator must face forward for all take-offs and landings.

(c) Folding benches are installed along each side of the main cargo compartment, providing accommodations for 28 passengers. The benches are so arranged as to fold down against the side of the compartment when not in use and serve to protect against damage to the fuselage when in this position. Twenty-eight type B-11 safety belts are installed.

(2) Lavatory. - A lavatory compartment is installed just aft of the main cargo compartment. A chemical disposal type toilet and a wash basin are installed in the compartment.

(3) Relief Tubes. - Relief tubes for the pilot and the copilot are provided under their respective seats.

(4) Step Ladders.

(a) An aluminum ladder is provided for the main cargo compartment door. When in use, the ladder clips to the door sill. Two elastic cords provide a means for stowing the ladder on the left-hand side of the aft wall of the main cargo compartment.

(b) An aluminum extension ladder is provided for the forward cargo loading door. When not in use, the ladder may be stowed in the left-hand baggage compartment.

(5) Cargo Provisions.

(a) The main cargo compartment is equipped with a snatch block, an idler pulley, a snatch block ring, and tie-down fittings to facilitate the handling of cargo. The snatch block is installed on the right side of the cargo compartment opposite the main loading door and may be stowed against the side of the fuselage when not in use. The idler pulley is provided for deflecting the cable over and clear of the door sill, and provisions are made for stowing it on the rear bulkhead of the compartment. A snatch block ring mounts in the floor at the forward end of the main cargo compartment to provide for the installation of an

additional snatch block. Sixteen tie-down fittings are provided on the floor of the main cargo compartment. In addition, the safety belt attaching fittings on the sides of the fuselage may also be used for securing cargo.

(b) Provisions are made for carrying four engine transportation cradles with Pratt and Whitney R-1830 engines, or four cradles with Curtis V-1570 engines, or three cradles with Allison V-1710 engines, or two cradles with Wright R-3350 engines. The engine cradles are attached to the airplane structure by hold-down bolts on the cradles.

(c) Eighteen litters may be installed in the main cargo compartment to provide for a hospital arrangement.

(d) Fittings are provided beneath the fuselage for carrying two propellers.

(6) Tie-Down Cables and Landing Gear Safety Pins. - Tie-down cables and landing gear safety pins are carried in a canvas pocket on the left-hand side of the aft bulkhead of the main cargo compartment.

(7) Life Raft Provisions. - Space for stowing two type A-2 life rafts is available in the compartment on the left side of the passageway connecting the main cargo compartment and the pilot's compartment. A type B-3 life raft may be stowed in the compartment on the right side of the fuselage under the radio shelf.

(8) Hydraulic Windshield Wipers. - Acrotorque hydraulically operated windshield wipers are provided to aid in clearing the windshield when flying in heavy rain or ice. Hydraulic pressure is supplied to the main power unit, which is mounted in the "vee" between the pilot's windshields. Arens controls transmit the motion to the wiper blades through rack and pinion gears. The speed of operation of the wipers is controlled by a valve mounted on the instrument panel just forward of the pilot's seat.

(9) Miscellaneous. - A map case and log book holder is installed on the side of the fuselage adjacent to each pilot's seat. A wiring diagram holder is mounted on the forward face of the door, between the pilot's compartment and the main cargo compartment. Two engine covers are stowed on the right-hand side of the aft bulkhead of the main cargo compartment. The hand starter crank for the engines mounts on the left side of the aft bulkhead of the main cargo compartment. A set of engine, propeller, and hydraulic tools are carried in the left-hand forward baggage compartment.

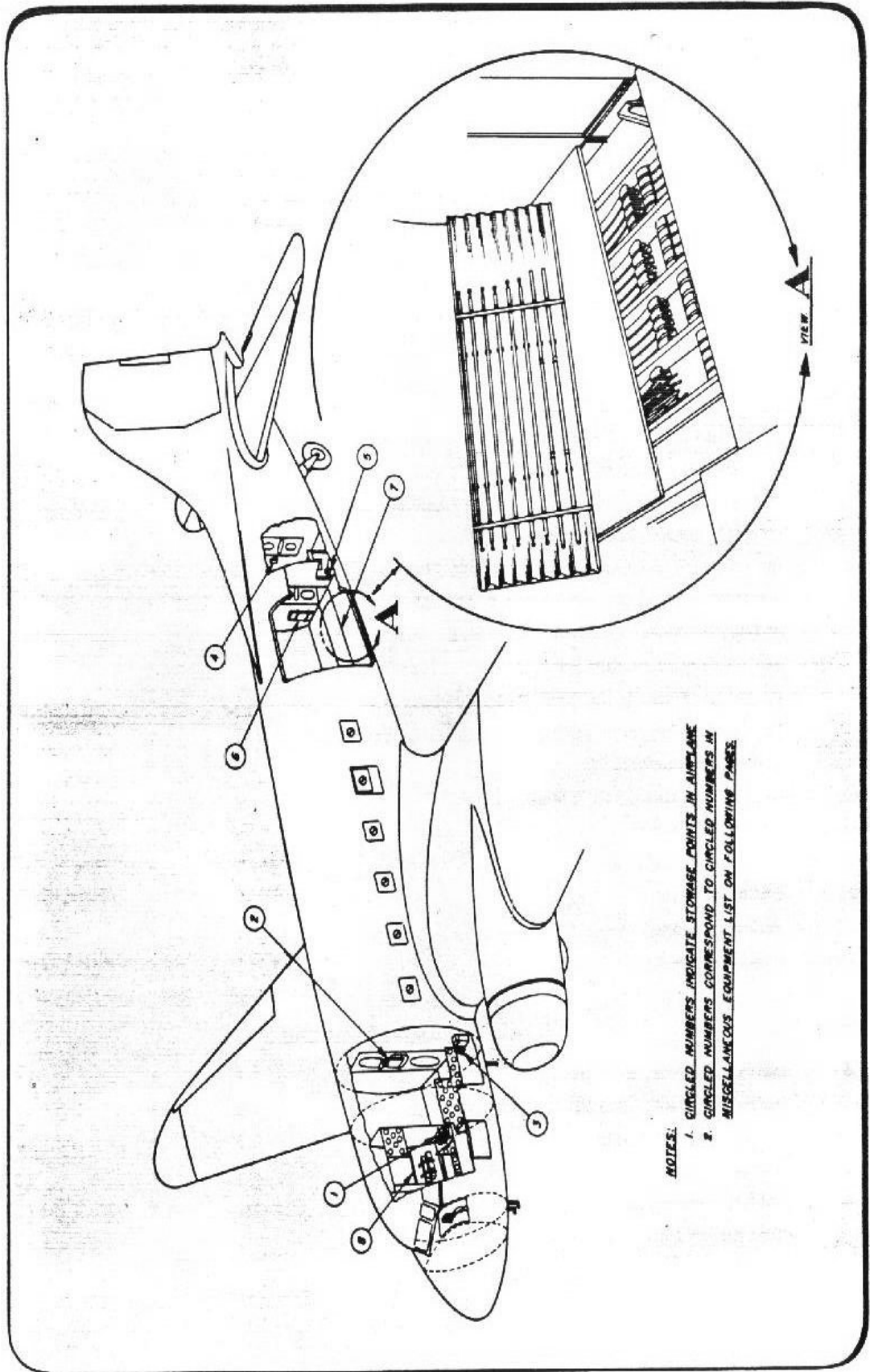


Figure 6 - Miscellaneous Equipment Stowage Points

MISCELLANEOUS EQUIPMENT STOWAGE LISTGOVERNMENT FURNISHED EQUIPMENT

NOTE: All items listed are to be shipped with the airplane.

NOTE: Items marked thus (\*) are to be stowed in their proper place in the airplane. All other items are to be crated and stowed. Only items marked (\*) are to be included in weight of airplane empty.

NOTE: Circled numbers indicating stowage points in airplane correspond to reference circles shown on figure 6.

<u>Part No</u>	<u>Title</u>	<u>No. Req.</u>	<u>Special Notes</u>	<u>Stowage Instructions</u>
	Instruction Book, RC-45 Interphone Equipment	1	*	(3)
	Instruction Book, C-184 Coil Set, XMTR	1	*	(3)
	Instruction Book, Marker Beacon RC-39 and RC-43	1	*	(3)
	Instruction Book, Receiver BC-224-B	1	*	(3)
	Instruction Book, Frequency Meter Set SCR-211-C	1	*	(3)
	Instruction Book, Command Set SCR-AN-183	1	*	(3)
	Instruction Book, Preliminary BC-224-B	1	*	(3)
GEI-13934	Preliminary Instruction Book, BC-191-C Transmitter	1	*	(3)
	Preliminary Instruction Book, Radio Compass SCR-280-A	1	*	(3)
	Preliminary Instruction Book, SCR-AN-183 Command	1	*	(3)
48678	Operator's Handbook	2	*	(3)
46966	Overhaul Manual (Pratt & Whitney)	2	*	(3)
PWA 1947	Engine Tool Kit	2	*	(1)
52829	Multiple Wrench	1	*	(1)
53004	Socket Wrench	1	*	(1)
52024	Puller Assembly	1	*	(1)
54101	Dome Handle	1	*	(1)

DOUGLAS FURNISHED EQUIPMENT

15-405	Instruction Book, Gyro-Horizon	1	*	(3)
15-728	Instruction Book, Gyro Pilot	1	*	(3)
5111604	Wiring Diagram, Radio	1	*	(2)
5111344	Wiring Diagram	1	*	(2)
2119796	Holder, Wiring Diagram	1	*	(2)
4119798	Tool Kit, Propeller	1	*	(2)

RESTRICTED

T. O. No. 01-40NC-1

<u>Part No.</u>	<u>Title</u>	<u>No. Req.</u>	<u>Special Notes</u>	<u>Stowage Instructions</u>
16	First Aid Kit, Johnson & Johnson	1	*	④
100	Door Keys	4	*	With Pilot
5131301	Engine Covers	2	*	⑥
2119795	Tool Kit, Hydraulic	1	*	①
2131397	Wrench, Hydraulic Hand Pump Packing Nut	1	*	①
4132023	Wrench, Landing Gear Retracting Strut and Wing Flap Strut Packing Nut	1	*	①
4132021	Wrench, Tail Wheel Shock Strut Packing Nut	1	*	①
4131638	Wrench, Main Landing Gear Shock Strut Packing Adjustment Collar	1	*	①
DPS-3.21	Process Bulletin	1	*	③
DPS-3.22	Process Bulletin	1	*	③
	Can, Lavatory Chemical	1	*	⑤
T. O. No. 01-40NC-2	Manual Airplane Maintenance	1	*	③
T. O. No. 01-40NC-1	Manual Airplane Operation	1	*	③
2132630	Tube	12	*	} These items included in litter stowage
AN394-45	Pin	84	*	
S-121873-S064-0019	Hinge Pin	84	*	
2132616	Tube	12	*	
2132615	Tube	12	*	
5132411	Support Assembly	36	*	
1132495	Tube Assembly	12	*	
3132671	Tube Assembly	2	*	
3132670	Tube Assembly	4	*	
4132891-8	Tube	1	*	
4132891-10	Tube	1	*	
4132891-6	Tube	2	*	
4132891-2	Tube	2	*	
4132891-4	Tube	2	*	
3132672	Tube	2	*	
2115041	Bar Assembly, Cargo Compartment Bin	2	*	⑧
2139382	Guard, Tail Wheel Axle RH	1	*	
2139383	Guard, Tail Wheel Axle LH	1	*	

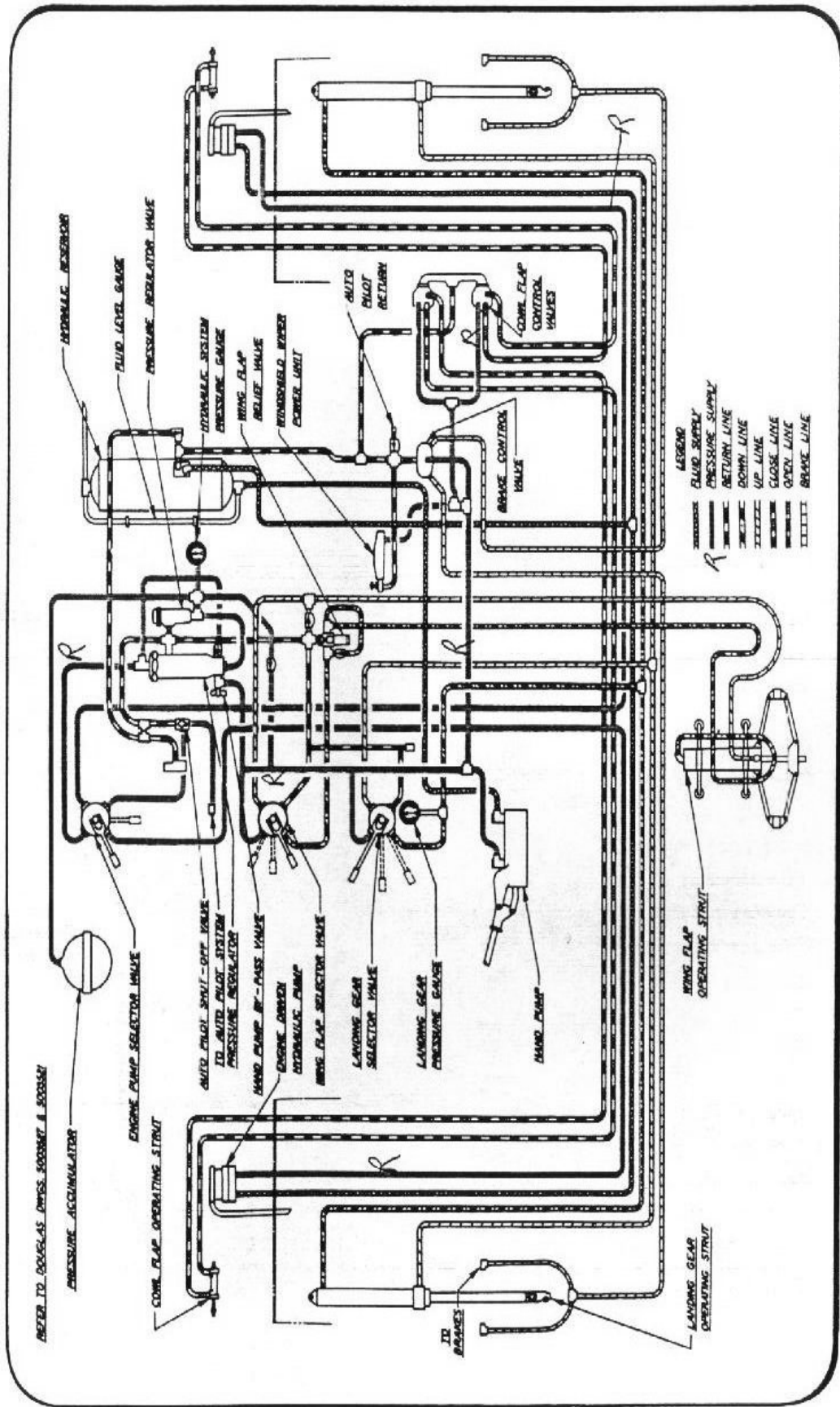


Figure 7 - Hydraulic System Diagram



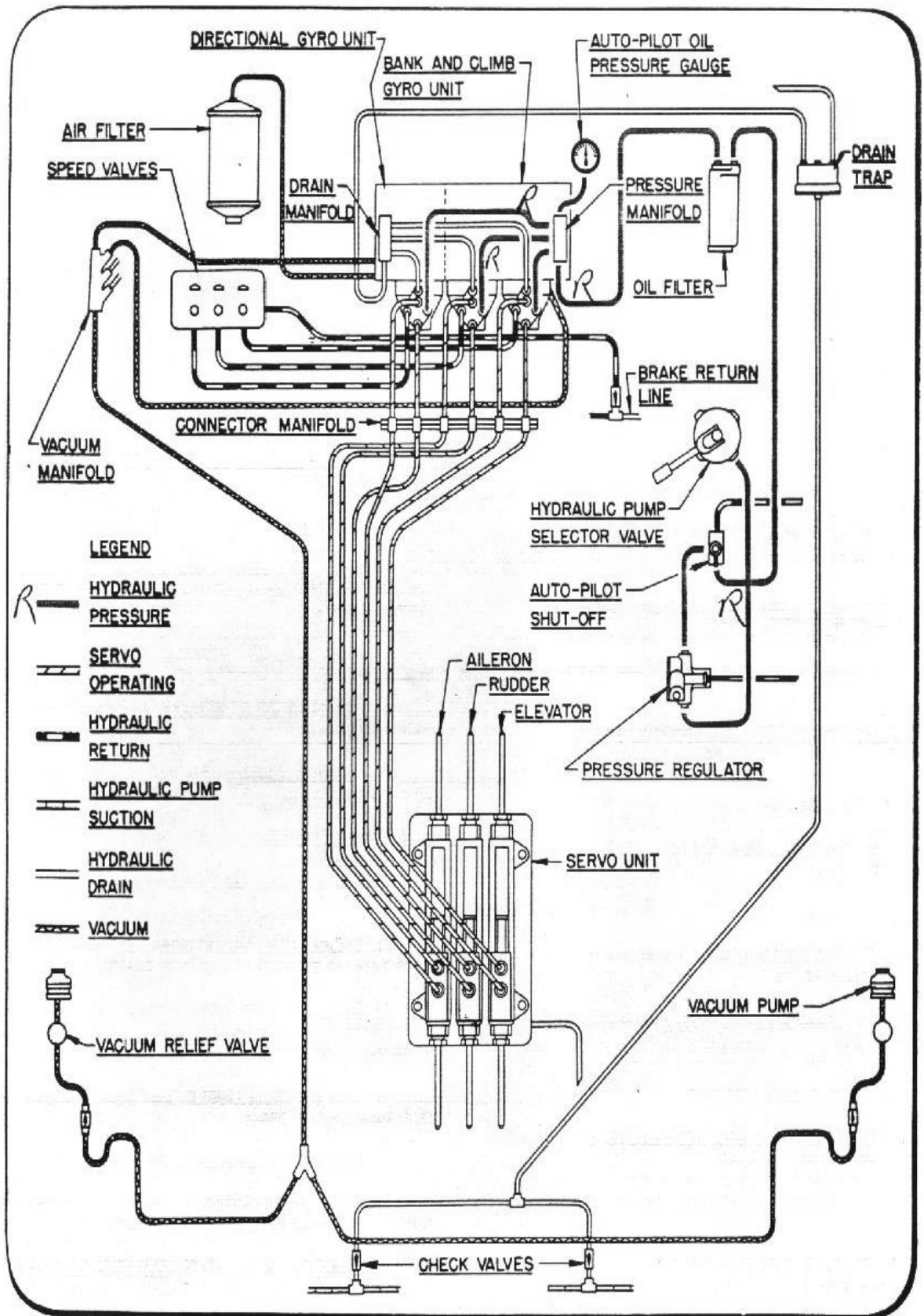


Figure 8 - Automatic Pilot Diagram

SECTION IIIGENERAL INSTRUCTIONS1. Location of Controls.a. Flight Controls.

- (1) Ailerons. - Control wheel.
- (2) Elevators. - Control column.
- (3) Rudder. - Rudder pedals.
- (4) Aileron Tab. - Crank on control pedestal base.
- (5) Elevator Tabs. - Wheel on control pedestal head.
- (6) Rudder Tab. - Crank on control pedestal base.
- (7) Wing Flaps. - Hydraulic control panel on bulkhead aft of copilot's seat.
- (8) Automatic Pilot Engaging Control. - Handle on control pedestal base.
- (9) Automatic Pilot Fluid Control. - Hydraulic control panel.
- (10) Automatic Pilot Speed Controls. - Instrument panel in front of pilot's seat.

b. Landing Gear Controls.

- (1) Landing Gear Control Handle. - Hydraulic control panel.
- (2) Safety Latch. - Floor adjacent to pilot's seat.
- (3) Tail Wheel Lock. - Lever underneath control pedestal head.
- (4) Parking Brake Lock. - Knob on control pedestal base.

c. Power Plant Controls.

- (1) Carburetor Air Temperature (C). - Right top of control pedestal base.
- (2) Carburetor Air Temperature Lock (L). - Right top of control pedestal base.
- (3) Cowl Flaps. - Side of fuselage adjacent to copilot's seat.
- (4) Cross-Feed. - Handle on control pedestal base.
- (5) Engine Selectors. - Top of control pedestal base.

(6) Ignition Switches. - Above windshield between electrical control panels.

(7) Mixture (M). - Right side of control pedestal head.

(8) Oil Temperatures (O). - Left top of control pedestal base.

(9) Oil Dilution Switches. - Lower right-hand corner of left-hand electrical panel.

(10) Primers. - Inboard side in each nacelle.

(11) Propeller Feathering Switches. - Center of each electrical panel.

(12) Propeller Pitch (P). - Left side of control pedestal head.

(13) Starter Switches. - Right-hand electrical panel.

(14) Throttles (T). - Center of control pedestal head.

(15) Throttle Control Brake. - Beneath control pedestal head.

(16) Wobble Pump. - Aft end to the right of pilot's seat.

d. Other Controls.

(1) Engine Hydraulic Pump Selector. - Hydraulic control panel.

(2) Engine Fire Extinguisher. - Under door in floor between pilot's and copilot's seats.

(3) Generator Main Line Switches. - In main electrical distribution box on left side of fuselage just aft of pilot's compartment.

(4) Hand Pump to Pressure Tank Shut-Off Valve. - Hydraulic control panel.

(5) Heating and Ventilating System Controls.

(a) Air Mixing Valve. - Aft of radiator above left-hand forward baggage compartment.

(b) Main Cargo Compartment Regulating Valve. - In main cargo compartment supply duct just aft of forward wall of compartment.

(c) Pilot's and Radio Operator's Compartments Regulating Valve. - In supply duct at top of radio operator's compartment.

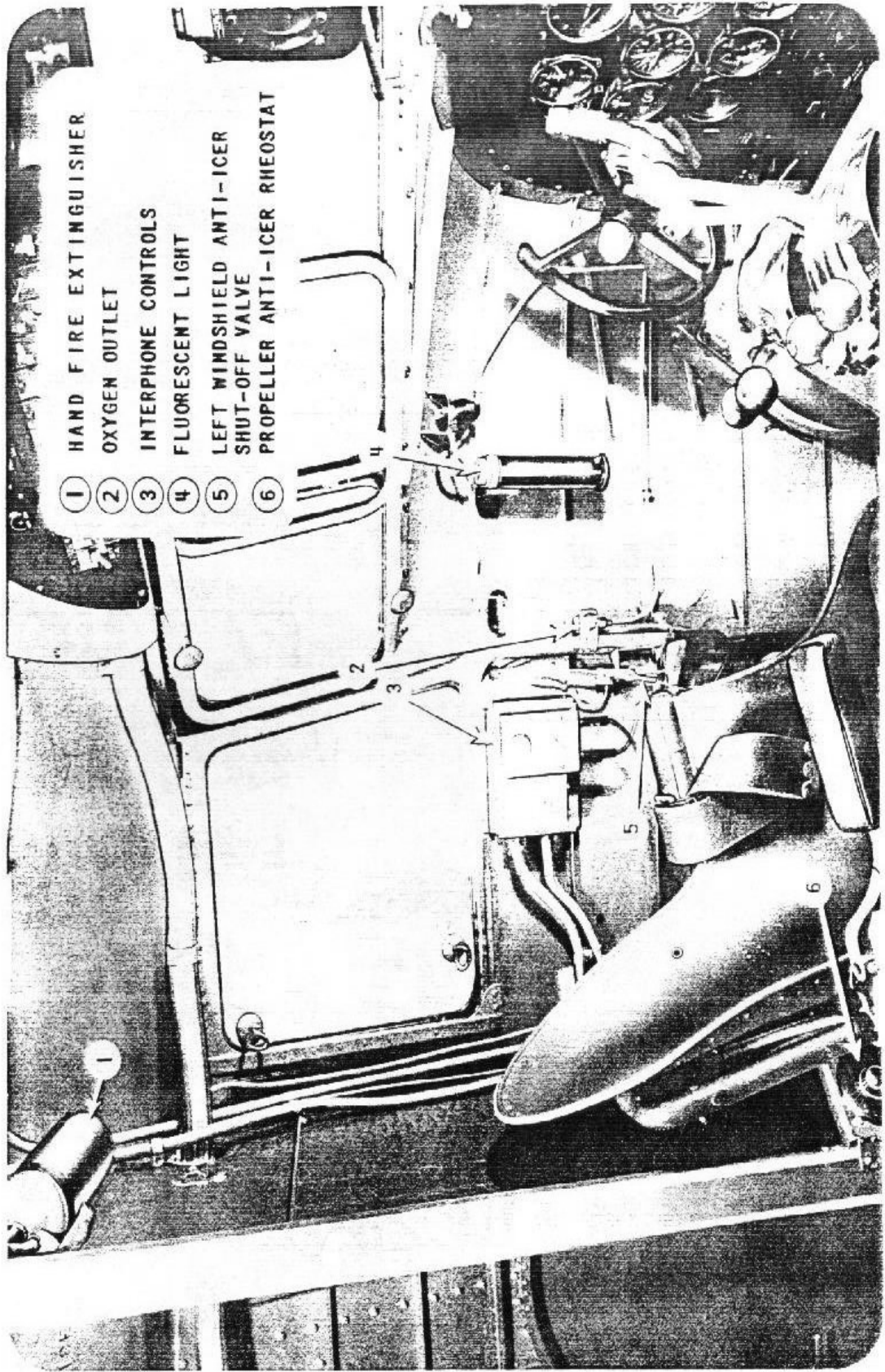


Figure 9 - LH Side of Pilot's Compartment

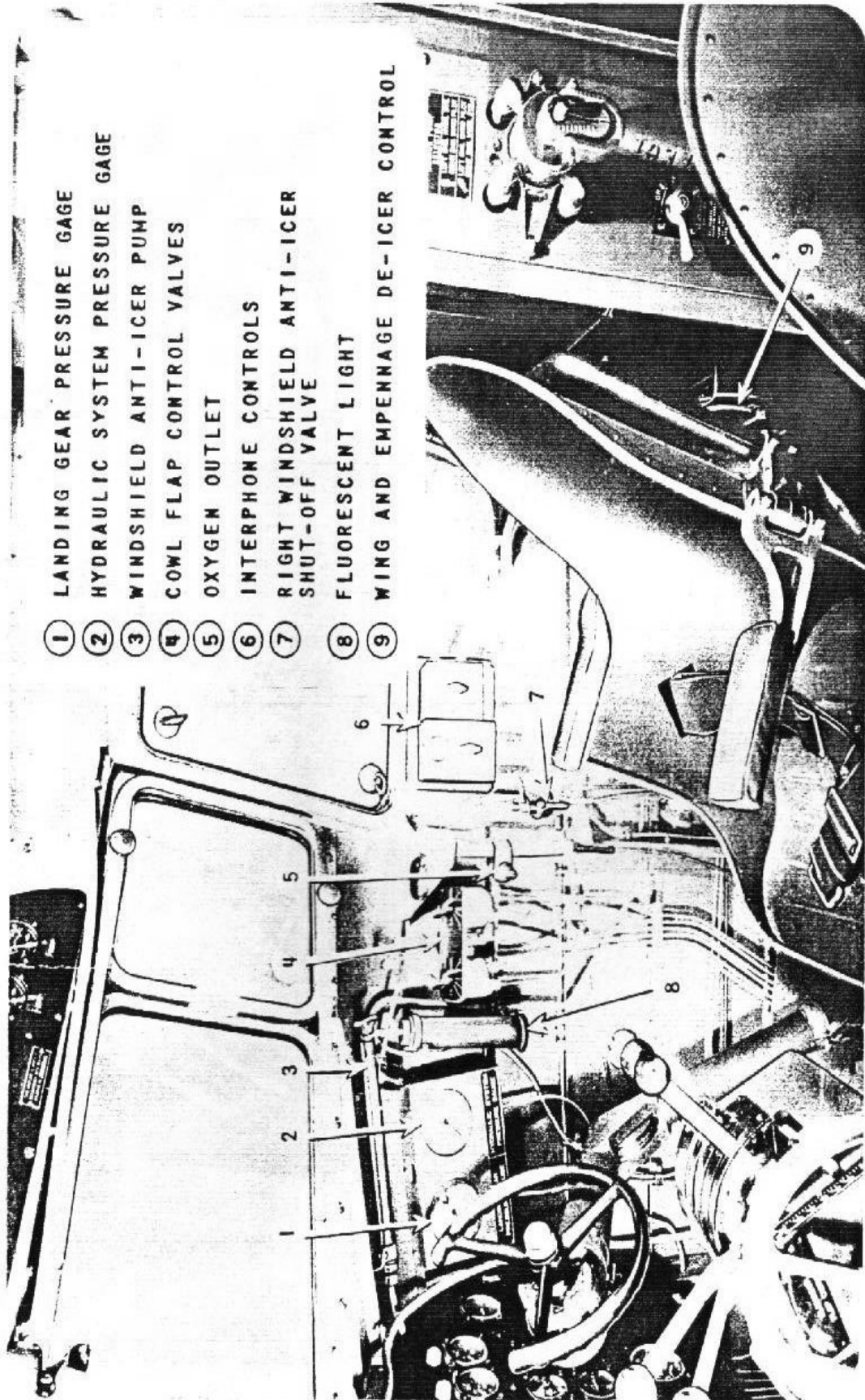


Figure 10 - RH Side of Pilot's Compartment



(d) Steam Shut-Off Valve. - On floor against aft bulkhead of radio operator's compartment.

(6) Hydraulic Hand Pump. - Bottom of hydraulic control panel.

(7) Left-Hand Electrical Panel. - Above left-hand windshield of pilot's compartment. Contains the following controls:

- (a) Compass light rheostat.
- (b) Left-hand propeller feathering switch.
- (c) Instrument panel lights rheostat.
- (d) Right and left battery master switches.
- (e) Right and left landing light switches.
- (f) Running lights switch.
- (g) Cockpit lights switch.
- (h) Fluorescent lights switch.
- (i) Propeller anti-icer switch.
- (j) Pitot heater switch.
- (k) Left and right oil dilution switches.
- (l) Parachute pack salvo switch.

(8) Oxygen System Controls. - Bulkhead behind copilot's seat.

(9) Propeller Anti-icer Rheostat. - Behind pilot's seat.

(10) Radio Controls.

(a) Command Receiver Control. - Left side of ceiling of pilot's compartment.

(b) Command Receiver Remote Control Band-switch. - Aft bulkhead of pilot's compartment above copilot's seat.

(c) Command Receiver Tuning Control. - Below windshield in front of copilot's seat.

(d) Command Transmitter Control. - Right side of ceiling of pilot's compartment.

(e) Compass Remote Control Unit. - Center of ceiling of pilot's compartment above electrical panels.

(f) Interphone Controls. - Sides of the fuselage adjacent to the pilot's and copilot's seats.

(g) Liaison Transmitter Switch. - Aft bulkhead of pilot's compartment above copilot's seat.

(h) Radio Compass Loop Control. - Forward of copilot's seat just above the instrument panel.

(11) Right-Hand Electrical Panel. - Above right-hand windshield of pilot's compartment - contains the following controls:

- (a) Starter safety switch.
- (b) Left and right starter mesh switches.
- (c) Right propeller feathering switch.
- (d) Left and right voltmeters.

(12) Rudder Pedal Adjustment. - Outboard side of each rudder pedal.

(13) Seat Adjustment.

(a) Pilot's and Copilot's Seats. - Handles on sides of seats.

(b) Radio Operator's Seat. - In center below seat.

(14) Windshield Anti-icer.

(a) Pump. - Below windshield in front of copilot's seat.

(b) Left Window Shut-Off Valve. - Side of fuselage adjacent to pilot's seat.

(c) Right Window Shut-Off Valve. - Side of fuselage adjacent to copilot's seat.

(15) Windshield Wiper Control. - Knob on instrument panel just forward of pilot's seat.

(16) Wing and Empennage De-icer Control. - Handle on bulkhead behind copilot's seat.

## 2. Operation of Controls.

### a. Flight Controls.

(1) General. - Operation of the control wheel control column and rudder pedals is conventional.

(2) Aileron Tab. - Turn crank to right to raise left wing, and to the left to lower the left wing.

(3) Elevator Tabs. - Rotate wheel forward to bring nose down, and aft to bring nose up.

(4) Rudder Tab. - Turn crank to left to bring nose to left, and turn crank to right to bring nose to right.

(5) Wing Flaps. - To lower wing flaps, move control handle to the "DOWN" position. When the flaps reach the desired position as shown on the wing flap position indicator, move the handle back to "NEUTRAL." The control handle should be kept in the "NEUTRAL" position while in flight; but when the airplane is on the ground, the control should be kept in the "UP" position at all times to prevent any excess pressure from being built up in the lines due to thermal expansion.

(a) Use of Wing Flaps.

1. Flaps are used to increase the lift of a wing by changing its effective camber or increasing its area, or both; and also to reduce the length of roll of the airplane upon landing, by providing a resisting surface to the passing air. The increase in lift is accompanied by a large increase in drag and by an increase in virtual angle of attack which, if the airplane remains in the same attitude, will cause it to approach dangerously near to the stall. Therefore, the correct use of flaps in flight is to increase the gliding angle of the airplane and NOT TO DECREASE THE GLIDING SPEED. A depressed flap produces a marked increase in wing diving moment, generally neutralized by increased down-wash on the tail. However, simultaneous use of the elevator trim tabs may be necessary to maintain longitudinal balance.

a. For take-off, the increase in drag tends to increase the run, while the increase in lift tends to reduce the run. These two effects combine to give a minimum take-off for a definite flap setting. A split or bent type flap may be lowered from one-fourth to one-half (usually 10 degrees to 20 degrees) to improve take-off. Within these limits the exact setting will vary with the individual type of airplane and can be obtained by experiment. In general, an airplane with flaps in optimum take-off position will clear an obstacle by a greater margin than it will if flaps are closed. The take-off run itself may be increased, however. There is no general rule which can be applied to cover this phenomenon, and information, determined by test, will be covered in the Operation Instructions for each type of airplane.

b. In the event of engine failure following take-off in a maximum performance climb of this nature, the danger of stalling is greater than with flaps up, due to the more abrupt stalling characteristics with flaps down. For this reason, partial lowering of the flaps as an aid to take-off is not recommended except in cases to emergency.

c. In case of engine failure with flaps down, it is important that the flaps be kept down. Sudden raising of the flaps may result in an excessive loss of lift.

d. When a forced landing is made from an altitude which permits maneuvering and when there is insufficient or unsuitable terrain for rolling to a stop,

the landing gear should be retracted and the flaps extended. The flaps will provide the normal drag and lift with which the pilot has become familiar in his normal landing routine. There should be no worry about possible damage caused by landing with flaps extended, since the damage will be relatively slight compared to what might ensue if they were not used.

2. Since split or bent type flaps limit the maneuverability of the airplane and eventually stall it more abruptly, the following procedure is recommended for landing:

a. With flaps down, the speed of glide must be established at not less than 15 miles per hour above the stalling or landing speed as listed in the Operation Instructions of the airplane to provide sufficient margin of safety against inadvertent stalls and to provide sufficient kinetic energy to permit the tail to be forced into position for landing.

b. Since in general an airplane stalls abruptly with flaps down, care must be taken to maintain the gliding speed to the point of leveling-off for landing. An airplane with flaps down stalls very rapidly when leveled-off, and consequently the altitude above the landing field at which this maneuver is made must be much lower than for airplanes not equipped with flaps.

3. The effect upon airplane of a crosswind in landing is to apply a yawing force tending to swing the nose of the airplane into the wind. In a given crosswind and at a given landing speed, the yawing force is greater (due probably to ground effect) for an airplane with flaps than for one not so equipped. The resultant effect upon the airplane is to increase the lift on the upwind wing and to decrease it on the downwind wing. This tends to tip the airplane over in a downwind direction. But since both wings stall rapidly the tipping force, though strong, is of short duration. The pilot, therefore, finds himself inadvertently overcontrolling and may, unless extreme caution is exercised, lose control. This is especially critical in a short coupled airplane. Pilots should use the utmost caution in making crosswind landings with flaps and should make them with sufficient excess speed to insure adequate control.

4. Flaps should not be raised immediately after take-off or at other times when near the stalling speed, as an appreciable interval of time may be required for speed and angle of attack to become adjusted to the new condition. When controllable pitch propellers are installed, the low pitch (high rpm) position should be used whenever flaps are depressed.

b. Landing Gear Controls.

(1) Landing Gear Retracting Procedure.

(a) Pull the landing gear safety latch lever full back to the "LATCH RAISED" position. Red light will go on.

(b) Swing the landing gear control handle out and up from the "NEUTRAL" to the "UP" position.

(c) Wheels will retract if lines are under pressure.

(d) Move landing gear control back to "NEUTRAL" position as soon as landing gear is fully retracted. Safety latch will snap back to "SPRING LOCKED" position and red light will go out.

(e) If, for any reason, the landing gear cannot be retracted with engine pump pressure, operate the hydraulic hand pump. Place the landing gear control in "NEUTRAL" when the operation is completed.

(f) At frequent intervals during flight, the pilot and copilot should visually check the position of the landing gear in the nacelle. If a wheel has lowered, pull the latch lever full back to the "LATCH RAISED" position and move the landing gear control to the "UP" position. Return control to "NEUTRAL" when gear is again fully retracted.

## (2) Landing Gear Extension Procedure.

(a) Move the landing gear control from "NEUTRAL" to "DOWN," making sure that the safety latch lever is in the "SPRING LOCKED" position. If one or both throttles are closed beyond approximately one-fifth segment, the horn will sound and the red warning light will remain on until the wheels are down and latched in the safe landing position and the control handle is returned to "NEUTRAL." The control should be returned to "NEUTRAL" after the pressure in the landing gear down line, as indicated on the forward pressure gage, reaches 500 pounds minimum.

(b) If the wheels are down and latched in the safe landing position, the horn will not sound with the throttles either open or closed, the red light will be off, and the green light will be on.

(c) Lock the safety latch lever to the floor (POSITIVE LOCK position) before landing.

(d) There are times, previous to extending the gear, when the pilot may inadvertently pull the latch lever up all the way to the "LATCH RAISED" position instead of allowing it to remain in its normal middle position "SPRING LOCKED" at an angle of approximately 45 degrees to the floor. Under this condition, the landing gear can be extended, but it will not latch in the down position. The pilot might also pull the latch all the way back preparatory to retracting the gear and then, due to circumstances, decide not to retract it. When the latch lever is pulled all the way back to the "LATCH RAISED" position, it is locked in this position by a dog at the landing gear control handle. Under the above two conditions, the pilot can correct the situation by either of the following methods:

1. He can reach back and trip the dog at the landing gear lever by means of a small knob attached to it, which should re-engage the latches.

2. In the event the pilot finds the operation of the dog too difficult, he can raise the landing gear control to the "UP" position slightly which will trip the latch handle and return it to the "SPRING LOCKED" position. The gear may retract part way, but it is not necessary to wait for the gear to completely retract. If this method is used, the landing gear control lever should be placed in the "DOWN" position and the extension of the gear completed as in the normal procedure.

(e) When the airplane is in flight, the control valve handle should be kept in the "NEUTRAL" position. However, when the airplane is to remain parked on the ground, check to see that the safety latch lever is clipped to the floor (POSITIVE LOCK position), and the landing gear control is in the "DOWN" position. This will prevent thermal expansion from building up relatively high pressures in the landing gear down lines.

## (3) Emergency Operation of Landing Gear System.

(a) Landing Gear Safety Latch Failure. - The airplane may be safely landed whether or not the safety latches are engaged, provided the landing gear is fully down, with the hydraulic fluid in the actuating struts under pressure, and the landing gear valve lever in the "NEUTRAL" position. Pressure in the landing gear actuating struts is indicated on the forward hydraulic pressure gage. The horn will continue to sound and the red light will stay on, since the switches are connected to the safety latch. If the airplane is landed under these conditions, the landing gear is held in the extended position by the pressure of the hydraulic fluid against the retracting strut pistons. Fluid pressure is locked in the landing gear down lines when the control handle is returned to "NEUTRAL." When the brakes are applied, the resulting rotative force will have a tendency to cause the landing gear to partially retract, moving the pistons up in the struts and resulting in an increased pressure in the landing gear down lines. To prevent the possibility of a line failure, due to the excessive rise in pressure caused by the piston moving up in the strut, the brakes should be used only if absolutely necessary. If the length of the landing field necessitates the use of brakes, apply them as lightly as possible and, in any event, limit the pressure applied to the brakes so that the pressure indicated on the landing gear hydraulic system pressure gage does not exceed 1500 pounds per square inch.

(b) Landing Without Fluid Pressure. - The only occasion necessitating landing without fluid pressure would be in case of failure in the lines from the hand pump to the actuating struts. In this case, the latches will hold the gear in place and a safe landing can be made. Put the landing gear control handle in



the "DOWN" position to allow all fluid possible to get into the actuating struts, and then zoom the airplane two or three times to snap the wheels down and engage the latches. Return the control handle to "NEUTRAL." If the warning light is green, it indicates that the latches have engaged, and a normal landing can be made.

(c) Landing Without Fluid Pressure or Safety Latches. - If the latches cannot be engaged as described in the preceding paragraph, put the landing gear control handle in the "DOWN" position and operate the hydraulic hand pump for several minutes immediately before the wheels touch the ground. DO NOT USE BRAKES.

(d) Emergency Braking. - If the system pressure gage reads under 500 pounds pressure, it will be necessary to operate the brakes by means of the hand pump. In order to do this, the brake pedals must be kept depressed, and the degree of brake pressure must be governed by the operation of the hand pump. If the brake pedals are released, all pressure is lost. All hydraulic control handles should be in the "NEUTRAL" or "OFF" position, and the hand pump to pressure tank control should be in the "OFF" position.

(4) Parking Brake Lock. - Pressure gage should read 500 pounds minimum for satisfactory brake operation.

(a) To Set Parking Brakes. - Depress pedals fully and pull out parking brake knob. Release pedals before releasing knob.

(b) To Release Brakes. - Depress pedals fully; control will return to released position. In case of spring breakage, depress pedals fully and push control in.

(5) Tail Wheel Lock. - To lock tail wheel in trailing position, push handle forward. Pulling the handle aft will release the lock and allow a full 360-degree castor.

#### Power Plant Controls.

(1) Engines. - For general engine operating instructions, see section IV in this Handbook.

(a) Starting. - The following starting procedure is recommended for this specific installation:

1. Engines which have been standing idle for four hours or longer should be turned over by hand four or five revolutions in the direction of rotation. When an engine stands idle for long periods, the oil from the crankcase drains through the piston rings into the bottom cylinders. If sufficient oil collects in the cylinders to fill up the compression volume, there is a possibility of damaging the engines on starting, unless the oil is drained out of the exhaust port as the

propeller is being pulled through by hand. It is advisable to remove the lower front spark plugs before turning the engine over if there is any reason to believe the cylinders are loaded.

2. Cross-feed valve control "OFF."

3. Carburetor air temperature controls in "COLD" position to prevent damage to the induction system in the event backfiring occurs on starting.

4. Set the right engine tank selector to a right tank.

NOTE: It is recommended that the engine tank selector valve for the engine not being started be in the "OFF" position to avoid the possibility of overpriming one engine while priming the other.

5. Cowl flaps full open and control "OFF."

6. Propeller pitch controls in "INCREASE RPM" (full low pitch) position.

7. Set throttles approximately one-fourth open.

8. Oil temperature controls to the full "HOT" position.

9. Mixture controls in "IDLE CUT-OFF."

10. See that generator main line switches are "ON."

11. If battery cart is being used for starting, see that both battery master switches are off. If the airplane's batteries are to be used, see that the ground battery cart plug is disconnected and set the battery master switches to the "ON" position.

12. Push the main ignition switch "ON" and set the switch for the engine being started to "BOTH."

13. Raise and maintain the fuel pressure to about 10 pounds per square inch with the wobble pump.

14. Where engines are warm from previous running or where outside air temperatures are 27° C (80° F) or above, external priming is not necessary. Under these conditions, care should be taken to avoid creating high fuel pressures with the wobble pump, as this may flood the engine. Avoid exceeding five to six pounds per square inch fuel pressure. Refer to paragraphs 21., 22., and 23. following for starting cold engines in cold weather.

15. While maintaining fuel pressure at 10 pounds per square inch, energize and engage the starter.

16. While the engine is being turned by the starter, move the mixture control out of "IDLE CUT-OFF" whether the engine has fired or not. During the



preliminary procedure, it is only necessary to move the mixture control to a position definitely out of "IDLE CUT-OFF"; i.e., the control does not have to be moved all the way to the "AUTO LEAN" or to the "AUTO RICH" position. If the engine does not start immediately (three seconds) while maintaining eight to ten pounds fuel pressure with the wobble pump, return the mixture control to "IDLE CUT-OFF." If the engine does not start in about the next five seconds while the mixture control is in "IDLE CUT-OFF," again move the mixture control out of "IDLE CUT-OFF," still keeping the engine turning over with the starter and maintaining the fuel pressure at eight to ten pounds and repeat the procedure. In general, one to three repetitions of this procedure will result in starting the engine.

However, if the engine does not start within a reasonable length of time, an investigation should be made to ascertain the cause. In warm or temperate weather, overloading will be indicated by a discharge of fuel from the drain located in the lower part of the blower section of the engine. In this case, keep the mixture control in "IDLE CUT-OFF," discontinue operating the wobble pump, move the throttle to the wide-open position and turn the engine over with the starter in order to clear it out. If the engine has been loaded and the ignition was left on, it is frequently possible to affect a start while clearing the engine out with the starter. In this case, it is necessary to be ready to immediately retard the throttle to prevent over-revving. If the ignition switch was not left on during the clearing-out procedure, a reasonable number of turns, such as six or eight revolutions of the propeller should be sufficient to clear out the engine. After making certain that the engine is not overloaded, repeat the starting procedure as outlined above, starting with the mixture control in "IDLE CUT-OFF" and being more careful this time about moving the mixture control out of "IDLE CUT-OFF."

If no drainage of fuel is evident from the engine blower, the difficulty is probably a condition wherein the engine has not yet obtained sufficient fuel due either to the fuel pressure not having been kept up during the starting procedure or to the mixture control not having been moved out of "IDLE CUT-OFF" a sufficient number of times or for long enough periods. In this case, repeat the starting procedure, operating the wobble pump and the mixture control with caution, so as to feed a little more fuel into the engine.

If it is still not possible to start the engine, in all probability some part of the ignition system is not functioning, such as the booster, and an investigation should be made. Protracted operation of the booster can sometimes overheat the coils so as to render the booster inoperative.

17. As soon as the engine starts, move the mixture control to "AUTO RICH" without hesitation

and continue to operate the wobble pump until the engine runs smoothly and builds up the fuel pressure to the desired 15 pounds per square inch.

18. Adjust the throttle to hold the engine to as low a speed as possible for the first 30 seconds after starting and watch for an indication of oil pressure on the gage.

**Caution** If oil pressure does not register on the gage within 30 seconds, STOP the engine and investigate.

19. When starts are made with cold oil, the oil pressure may rise to 300 pounds per square inch for a minute or more while the delayed action of the oil pressure relief valve is controlled by the temperature of the incoming oil. This high pressure is reduced when an oil-in temperature of 40° C (104° F) is obtained.

20. As soon as oil pressure registers on the gage, adjust the throttle to 1000 rpm.

21. Where engines are COLD and have been exposed to outside air temperatures below 15° C (60° F) priming is necessary. The lower the temperature, the greater the amount of priming which will be required. Under the various temperature conditions which may be encountered, experience will dictate how much priming is necessary to obtain good starting.

22. Maintain the fuel pressure to at least two to three pounds per square inch in order to furnish fuel to the primer pump during the priming operation and prime as necessary. One stroke of the hand primer pump will fill about five feet of primer line, and this should be kept in mind in gaging the number of strokes required. The number of strokes will vary with the temperature of the engine from one or two strokes with a moderately cold engine to six or eight strokes with a very cold engine. Excessive priming will load the cylinders with raw fuel, making it difficult to start the engine, and will also have a tendency to wash the oil off the cylinder walls which can cause cylinder barrel scoring and piston seizure. Rusting of the piston rings and cylinder walls will occur if the engine is allowed to stand for a day or more after unsuccessful attempts to start, unless the surfaces are protected by a fresh application of oil. Under-priming is usually indicated by backfiring of the engine through the intake system with attendant hazards.

23. With the priming accomplished, follow the starting instructions as outlined for warm engines.

**NOTE:** On cold engines in cold weather, overloading is not necessarily indicated by a discharge of fuel from the engine blower, but rather by the presence of raw gasoline in the exhaust collector ring. In this case, follow the procedure outlined for clearing out a warm engine when loaded.

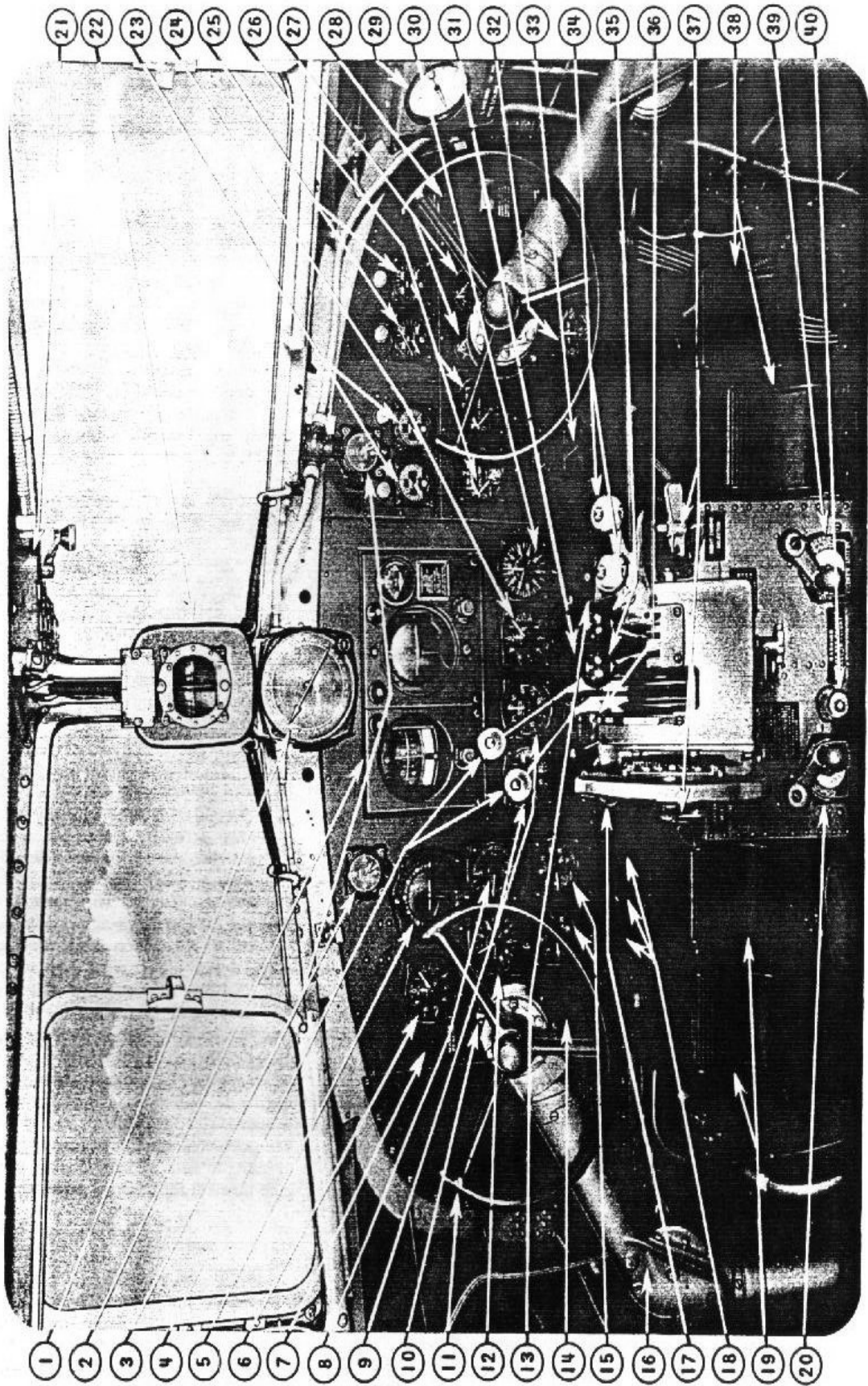


Figure 11 - Instrument and Control Panel

- |                                   |   |
|-----------------------------------|---|
| (1) AZIMUTH INDICATOR             | (21) TUNING CONTROL COMMAND RECEIVER SET  |
| (2) AUTOMATIC PILOT               | (22) MAGNETIC COMPASS                     |
| (3) CLOCK                         | (23) FUEL PRESSURE GAGE                   |
| (4) PROPELLER GOVERNOR CONTROL    | (24) ALTIMETER                            |
| (5) ARTIFICIAL HORIZON            | (25) OIL PRESSURE GAGE                    |
| (6) ALTIMETER                     | (26) CYLINDER HEAD TEMPERATURE INDICATOR  |
| (7) MARKER BEACON INDICATOR       | (27) OIL TEMPERATURE INDICATOR            |
| (8) RATE OF CLIMB INDICATOR       | (28) DE-ICER PRESSURE GAGE                |
| (9) MANIFOLD PRESSURE GAGE        | (29) LANDING GEAR HYDRAULIC PRESSURE GAGE |
| (10) BANK AND TURN INDICATOR      | (30) AIR SPEED INDICATOR                  |
| (11) AILERON CONTROL              | (31) STATIC SELECTOR VALVE                |
| (12) AIR SPEED INDICATOR          | (32) CARBURETOR AIR TEMPERATURE INDICATOR |
| (13) OXYGEN PRESSURE GAGE         | (33) FUEL QUANTITY GAGE                   |
| (14) RADIO COMPASS INDICATOR      | (34) MIXTURE CONTROL                      |
| (15) TACHOMETER                   | (35) THROTTLE CONTROL                     |
| (16) ELEVATOR CONTROL             | (36) MANIFOLD PRESSURE SELECTOR VALVE     |
| (17) OIL PRESSURE GAGE            | (37) FUEL TANK SELECTOR VALVES            |
| (18) AUTOMATIC PILOT SPEED VALVES | (38) RUDDER PEDALS                        |
| (19) RUDDER PEDALS                | (39) AILERON TAB CONTROL                  |
| (20) RUDDER TAB CONTROL           | (40) PARKING BRAKE                        |

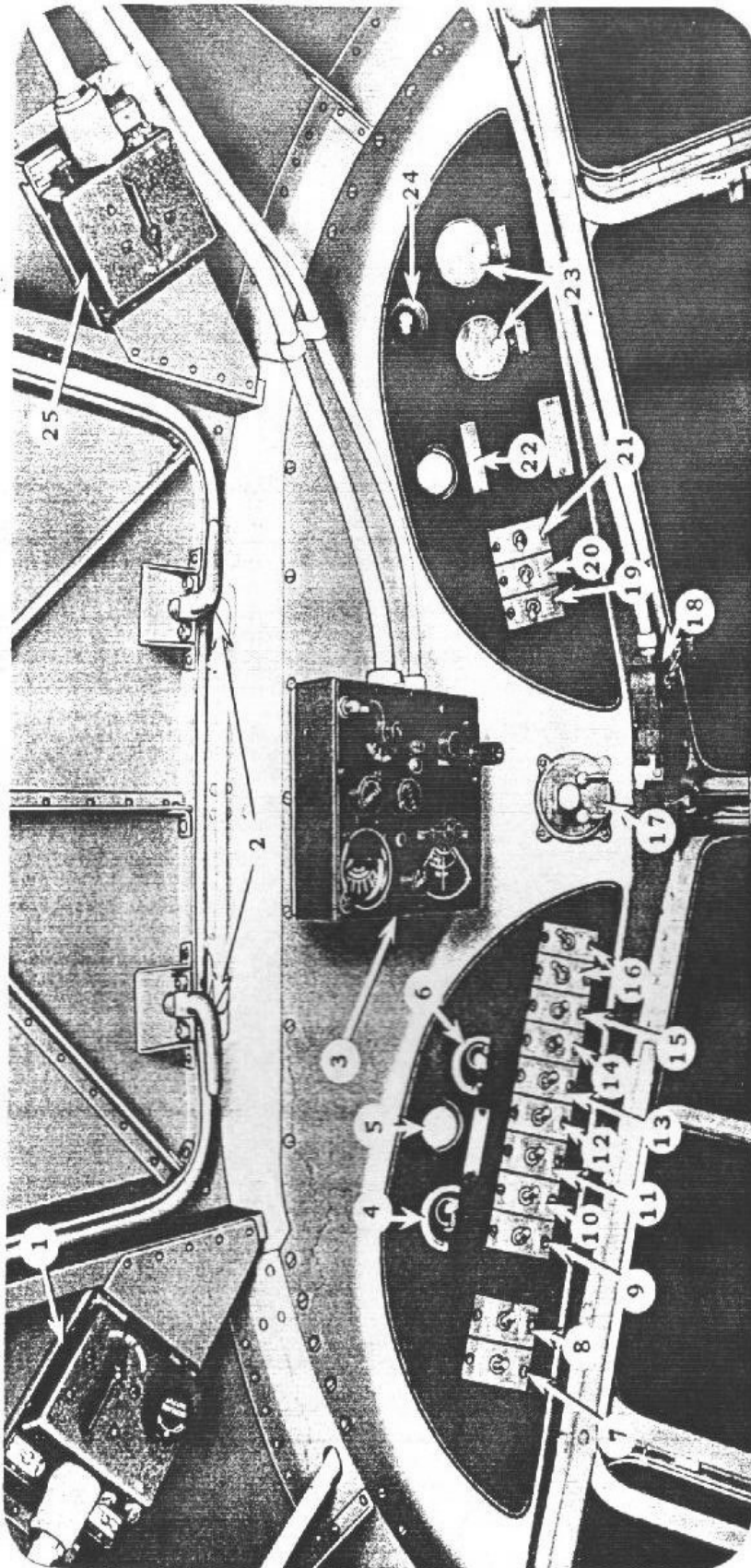


Figure 12 - Electrical Control Panels

- |   |                                  |   |                            |   |                                   |
|---|----------------------------------|---|----------------------------|---|-----------------------------------|
| ① | COMMAND RECEIVER CONTROLS        | ⑩ | LEFT LANDING LIGHT SWITCH  | ⑲ | RADIO COMPASS LOOP CONTROL        |
| ② | ESCAPE HATCH RELEASE HANDLES     | ⑪ | RIGHT LANDING LIGHT SWITCH | ⑲ | LEFT STARTER MESH SWITCH          |
| ③ | COMPASS REMOTE CONTROL UNIT      | ⑫ | RUNNING LIGHTS SWITCH      | ⑲ | STARTER SAFETY SWITCH             |
| ④ | COMPASS LIGHT SWITCH             | ⑬ | COCKPIT LIGHTS SWITCH      | ⑲ | RIGHT STARTER MESH SWITCH         |
| ⑤ | LEFT PROPELLER FEATHERING SWITCH | ⑭ | FLUORESCENT LIGHTS SWITCH  | ⑲ | RIGHT PROPELLER FEATHERING SWITCH |
| ⑥ | ELECTRICAL PANEL LIGHTS SWITCH   | ⑮ | PROPELLER ANTI-ICER        | ⑲ | VOLTTMETERS                       |
| ⑦ | LH BATTERY MASTER SWITCH         | ⑯ | PITOT HEATER SWITCH        | ⑲ | LAMP                              |
| ⑧ | RH BATTERY MASTER SWITCH         | ⑰ | OIL DILUTION SWITCHES      | ⑲ | COMMAND TRANSMITTER CONTROLS      |
|   |                                  | ⑱ | IGNITION SWITCHES          |   |                                   |



If there is no evidence of raw fuel in the exhaust collector, in all probability the engine has not been given sufficient prime, even though fuel may be draining from the blower. In cold weather, considerable quantities of fuel may be discharged into the blower and pass out through the drain and still leave the engine underprimed. The reason for this is that fuel at low temperatures discharged into the blower is not sufficiently atomized to be carried into the cylinders in mixture strengths necessary for combustion when the engine is turned over. For this reason, direct atomized priming to the cylinders is required in cold weather. On the other hand, in warm weather, both the fuel and the engine are at higher temperatures so that the fuel discharged into the blower is atomized sufficiently to be carried into the cylinders in mixture strengths necessary for combustion when the engine is turned over. When under-priming is suspected, additional priming should be made cautiously and the starting procedure repeated as outlined for warm engines.

**Caution** Be sure that the cowl flaps are full open. Do not attempt to warm the engine more quickly by closing the cowl flaps in extremely cold weather. This may cause burning of the ignition system at the spark plug elbows.

24. Turn the left engine tank selector valve to a left-hand tank and repeat the above procedure to start the left-hand engine.

(b) Stopping. - Refer to T. O. No. 02-1-29 for instructions on ground operation, use of oil dilution system and stopping. The following instructions pertain to the stopping of this particular engine installation:

1. If the cylinders are hot, due to hard taxiing, permit the engine to idle a short time to allow the cylinder heads to cool to about 180° C (350° F).

2. See that the propeller pitch controls are in the "INCREASE RPM" position (full low pitch).

3. Move the mixture control to "IDLE CUT-OFF" and at the same time open the throttle. This will give a clean cut-off without "after-firing."

4. When engines have stopped, turn all ignition switches "OFF."

5. Turn the engine fuel tank selector valves to the "OFF" position. Do not stop the engine by shutting off the selector valve. This allows vapor to be pumped into the Bendix-Stromberg injection carburetor.

6. Leave the mixture controls in the "IDLE CUT-OFF" position at all times when the engines are not operative.

**Caution** Do not move the propellers until the engines have properly cooled.

(2) Propellers.

(a) General. - This airplane is equipped with Hamilton standard hydromatic quick-feathering constant speed propellers.

(b) Propeller Pitch Controls.

1. General. - Forward movement of the propeller pitch control levers marked "P" to LOW PITCH position increases the engine rpm; aft movement to HIGH PITCH position reduces engine rpm.

2. For Take-Offs. - Set controls to give 2700 rpm.

3. During Flight. - Set controls to obtain desired rpm.

4. For Landing. - Set the controls to obtain maximum cruising rpm (2300) to prevent overspeeding of the engine and dangerous reverse thrust during the period of time required for the synchronism of the propeller governor and the engine in the event a sudden burst of power is applied.

(c) Propeller Feathering Switches.

1. Test Feathering Procedure (in Flight).

- a. Close throttle.
- b. Set propeller pitch control to "DECREASE" (high pitch) position.
- c. Place mixture control in "IDLE CUT-OFF."
- d. Close cowl flaps.
- e. Close oil cooler shutters.
- f. Turn hydraulic pump selector to running engine.
- g. Turn engine tank selector valve to "OFF" for failing engine.
- h. Turn cross-feed valve to "OFF."
- i. Push feathering switch. When blades are fully feathered, switch will kick out automatically.
- j. After engine stops, turn ignition switch "OFF."

2. Emergency Feathering Procedure. - In the event of an engine failure in flight, the immediate problem is to determine the cause which will, in turn, determine whether or not the propeller should be

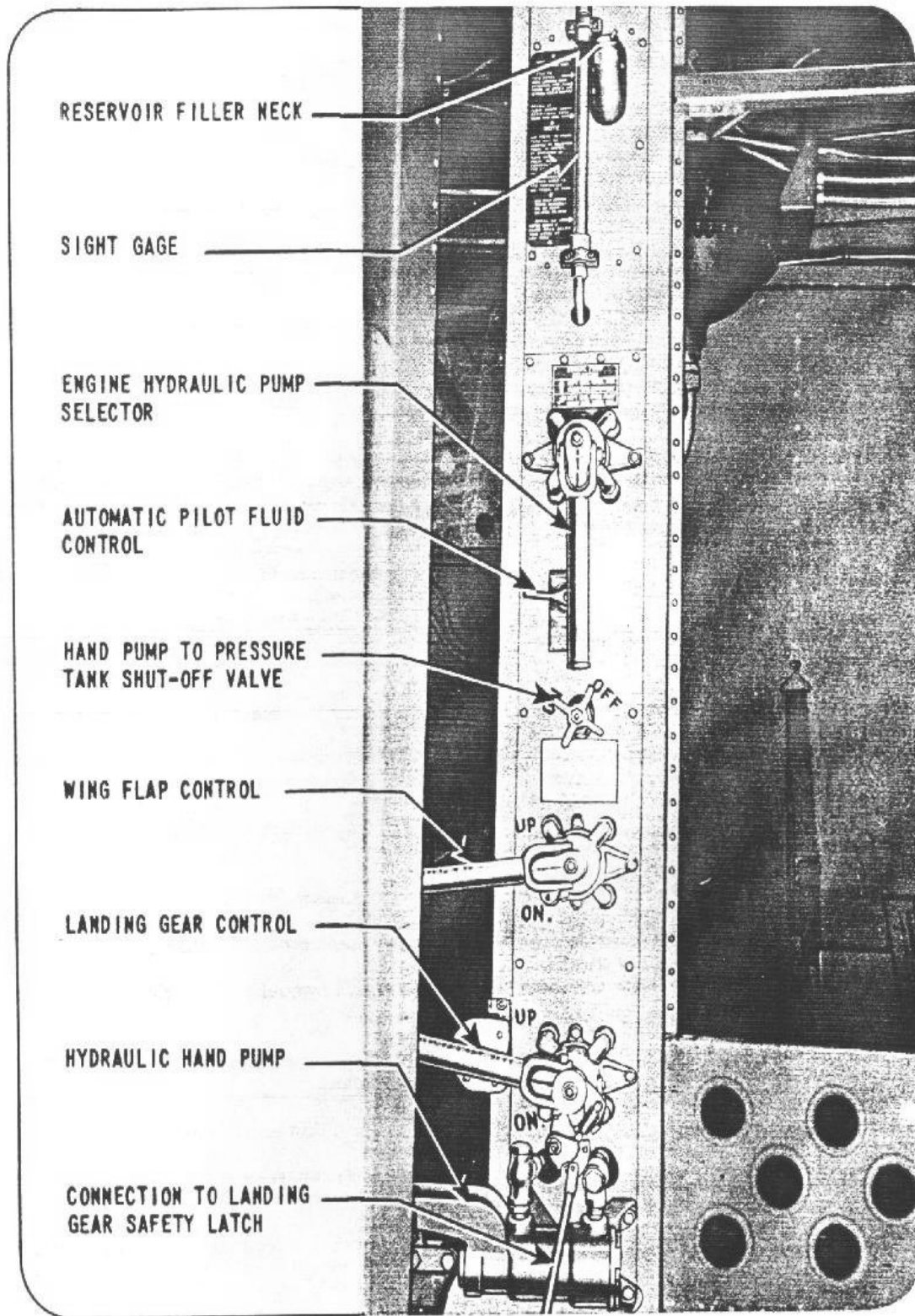


Figure 13 - Hydraulic Control Panel

feathered and the engine stopped. A check of the instruments will usually disclose the trouble. In some cases, for example low fuel pressure or loss of power, it is desirable to allow the engine to windmill while making certain adjustments from the pilot's compartment, such as setting the cross-feed valve or operating the wobble pump. On the other hand, with low oil pressure, etc, it is important that the engine be stopped as soon as possible by feathering the propeller. It is very important in most cases of engine failure to get the live engine properly adjusted first so as to continue safe single engine flight. As soon as the live engine has been adjusted to give satisfactory performance, proceed with the failing engine as follows:

- a. Push feathering control switch.

**NOTE:** The propeller feathering operation can be interrupted at any time before the propeller has fully feathered by pulling out the feathering control switch. The engine will return to normal rpm if the engine is still turning over 800 rpm or more and the controls are in their previous setting. If the engine speed is less than 800 rpm and the switch is pulled out, the engine will stop. In order to start the engine again, the feathering control switch must be pushed in to complete the feathering cycle and the normal unfeathering procedure must be followed.

- b. Close throttle.
- c. Set the propeller pitch control to "DECREASE" (high pitch) position.
- d. Place mixture control in "IDLE CUT-OFF."
- e. Close cowl flaps.
- f. Close oil cooler shutters.
- g. Turn engine fuel tank selector valve to "OFF" for failing engine.
- h. Turn hydraulic pump selector to good engine.
- i. See that cross-feed valve is off.
- j. Leave ignition switch at "BOTH" until engine stops, then turn to "OFF."

### 3. Unfeathering.

- a. With throttle closed and propeller pitch control in "DECREASE" (high pitch) position, switch ignition to "BOTH."
- b. Check to see that mixture control is in "IDLE CUT-OFF."

c. Turn engine fuel tank selector to desired tank.

d. Push feathering button and hold until engine windmills 600 rpm to 800 rpm.

e. Release button and "jog" if necessary to prevent from exceeding 800 rpm until at least 40 pounds oil pressure shows on gage.

f. When engine is running, place mixture control in "AUTO RICH."

g. After oil pressure is developed, allow engine to increase to minimum governing rpm.

h. Warm up engine under these conditions, gradually advancing throttle and propeller controls to the desired operating position.

### (3) Fuel System.

#### (a) Fuel Selector Switch Points.

- No. 1 - Left auxiliary tank
- No. 2 - Left main tank
- No. 3 - Right main tank
- No. 4 - Right auxiliary tank

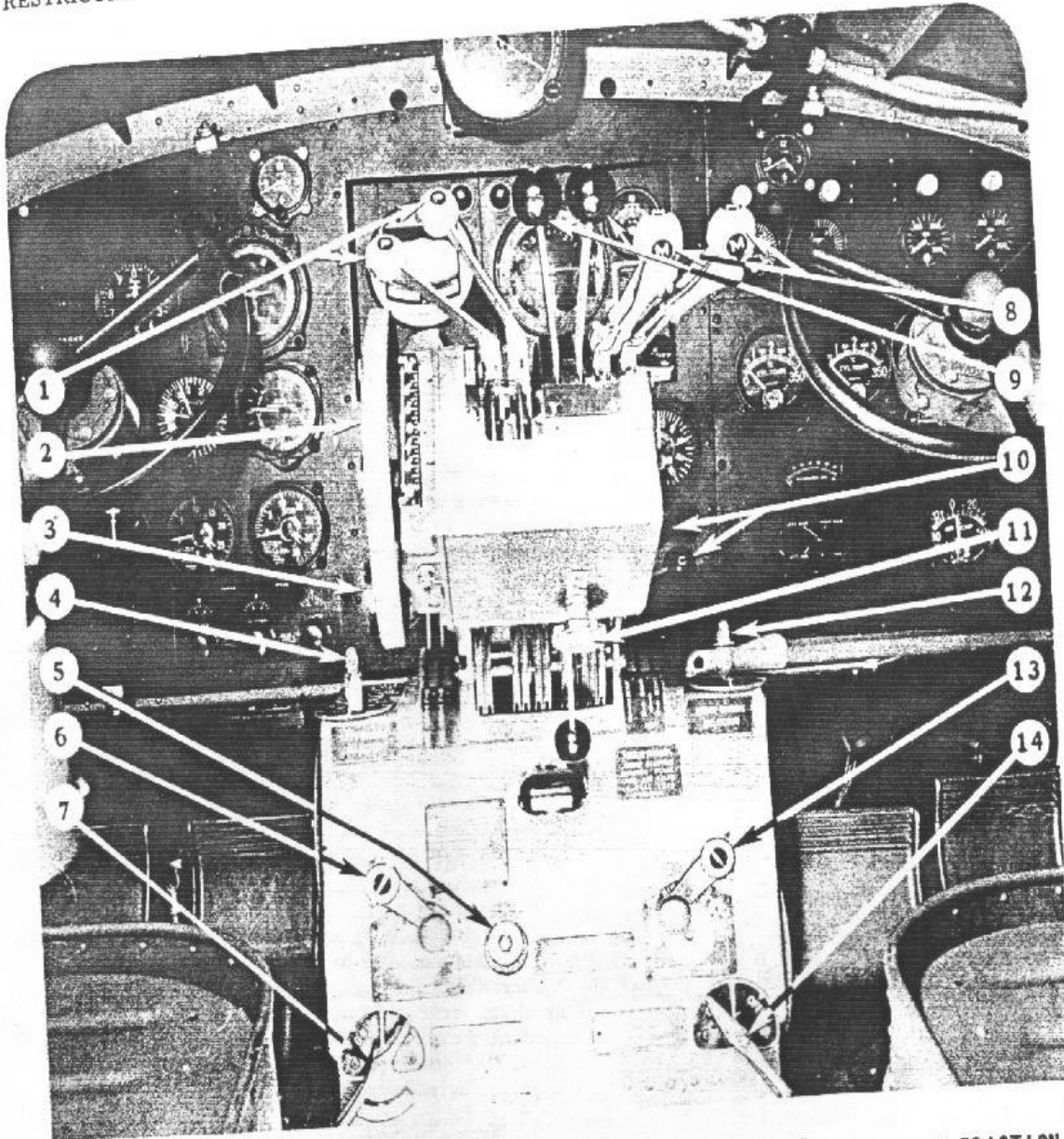
(b) Engine Fuel Tank Selectors. - Two engine fuel tank selector controls are provided. In normal operation, each engine has an individual fuel system and the left selector should be set to supply fuel from a left-hand tank to the left engine and the right selector to supply the right engine from a right-hand tank. The auxiliary (rear) fuel tanks should be filled first and the fuel should be used from the main (front) tanks first. The quantity of fuel in each system should be approximately the same.

(c) Cross-Feed. - Set control to "OFF" for starting engines, fuel pump pressure check and flight operation; to "ON" for take-off. In case of pump failure, set cross-feed to "ON" and in the event of line failure or fire, set control to "OFF." See T. O. No. 02-1-29 and T. O. No. 03-10-15 for use of fuel valve controls.

(d) Wobble Pump. - The wobble pump handle should be operated slowly and smoothly. Under all conditions when fuel pressure failure occurs, use the wobble pump immediately and then attempt to determine the cause.

#### (e) Operation in Case of Fuel System Failure.

1. Fuel Pump Drive or Vane Failure. - In the event of a fuel pump drive or vane failure, warning will be given by the illumination of the red fuel pressure warning light and a loss of fuel pressure. When



- |                                  |                                    |                                   |
|----------------------------------|------------------------------------|-----------------------------------|
| ① PROPELLER PITCH                | ⑥ RUDDER TAB                       | ⑪ THROTTLE FRICTION ADJUSTMENT    |
| ② ELEVATOR TAB                   | ⑦ AUTOMATIC PILOT ENGAGING CONTROL | ⑫ RIGHT ENGINE FUEL TANK SELECTOR |
| ③ OIL COOLER SHUTTERS            | ⑧ MIXTURE                          | ⑬ AILERON TAB                     |
| ④ LEFT ENGINE FUEL TANK SELECTOR | ⑨ THROTTLE                         | ⑭ CROSSFEED                       |
| ⑤ TAIL WHEEL LOCK PARKING BRAKE  | ⑩ CARBURETOR AIR                   |                                   |

Figure 14 - Control Pedestal



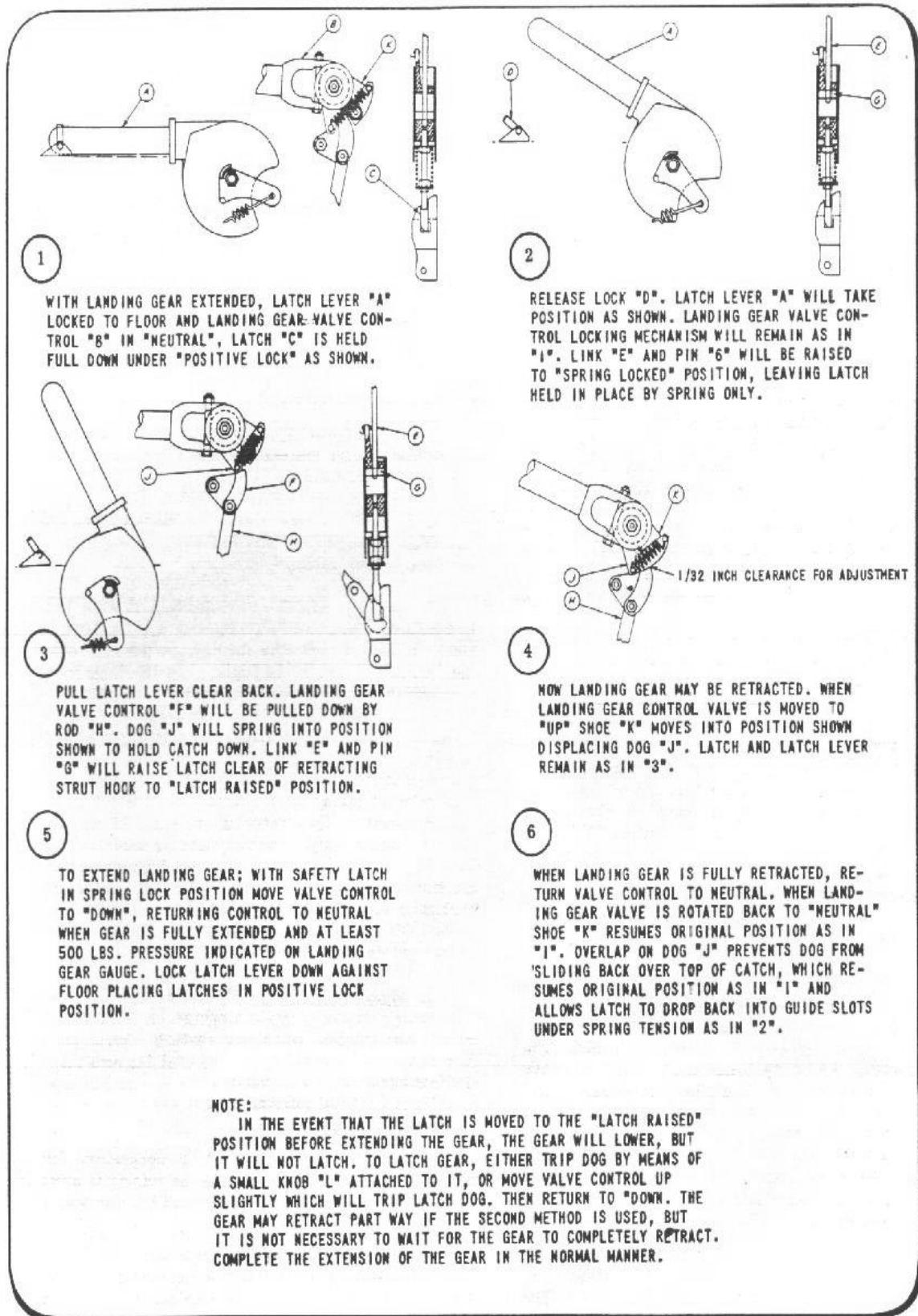


Figure 15 - Safety Latch Operation

such a condition exists, operate the wobble pump and turn the cross-feed valve control to "ON." This will allow the good fuel pump to supply fuel under pressure to both carburetors.

2. Fuel Pressure Relief Valve Failure. - In the event of a fuel pressure relief valve failing, the fuel pressure will drop on the engine affected. Operate the wobble pump and turn the cross-feed valve control to "ON." If the fuel pressure is still insufficient, it indicates that fuel is being forced back into the tank through the defective relief valve. In this case, the engine fuel tank selector for the affected engine should be turned to "OFF." This will block the return flow through the feed line with the defective valve and both carburetors will be supplied through the other main feed line and the cross-feed line.

3. Broken Fuel Line. - If a break occurs in a fuel line, warning will be given by the illumination of the red fuel pressure warning light and a loss of fuel pressure. Operate the wobble pump immediately; if operating the wobble pump does not bring up the fuel pressure, it indicates a broken fuel line. If such a condition arises, the fuel supply to the affected engine should be turned off by setting the engine fuel tank selector for the failing engine to "OFF." The engine should then be stopped by feathering the propeller and flight should be continued on one engine.

4. Power Recovery After Fuel Run-Out. - Power recovery after a fuel tank has run dry is considerably delayed by air and vapor passing through the vapor separator into the regulator body of the carburetor. It has been found that power recovery is quickest when the mixture control is placed in the "EMERGENCY" position. If a tank is allowed to run dry to the extent that the engine slows down, the throttle on the affected engine should be closed, the mixture control moved to the "EMERGENCY" position and the engine fuel tank selector set to supply fuel to the affected engine. The throttles should then be opened and the mixture control should be returned to its previous setting after the engine has assumed its normal operation.

(4) Starter Switches. - Three switches are provided for engine starting. All three switches are of the double-throw momentary contact type and will return to their original position when released. The center switch is a safety switch and is "ON" in either the up or down position. The other two switches control the starters of the right and left engines. To start either engine, hold the switch for that engine and the safety switch to the "UP" position to energize the starter. When the starter is sufficiently energized, pulling down on both switches will mesh the starter with the engine.

(5) Ignition Switches. - The ignition switch panel is located on the center line of the airplane just above the "vee" in the pilot's compartment windshield. The switch panel incorporates a master ignition switch and two individual switches as follows:

(a) Master Ignition Switch. - The master ignition switch has two positions controlling the circuits as follows:

"OFF." - All magneto and booster circuits grounded (magneto and booster inoperative).

"ON." - All magneto and booster circuits undergrounded (magneto and booster operative).

(b) Individual Engine Switches. - Each individual ignition switch controls the ignition of one engine and has four positions controlling the circuits as follows:

"OFF." - Both magnetos and booster inoperative (magneto and booster circuits grounded).

"R." - Right magneto operative; left magneto inoperative; (left magneto circuit grounded and right magneto circuit open).

"L." - Left magneto operative; right magneto inoperative; (right magneto circuit grounded and left magneto circuit open).

For normal operation, the master ignition switch should be pulled "ON" and the individual engine switches set to "BOTH."

(6) Cowl Flaps. - The cowl flap control valve has five positions: "CLOSE," "OFF," "TRAIL," "OFF," and "OPEN." To open the flaps, move the control to the "OPEN" position. In flight when the flaps have reached the desired position, return the control to "OFF." To trail the flaps move the control to "TRAIL" and leave it in that setting until it is desired to either open or close them. The cowl flaps should be fully open at all times when the airplane is on the ground. Just prior to taking-off the flaps should be put in the trailing position. Upon reaching cruising altitude, the flaps should be fully closed or used as necessary to keep the cylinder head temperatures from exceeding the maximum allowable limit. When the airplane is parked on the ground, the flap control should be kept in the "OPEN" position to prevent line breakage due to thermal expansion.

(7) Mixture Controls. - The metering injection carburetors installed in the airplane incorporate the Bendix one-position automatic mixture control unit. The floatless carburetor meters fuel through fixed orifices according to air venturi suction, and is provided with a manual mixture control which may be set in the following positions:

"EMERGENCY." - Without compensation for altitude or temperature by making the automatic mixture control inoperative (recommended for emergency operation only).

"AUTOMATIC RICH." - Usual operation position, automatically maintaining the desired mixture at all engine speeds and loads, independent of changes in altitude, temperature, propeller pitch, or throttle position.

"AUTOMATIC LEAN." - A leaner setting than "AUTOMATIC RICH" and suitable for cruising operation under favorable conditions. This setting may be too lean for good acceleration.

"IDLE CUT-OFF." - For stopping and for priming while starting.

**NOTE:** The accelerating pump is operated by and in proportion to the momentary changes in air pressure in the supercharger entrance. The accelerating pump is not connected with the throttle or throttle controls. Hence, no matter how rapidly the throttle is moved, no fuel is pumped from the carburetor when the engine is not running.

(8) Carburetor Air Controls. - Moving the controls aft to the "HOT" position opens the flap valves in the carburetor air scoops and allows heated air to enter the carburetor. Moving the controls forward closes the valves and allows only air at outside temperature to enter the carburetor. The lock lever (L) to the left of the carburetor air temperature controls will lock the controls in any position they are set. Use either full "HOT" or full "COLD" settings only.

**NOTE:** It has been found that the carburetors are most susceptible to icing near the closed throttle position. Consequently, when conditions arise that necessitate flying at a reduced air speed and a relatively high humidity, this reduction should be accomplished by lowering the landing gear or by means other than closing the throttles.

(9) Oil Temperature Controls. - Move controls forward to "HOT" position to close the shutters on the oil cooler and move controls aft to open the shutters.

(10) Manifold Pressure Gage Selector Valve. - The manifold pressure gages installed in this airplane are very important in their relation to engine power and engine trouble determination because the constant speed-type propellers remove two factors of engine performance which have normally been used as a double check of engine operation. In order that manifold pressure gage inaccuracies may be checked at any time in flight or on the ground, a four-way broach valve is installed on the lower section of the pilot's instrument panel which may be used as follows when there is any question as to the accuracy of the gages or the operation of the engines.

(a) The position of the valve to the extreme left connects the left gage to the left engine and the right gage to the right engine in the normal manner.

(b) The next position of the valve to the right vents both gages to the atmosphere. If the gages themselves are accurate, they should both read the same when the valve is in this position.

(c) The third position to the right reverses the instruments, the right gage showing the left engine pressure and the left gage showing the right engine pressure. A variation of manifold pressure with the valve in this position will indicate an actual difference in the engines, or oil in the manifold pressure gage lines.

(d) The extreme right position opens both manifold pressure lines to cockpit pressure for the purpose of removing oil from the lines on the ground or in flight. Before going to this position, the throttles should be set to give a manifold pressure reading lower than the true pressure altitude, reading obtained with the valve in position "2." This will assure that any oil in the lines will be sucked back into the engine rather than be blown out behind the instrument panel.

#### d. Other Controls.

(1) Engine Hydraulic Pump Selector. - In normal operation, the pump selector handle is in the vertical position, the hydraulic pump on the left-hand engine supplying pressure to the hydraulic system and the right-hand engine pump furnishing pressure to the automatic pilot system. By swinging the handle out into the aisle and moving it clockwise approximately 45 degrees, the flow of both pumps may be reversed, allowing the left pump to operate the automatic pilot and the right pump the main hydraulic system.

(2) Engine Fire Extinguishers. - A CO<sub>2</sub> pressure fire extinguisher system is installed in the airplane to put out any fires in the engine section. The controls for the fire extinguisher are located in a box under the floor between the pilot's and copilot's seats. In bringing an engine section fire under control, the following should be kept in mind:

(a) Prompt action in cutting off the fuel supply to the affected engine and operating the fire extinguisher system will aid in reducing the damage.

(b) Stop rotation of the affected engine immediately by feathering the propeller to prevent fuel and oil being fed into the blaze.

**NOTE:** Immediately after noticing a fire, proceed as follows:

(c) Turn the engine fuel tank selector to "OFF" for the engine on fire.

(d) Be sure that cross-feed is "OFF."

(e) Move the mixture control to "IDLE CUT-OFF."

(f) Feather the propeller and turn the individual ignition switch to the "OFF" position for the affected engine.

(g) Close the cowl flaps and oil cooler shutters.

(h) Set the fire extinguisher selector valve to the engine on fire and pull the "RED" handle.

(3) Generator Main Line Switches. - In case of the failure of one generator, or in case it is desired to operate one generator only, the generator main line switch for the generator that is to be isolated may be switched "OFF." In normal operation, both switches should be in the "ON" position.

(4) Heating and Ventilating System.

**Caution** When operating in extreme cold weather, to prevent the freezing of the steam heating system, the following method will be used immediately upon landing whenever precautionary measures are indicated. With the engines still running, drain the water from the system. When the system is free of water, stop the engines. Close the drain valve and pour approximately one quart of alcohol in through the filler opening. When the airplane is to be flown again, allow the engines to warm up. This permits the alcohol to vaporize. Then fill with water.

(a) To Fill on the Ground with the System Cold (Right-Hand Engine not Running).

1. Close the drain cock below boiler in the right-hand nacelle and open filler-funnel valve at the water tank in nacelle.

2. Fill the system with distilled or soft water (approximately four U. S. quarts, 3.3 Imperial quarts).

3. Close filler-funnel valve.

4. Check to see that the steam shut-off valve is in the "ON" (down) position before starting right engine.

(b) To Fill on Ground When Temperature Is Below Freezing and System Is Empty.

1. Close the drain cock below the boiler.

2. Check to see that the steam shut-off valve is in the "ON" (down) position before starting the right engine.

3. Start the right engine and allow the boiler to become hot.

4. Open valve at filler-funnel and add approximately 4 U.S. quarts (3.3 Imperial quarts) of hot water.

5. Close the valve at the filler neck immediately.

(c) To Drain System. - Open the drain cock below the boiler and drain the system.

(d) To Shut Off Heat. - In case of a steam line failure or in case it is desired to shut off the steam, pull the steam shut-off valve to the "OFF" (up) position.

(5) Hydraulic Hand Pump. - The hand pump will supply all hydraulic units including the brakes when the hand pump-to-pressure tank shut-off valve is in the "OFF" position. To charge the pressure tank (ACCUMULATOR), the shut-off valve must be opened. Use slow, smooth strokes when operating the hand pump.

(6) Oxygen and Its Use.

**Danger** Every precaution must be observed to prevent spontaneous combustion. Keep oil, grease, and all readily combustible material well away from all oxygen apparatus. Be sure hands and clothes are clean.

(a) Oxygen is required by the human body to maintain proper functioning of the nervous system and to prevent injury to the body cells. The body obtains its supply of oxygen from the blood which in turn absorbs oxygen from the air in the lungs. The oxygen content of the air decreases proportionally with increased altitudes, thus decreasing the quantity of oxygen in the lungs available for absorption by the blood.

(b) Due to the decreased density of the air, altitudes of 10,000 to 12,000 feet will require the use of an additional supply of oxygen, if flight is maintained for one hour or longer. At altitudes of 15,000 feet and above, the continuous use of an additional supply of oxygen is required.

(c) Oxygen is nonpoisonous, and has no deleterious effect on the dental restorations, and no ill effects will result from supplying more than the required amount of oxygen other than unnecessarily depleting the available oxygen store.

(d) The requirements of oxygen by the body is increased by the following factors:

1. Physical effort performed.

2. Shivering.

3. Excitement.

(e) Only through experience can personnel recognize oxygen deficiencies since the lack of oxygen in the body produces very few recognizable symptoms. Most cases of oxygen deficiencies are caused by one of the following reasons:

1. Oxygen being partly or totally shut off by kinking of the tubing leading from regulator to mask.

2. Orifices in regulator becoming obstructed.



3. Attempts of personnel to do hard work.

4. Freezing of moisture in the oxygen at extremely low temperatures caused by using oxygen having moisture content in excess of specification limits.

5. Oxygen supply exhausted by leaks.

6. Accelerated Breathing. - The partial vacuum created inside the mask by accelerated breathing tends to draw outside air into the mask through the sponge-rubber exhaust discs or to partially collapse the mask to the face permitting outside air to be drawn into the mask. Both of these conditions tend to dilute the pure oxygen within the mask.

(7) Propeller Anti-icer. - When icing conditions are prevalent, turn the propeller anti-icer switch "ON" and turn the propeller anti-icer rheostat to the full capacity position and after one-half minute turn back to desired output setting. The output of the pump varies from 10 U. S. quarts (8.3 Imperial quarts) of fluid per hour at a fast setting to 4 to 6 U. S. quarts (4.99 Imperial quarts) per hour at a slow setting.

(8) Communications Equipment.

(a) General. - All of the communications equipment may be operated to some extent from the pilot's compartment. Receiver and transmitter frequency selection of this equipment may be controlled, with the exception of the liaison equipment which must have both its transmitter and receiver frequencies set from the radio operator's position.

**Caution** For normal operation of all communications equipment the crystal filter selector switch should be set at "BOTH." To receive the radio range without possibility of voice interference, set the selector switch to "RANGE." To receive voice without range interference, set selector switch to "VOICE." It is impossible to receive voice when this switch is set on "RANGE."

**NOTE:** The headset extension cord should be plugged into the crystal filter selector control box, and not into the interphone jack box or the receiver control box.

**IMPORTANT:** When the throat microphone is being used for either interphone or radio communication, it must be adjusted so that its two circular elements are held snugly against each side of the throat just above the "Adam's apple." SPEAK SLOWLY, DISTINCTLY, AND IN A NORMAL TONE OF VOICE. Shouting will seriously distort the voice signal.

A possible means of limiting noise level in all radio equipment, caused by adverse conditions such as rain, snow, ice, or sand, is to direct the radio operator to proceed as follows:

1. Place the antenna change-over switch to the fixed antenna position.

2. Release approximately 50 feet of the trailing wire antenna.

3. Ground the trailing wire antenna post directly to the airplane structure (for instance, the metal support for the transmitter tuning units).

**NOTE:** The C-47 Airplane may be equipped with either the type SCR-183 or the type SCR-274N command set and because of this condition the operation for both type of sets are given.

(b) Command Set Type SCR-183.

1. Description.

a. The radio installation consists of a type SCR-183 command set equipped with a range filter and a throat microphone. A "push-to-talk" button is provided on the engine throttle, with all other operating controls located on the right side of the cockpit.

b. Receiver. - The receiver is calibrated and adjusted to receive the radio range frequencies between 201 kc and 398 kc, and the tactical communication range between 2500 kc and 7700 kc. Provisions for receiving other frequencies can be installed by a radio technician.

c. Transmitter.

(1) The transmitter will operate on any frequency between 2500 kc and 7700 kc at which it is set by the radio technician. It is capable of transmitting voice, modulated CW (MCW) or straight CW signals.

(2) The effective range of the transmitter for dependable voice transmission is approximately 25 miles.

2. Operating Instructions.

a. Receiver.

(1) Turn receiver control box selector switch on "MANUAL." Plug receiver phones in jack number JK-26 and turn "INCREASE OUTPUT" control knob to the right until a frying noise or signal is heard in the receiver.

**Caution** For all normal (voice or MCW) reception, the radio receiver crystal filter selector switch should be set at "BOTH." To receive the radio range (MCW) without possibility of voice interference, set the selector switch to "RANGE." To receive voice without possibility of radio range interference, set the selector switch to "VOICE."

**Caution** It is impossible to receive voice when this selector switch is set on "RANGE."

(2) To receive the radio ranges and control tower on 201 kc to 398 kc, set the "Hi-Lo" selector switch to "Lo." Refer to CAUTION under paragraph 2.a.(1). Adjust tuning dial knob for desired frequency as calibrated on the inner scale of tuning dial.

**NOTE:** When tuning receiver for a definite frequency, always turn dial a little to each side of the frequency calibration mark to find the point where the signal is strongest. This procedure is to be followed when the receiver selector switch is set on "MANUAL."

(3) To receive tactical frequencies, turn the "Hi-Lo" selector switch to "HI." Adjust tuning dial knob for desired frequency as calibrated on the outer scale of the tuning dial. The intermediate scale on the tuning dial (0-100 scale) is used only in special instances when special frequency ranges are being used, and require installation of special coils by radio maintenance personnel. In this case, there will be found a metal "FREQUENCY IN KC" calibration chart installed in every cockpit near the tuning dial.

**NOTE:** The "Hi-Lo" selector switch is connected to the receiver by a spring cable and must be operated by the "click-and-feel" method. Care must be taken to insure proper contact in either "HI" or "LO" position, since the position of the pointer does not accurately indicate the setting.

#### (4) To Receive Code.

(a) Straight continuous wave signals (CW) cannot be heard on this receiver as it is not equipped with a beat frequency oscillator.

(b) Tone (MCW) signals may be heard on this receiver by tuning in the same manner as for voice reception with the radio range filter selector switch set on "BOTH."

(5) The receiver (and transmitter filaments) may be turned off by placing the control box selector switch in its "OFF" position.

#### b. Transmitter.

(1) Microphone Instructions. - Place throat microphone around neck and adjust the band so that its two circular elements are held snugly against each side of the throat just above the "Adam's apple."

(2) Transmitting Etiquette. - Before transmitting, adjust radio receiver to the same frequency as the station to which you desire to talk, and "listen-in" to be sure the operator is not talking to some one else. If the station is transmitting, take advantage of

the opportunity to more accurately set the airplane receiver on the assigned frequency, and when the other operator is through, proceed with your transmission.

#### (3) Voice Transmission.

(a) Set transmitter emission selector switch to "VOICE."

(b) When the selector switch is set on "AUTO" or "MANUAL," press the microphone button located on the engine throttle and start talking. Speak slowly, distinctly, and in a normal tone of voice. Shouting will seriously distort the voice signal.

(c) Release the microphone button when through talking.

#### (4) Code Transmission.

(a) Tone (MCW). - Set transmitter emission selector switch to "TONE" and operate transmitter key.

(b) CW. - Set transmitter emission selector switch to "CW" and operate transmitter key.

**NOTE:** Any receiving station "standing by" a particular frequency and expecting voice signals will hear any "TONE" (MCW) code transmissions. However, this station will not hear "CW" signals unless his receiver is equipped with a beat frequency oscillator and the oscillator is turned on. Ground stations and bombers are usually equipped with receivers containing a beat frequency oscillator. Fighter airplanes are not equipped to receive "CW" signals.

### OPERATION NOTES FOR PILOT.

#### a. Unable to Receive.

(1) Ascertain that receiver selector switch is on "MANUAL" or "AUTO."

(2) Ascertain that the "Hi-Lo" switch is in proper position and making good contact. Refer to NOTE under paragraph 2.a.(3). Test receiver operation on band known to be in use.

(3) Systematically check for secure connections in all cables and wires about the radio controls, starting with headset and ending at the receiver control box.

(4) Turn range filter switch pointer to all positions to be sure internal contact points were making good electric connection, or that it was not set somewhere between positions.

(5) Turn volume control through its entire range to test for an intermittent short circuit or some isolated position where receiver is inoperative.

b. Unable to Transmit.

(1) Ascertain that receiver (and transmitter filament) selector switch is set on "MANUAL" or "AUTO."

(2) Be sure the transmitter emission selector switch is not setting between positions.

(3) Carefully inspect microphone for evidence of damage due to rough treatment.

(4) Systematically check for secure connections in all cables and wires about the radio controls, starting with the microphone and ending at the transmitter control box.

(5) If transmitter does not "come on" for voice transmission when the "press-to-talk" button on the engine throttle is operated, hold the transmitter key down; operate the "press-to-talk" button if failure was on "TONE" or "CW."

NOTE: The key and "press-to-talk" button may be substituted for each other for any three positions of the transmitter emission control.

(c) Command Set Type SCR-274-N.

1. General. - The command set is designed for short range operation and is used for communicating with nearby aircraft for tactical purposes and with ground stations for navigational and traffic control purposes.

2. Receiving. - The interphone jack box switch must first be placed in the "COMMAND" position. The receiver control box is divided into three identical sections, each of which controls the particular receiver to which it is electrically and mechanically connected. Reception of a signal of specific frequency as indicated on the dial is accomplished by the use of the section of the receiver control box which controls the particular receiver involved. The desired receiver is turned on and off by a switch located in the right aft corner of the control box section used. This switch, in addition to having an "OFF" position, has two selective positions marked "CW" and "MCW," each of which is an "ON" position and indicates the type of signal which is to be received. The "A-B" switches should be left in the "A" position at all times and need not be turned off when the receivers are turned off.

NOTE: When tuning receiver for a definite frequency, always turn dial a little to each side of the frequency calibration mark to find the point where the signal is the strongest.

3. Transmitting.

a. Before transmitting, adjust radio receiver to the same frequency as the station with which you

desire to converse, and listen in to be sure that the operator is not talking to someone else. If the station is transmitting, take advantage of the opportunity to more accurately set the airplane receiver on the assigned frequency, and when the other operator is finished, proceed with your transmission.

b. Throw the switch marked "OFF-ON" on the transmitter control box to the "ON" position. Select type of transmission desired with switch marked "TONE-CW-VOICE." With the switch in the "VOICE" position, the microphone from any interphone jack box switched to the "COMMAND" position will be operative and voice will be transmitted when the "push-to-talk" button on the control wheel is pressed. With the switch turned to the "CW" position, a "continuous wave," or unmodulated signal will be transmitted, and with the switch turned to the "TONE" position, a modulated tone signal is transmitted. Greatest effective range can be obtained on "CW." Range is most limited when operating on "VOICE."

c. On both the "CW" and "TONE" positions, the microphones are inoperative, and signaling by code is accomplished by a key which is located on the forward end of the transmitter control box.

NOTE: To reduce battery drain and to increase dynamotor life, the "TONE-CW-VOICE" switch should be left on "VOICE" unless continued use on "CW" or "TONE" is expected.

(d) Interphone Equipment RC-36 or RC-45. - The interphone jack boxes have five selective positions marked on the face of the box, as follows:

1. "COMP." - The audio output of the radio compass is heard.

2. "LIAISON." - The pilot may voice modulate the liaison transmitter and can hear the audio output of the receiver.

3. "COMMAND." - The pilot is able to modulate the command transmitter and can hear the audio output of the receiver.

4. "INTER." - In this position the pilot may communicate with any other crew member who also has his interphone jack box switch at the "INTER" position.

5. "CALL." - This is an emergency position which enables any crew member to call all other members of the crew regardless of the position of their interphone jack box switch.

(e) Radio Compass SCR-269 or SCR-280.

1. Set the interphone jack box switch to the "COMPASS" position, if aural reception of the compass receiver is desired. If only visual indication is desired, the switch does not have to be set in the "COMPASS" position.

2. The radio compass equipment is designed to perform the following functions:

a. Aural reception from the fixed antenna or from the rotatable loop. For signal reception during interference caused by precipitation, static, or proximity of signal, the loop will prove superior.

b. Aural-null directional indication of an incoming signal with the loop only in use.

c. Visual unidirectional left-right indication of an incoming signal.

3. The receiving unit is turned on or off by a switch on the face of the remote control box, which in addition to having an "OFF" position, has three other positions: "COMP," "ANT," and "LOOP."

a. With the switch in the "COMP" position, both the rotatable loop and the fixed antenna are in use.

b. In the position marked "ANT," only the fixed antenna is in use.

c. With the switch turned to the "LOOP" position, only the rotatable loop is in use.

4. If the green indicator on the face of the control box does not light, depress button marked "CONTROL" to establish control. Select frequency band desired as indicated in kilocycles on the face of control box and tune by use of the crank to the desired frequency. The loop may be rotated to any position as indicated on the radio compass azimuth indicator by use of the crank MC-204. This particular operation is necessary only when operating on "LOOP" position of the selector switch. During periods of precipitation static, operate on "LOOP." For best aural reception, rotate the loop until a maximum signal is obtained. Proper volume may be obtained by use of knob marked "AUDIO."

5. Select radio stations providing stable bearing. Tune the equipment carefully. If an interfering signal is heard in the headset, it is probably causing an error in bearing. To check, tune a few kilocycles either side of resonance. A change in bearing with tuning indicates an interfering signal. If station interference exists, select another station or proceed by other means of navigation until closer to the desired station. Do not use a station for bearing unless it can be identified by the headset signal on "COMP" operation.

**Warning** Do not depend on the tuning meter as a distance meter.

When encountering severe precipitation static (rain, snow, or sleet), use radio compass on "LOOP" to limit noise and turn loop by use of the crank until maximum signal is received.

**NOTE:** If radio compass SCR-269 is installed instead of the type SCR-280, the operation is identical, EXCEPT that the loop is rotated electrically by means of the "L-R" loop antenna switch.

(f) Marker Beacon Equipment RC-39 or RC-43. - Since the operation of the marker beacon equipment is fully automatic, no manual operation is necessary. As the ship passes over a fixed point from which a marker beacon signal is being transmitted, the signal is picked up by the receiver, causing the indicator to flash on, showing the pilot that he has passed over a marker beacon. The marker beacon equipment is simultaneously turned on when the radio compass is put into operation. The position of the interphone jack box switch does not affect the operation of the marker beacon equipment.

(g) Liaison Set SCR-187 or SCR-287.

1. The liaison equipment is to be used for long range communication. Limited control is available to the pilot. The type of reception and transmission desired must be forwarded to the radio operator who will in turn put the radio equipment in operating condition.

2. Set the interphone jack box switch to the "LIAISON" position to receive or transmit with the liaison equipment.

3. It is possible for all crew members to receive on this equipment, but only the pilot, copilot, and radio operator may transmit.

(h) Radio Set SCR-535 (IFF). - The remote OFF-ON switch for this equipment is located adjacent to the pilot's position. The two destroyer push buttons are located adjacent to the "OFF-ON" switch. The destroyer switches should be used only when it is contemplated abandoning the airplane over unfriendly territory. When both destroyer push buttons are pressed simultaneously a detonator is set off in the receiver which is located in the radio compartment. The explosion of the detonator will destroy the receiver internally. No damage should be done to either the airplane or personnel at the time of destruction of the set, but bodily contact with the receiver at the time of detonation should be avoided.

**NOTE:** Regeneration adjustment of the "IFF" set must be made on the ground prior to flight in order to insure correct operation of the equipment.

(i) Radio Set SCR-578 (Emergency Transmitter). - The emergency transmitter, is meant to be used in the event of an emergency landing on water.

**DANGER:** The voltages developed by aircraft radio transmitters are sufficiently high to cause severe burns or even death, and this equip-



ment will not be operated unless all cover plates are in place. To avoid the possibility of fire, no installed radio transmitter will be tested or operated in any way so that the dynamometer is running, until all parts of the antenna system are at least one foot removed from any object other than the airplane itself.

(9) Rudder Pedal Adjustment. - Push lever out with side of foot, adjust pedal to desired position and release lever. Insure that plunger is again properly seated.

(10) Seat Adjustment.

(a) Pilot's and Copilot's Seats. To move seat fore and aft, pull out on the cable located on the inboard side of the seat and slide the seat to the desired position. Release the cable and insure that the locking pins are properly engaged. To raise the seat, pull up on the lever located on the outboard side of the seat and ease the body weight off the seat, allowing the seat to raise to the desired position. Release the lever and insure that the locking pins are properly engaged. To lower the seat, pull up on the lever and allow body weight to move the seat down. At the desired position, release the handle and insure that the locking pins are properly engaged.

(b) Radio Operator's Seat. - Pull out on handle and swivel seat to desired position. When seat is in desired position, release handle. There is no adjustment for height on the radio operator's seat. The radio operator must face forward for all take-offs and landings.

(11) Windshield Anti-icer. - When icing conditions are prevalent, see that the valve below the supply tank above the pilot's entrance door and the shut-off valves below each window are open, and operate the hand pump as required.

(12) Windshield Wiper. - When ice forms on the windshield and the windshield anti-icer does not remedy this condition, the wiper should be used as necessary to assist the anti-icer in removing the ice.

(13) Surface De-icer Equipment. - De-icing Equipment - General: Goodrich de-icing shoes are installed on the leading edges of the wing and horizontal and vertical stabilizers. The shoes are inflated by the exhaust from the vacuum pumps. Air lines run from the pumps to the oil separators which are also located in the engine section. The oil from the oil separators passes to the engine crankcase at

the oil vent fittings. The air lines from the separators connect at the three-way valve which is a part of the distributor valve. When the de-icing system is in use, this valve connects the pumps and the distributor valve through an Eclipse air filter. When not in use, the air is discharged into the engine exhaust manifold. The outlet ports of the distributor valve are connected directly to the shoes. The valve is rotated by an electric motor once every 40 seconds, and on every rotation all of the shoes are inflated and deflated. Each shoe remains inflated for approximately eight seconds. The cycle is as follows:

(a) Center tubes on right and left outboard outer wing shoes.

(b) Upper and lower tubes on right and left outboard outer-wing shoes.

(c) Center tubes on right and left inboard outer-wing shoes.

(d) Upper and lower tubes on right and left inboard outer-wing shoes.

(e) Empennage shoes.

(14) Emergency Exits.

(a) Pilot's Upper Escape Hatch. - The pilot's upper escape hatch is located in the roof of the pilot's compartment. The hatch is opened by rotating the handles toward the center and pushing up on the forward edge of the panel. If the airplane is in flight, the air stream will carry the panel away.

(b) Main Cargo Compartment Emergency Exits. - Three emergency exits are provided in the main cargo compartment, two of these are incorporated in windows on each side of the airplane and one is in the main cargo loading door. To open the window emergency exits, turn the handle below the window to the right and push the panel out and up clear of the airplane. To open the main cargo compartment door panel, turn the handle on the removable panel in the door and pull the door into the airplane. This door may also be used for parachute troop training purposes.

(c) Emergency Equipment and Routes of Egress. (See figure 2.)

(d) Parachute Pack Salvo Switch. - The parachute pack salvo switch is located on the electrical control panel and permits release of the packs in case of emergency.

## SECTION IV

PILOT'S OPERATING INSTRUCTIONS1. Engine Starting.

a. If engines have been standing idle in excess of one hour, make certain that engines are pulled through by hand with switches "OFF."



b. With auxiliary battery cart connected to airplane, airplane battery switches should be in the "OFF" position.

c. Cross-feed valve position - "OFF."

d. Right engine tank selector - "RH MAIN."

e. Left engine tank selector - "OFF."

f. Cowl flaps "OPEN" for all ground operation.

g. Propellers - "LOW PITCH."

h. Throttles - "1/4 OPEN."

i. Mixture - "IDLE CUT-OFF."

j. Carburetor air - "COLD."

k. Main ignition switch - "ON."  
Right engine switch - "BOTH."

l. Raise fuel pressure to two to three pounds per square inch with wobble pump.

m. Prime with hand primer as required.

n. With the fuel pressure at 10 pounds, operate starters by moving right starter and safety switch up to the "START" position and pulling down on both switches when the starters have reached speed.

o. As soon as engine fires, move the mixture control without hesitation to "AUTOMATIC RICH."

p. Continue to operate the wobble pump until the engine is running smoothly.

q. Idle the engine at 600 to 800 rpm until oil pressure shows on gage, then adjust throttle to 1000 rpm. Do not continue running engine if oil pressure does not respond within first 30 seconds.

r. Turn left engine tank selector to "LH MAIN" and repeat the procedure to start the left engine.

2. Warm-Up.

a. Warm up engine at 800 to 1000 rpm with propeller in "LOW PITCH" until oil temperature reaches 40°C (104°F) minimum. Cylinder head temperatures should not exceed 232°C (450°F).

b. Adjust the engine speed to 1500 rpm by the throttles and move the propeller controls from low to high pitch a few times to bring warm oil into the propeller hub.

c. Run engines at 30 inches Hg manifold pressure. Engine speed should be approximately 2350 rpm.

d. Check magnetos at 25 inches to 30 inches manifold pressure. Drop-off from two magnetos to one should be 50 to 75 rpm. The difference in magneto drop between left and right should not exceed 30 to 40 rpm.

e. Check operation of cross-feed and of all fuel lines.

3. Prior to Taxying.

a. When battery cart is disconnected from airplane, turn airplane battery switches "ON."

b. Have landing gear pins pulled when landing gear pressure indicates 750 pounds per square inch.

c. Check flight controls for freedom of movement.

d. Both auto pilot control valves "OFF."

e. Tail wheel - "UNLOCKED."

f. Cowl flaps - "OPEN."

g. Mixture - "AUTO RICH."

4. Taxying.

a. Taxying is done by using the brakes and the engines. Open and close the throttles gradually and do not accelerate the engines fast enough to cause detonation.

d. Cowl flaps - "OPEN."

c. Mixture - "AUTO RICH."

5. Prior to Take-Off.

- a. Fuel selector valves on main tanks.
- b. Carburetor mixture controls - "AUTO RICH."
- c. Carburetor heat - "FULL COLD."
- d. Oil cooler shutters - as necessary.
- e. All trim tabs - "NEUTRAL."
- f. De-icer valve - "OFF."
- g. Propeller pitch control - full "LOW PITCH," high rpm.
- h. Cross-feed valve - "OFF."
- i. Cowl flaps position - "TRAILING."
- j. Wing flaps position - "UP," valve in "NEUTRAL."
- k. Tail wheel - "LOCKED."

6. Take-Off.

a. Copilot should have his left hand on the wobble pump handle in order to maintain fuel pressure in event of engine fuel pump failure, and his right hand on back of the throttle controls in order to prevent creeping.

b. When sufficiently clear of ground, and on signal from pilot, copilot will unlatch mechanical latch handle and pull to "LATCH RAISED" position and move landing gear hydraulic control valve handle to the "UP" position. When landing gear is fully retracted, landing gear hydraulic control valve handle will be returned to neutral.

c. Maximum take-off power is recommended for each take-off. This power should not be reduced until approximately 120 mph has been reached. Throttles should then be moved to give approximately 35 inches and propeller rpm reduced to 2550. When approximately 400 feet has been reached, power should again be reduced - first with the throttles to 29 inches and rpm then reduced to 2250.

d. When cruising altitude has been reached, cowl flaps should be placed in "CLOSED" position and the valve returned to "OFF" position; and the engine power should be reduced to desired cruising setting (mixture control in "AUTO LEAN").

7. Approach and Landing. 2300 RPM

a. Set fuel tank selector valves to tank containing greatest amount of fuel for left side and right side.

b. Engine cross-feed valve "OFF."

c. Wind de-icer valve "OFF."

d. Both auto pilot valves "OFF."

e. Mixture controls set to "AUTO RICH."

f. Cowl flaps closed.

g. Extend landing gear, at an indicated speed not in excess of 160 mph, by placing landing gear hydraulic control valve handle in the "DOWN" position. When 750 pounds is indicated on the landing gear pressure gage, return landing gear hydraulic valve control handle to neutral and lock mechanical latch handle in the "DOWN" position with the floor clip.

h. On final approach, extend flaps at a speed not in excess of 125 mph indicated.

i. Adjust propeller controls to give approximately 2500 rpm.

j. Make certain tail wheel is locked and depress brakes to check for normal pedal pressure.

k. With gross weight of 26,000 pounds or less, final approach may be made with very satisfactory control at 100 mph indicated.

l. Speed may be reduced to approximately 85 mph as the field boundary is passed and the landing flare is started.

m. Normal three-point landings can easily be accomplished with the airplane although it is advisable for pilots with limited experience in this type of airplane to bring the ship in on the main wheels.

n. In the event of possible over-shooting, brakes may be fully applied, even though ship is in the "TAIL HIGH" position, if speed has not been reduced below approximately 40 mph and providing "UP" elevator is applied. Below this speed it is advisable to gradually decrease brake pressure.

o. After landing, tail wheel should be unlocked and cowl flaps fully opened, landing flaps raised.

8. Stopping Engines.

a. Idle at 1000 rpm to cool engine below 180°C (350° F).

b. Propellers - "LOW PITCH."

c. Stop engine by placing mixture control in "IDLE CUT-OFF."

d. Turn ignition "OFF" after engine stops.

e. Fuel tank selectors - "OFF."

9. Oil Dilution.

a. If a cold weather start is anticipated, stop engine in normal manner and allow to cool for 15 minutes.

b. Restart engine, run at 800 rpm and hold down the oil dilution switch from one to five minutes, stopping the engine in the normal manner.

c. When starting engines with diluted oil, take-offs may be made four minutes after starting if there has been any rise in oil temperature, if the oil pressure remains steady and if the engine runs smoothly; or as soon after four minutes as these conditions are obtained.

10. Flight Restrictions.a. Maneuvers Prohibited.

- (1) Loops.
- (2) Spins.
- (3) Rolls.
- (4) Immelmans.
- (5) Dives.
- (6) Vertical banks.
- (7) Stalls.
- (8) Inverted flight.

b. Other Restrictions.

(1) Do not exceed air speed of 207 mph indicated in level flight.

(2) Do not exceed air speed of 255 mph indicated in a glide.

(3) Do not exceed an engine speed of 3060 rpm in a dive.

(4) Do not lower wing flaps at a speed in excess of 125 mph indicated.

(5) Do not lower landing gear at a speed in excess of 160 mph indicated.

(6) No glider tow ropes will be used which have a breaking strength in excess of 9000 pounds.

(7) Restrictions on the Use of the Automatic Pilot.

(a) The airplane will not be operated by means of the automatic pilot in extremely turbulent air, when surface de-icers are operating or when one or more engines are not delivering normal power output.

(b) The airplane will not be placed under control of the automatic pilot at any speed or altitude

until the pilot has determined by manual operation that the existing flight conditions permit safe control by the automatic pilot, and in no case will automatic pilots be used when the airplane is flying at less than an indicated air speed of 40 mph above the stalling speed.

(c) The airplane will not be operated under control of the automatic pilot without at least one rated pilot remaining "on watch" and maintaining a close check of the airplane and instruments.

(8) Restrictions on Practicing Single Engine Operation. - Practice flights involving single engine operation may be made at any altitude, provided that at no time will propellers be feathered, unfeathered, or braked at less than 5000 feet above the surface over which the flight is being made. Owing to the damage to the brakes incurred each time they are operated, propeller brakes will be used only in case of emergency, except where practice is deemed necessary for personnel to become familiar with the operation of this equipment and the attitude of the airplane. In such a case the number of applications will be limited to the absolute minimum. Use of the engine remaining in operation will be such as to avoid a power output which will damage them.

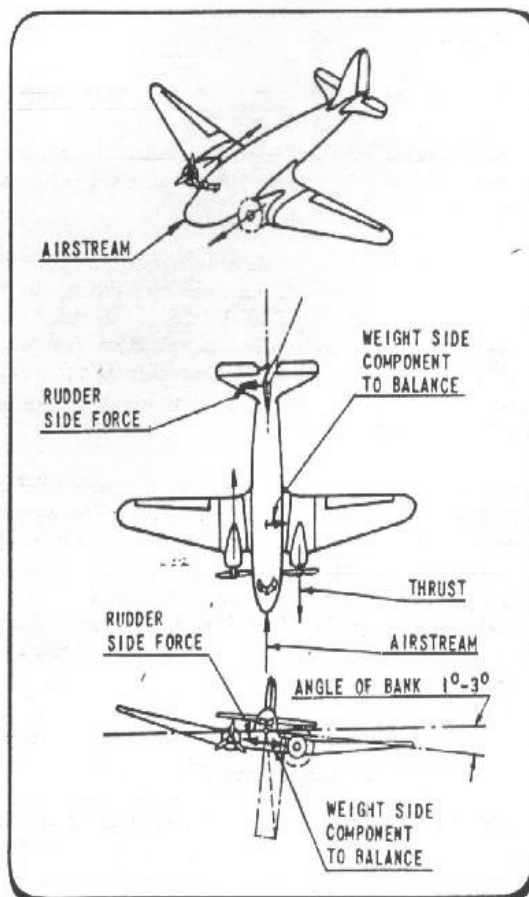


Figure 16 - Correct Attitude for Single Engine Flight



(a) Technique.

1. General. - The technique of flying multi-engine airplanes with one or more engines inoperative, is essentially the same for all airplanes of this type. However, the severity of control necessary to maintain the airplane in its normal attitude in this condition depends primarily on the power loading and high speed of the airplane. In general, the lower the power loading and the higher the maximum speed of multiengine airplanes becomes, the more difficult it is to maintain directional control in this condition. It has not been proved practicable in most modern high-performance multiengine airplanes to provide sufficient directional control at speeds near the stalling speed to offset the yawing effect of the engine or engines on one side operating at full power while those on the other side are inoperative. Furthermore, as the wing loadings are increased and power loading decreased, the change in directional trim with changes in speed becomes more marked. It may be very difficult if not impossible to maintain directional trim or control during rapid changes of speed, with partial engine operation. It is therefore essential that all pilots on high-performance, multiengine airplanes ascertain the minimum indicated air speed and appropriate technique for safe controllable flight during partial engine operation for each type of airplane flown.

2. Operation of Engines. - The following engine operation instructions will be used when flying multiengine airplanes with one or more engine use-  
less:

a. Place the propeller of the useless engine in the full feathered position as soon as possible after the airplane is under control to reduce the propeller drag to a minimum and to prevent "windmilling." If the propeller will not feather, an attempt will be made to "windmill" the propeller at the lowest possible speed ("HIGH PITCH" position, low rpm).

b. Shut off the fuel to the useless engine and the fuel cross-feed valve as soon as practicable.

c. Increase the rpm of the useful engine through the propeller control to increase the power output.

d. Keep to a minimum the full throttle operation below the critical altitude of the engines, or the use of more than rated power at any altitude, to avoid overheating and detonation which will result in damage to, if not complete failure of, the remaining engine.

e. Use rich mixtures to help keep the engine temperatures down.

f. If an engine has been stopped in flight for any length of time, run at reduced rpm and power when restarting until the oil and cylinder temperatures indicate safe operation.

g. Fly with as low power on the live engine as practicable to maintain satisfactory flight to avoid excessive trim.

h. Avoid rapid changes in speed or power.

i. If for any reason the speed falls below the minimum for control, regain the speed by losing altitude at reduced power and not by applying additional power.

j. Avoid violent maneuvers. Never make steep turns with the inoperative engine down.

3. Use of Rudder. - In the event of engine failure or intentional partial engine operation, throttle the live engine or engines, lead with directional control and trim tab. Then open the live engine or engines to balance the directional control which is being applied.

4. Landing Gear and Flaps. - Generally speaking, airplanes with partial power plant failure will maintain altitude with the landing gear down, but do so much more readily with the gear retracted. Where only one engine is useful, an airplane cannot be expected to maintain altitude with both landing gear and flaps extended.

5. Landing. - The following landing instructions will be used when flying with one engine use-  
less:

a. Make the approach for landing at an altitude of at least 1000 feet above the field.

b. Lower landing gear and lower wing flaps approximately 20 degrees (one-half flaps). Trim the airplane for a low power condition and a speed comfortably in excess of stalling speed with flaps up. The margin of speed over flaps-up stalling speed which should be maintained will vary from airplane to airplane but will normally be 20 mph to 30 mph. Maintain constant power and constant speed until a successful landing is reasonably assured, particularly until the danger of "under-shooting" is eliminated. At this point lower the wing flaps to full down, leaving power as previously set, and land in the normal manner.

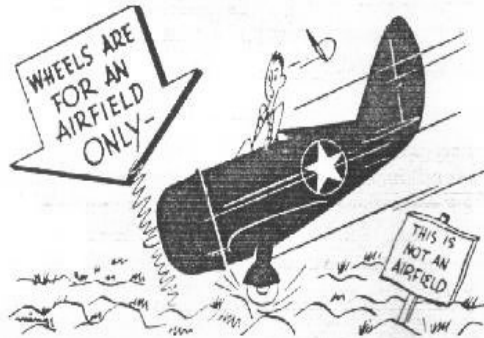
c. If, during the approach, it becomes desirable to go around again, raise the landing gear promptly. Apply power gradually, keeping the airplane trimmed directionally. Avoid excessive yaw caused by too rapid application of power and failure to adjust directional trim. Do not permit speed to decrease below that maintained in the approach. If altitude is available, it is advisable to increase speed somewhat while setting power and trim. Raise wing flaps as soon as power and directional trim are set. Do not raise wing flaps until after checking to see that air speed is in excess of flaps-up stalling speed.

d. Where an engine has been shut down for low oil pressure or some other fault not actually rendering it out of commission, start the defective engine and operate at reduced power to make a normal landing with all engines operating.

#### 6. Failure on Take-Off.

a. In case of engine failure on take-off, quickly throttle the live engine from take-off power to some lower value so that the airplane can be controlled directionally. There is immediate danger from loss of directional control due to stalling of the vertical tail in attempting to compensate the asymmetrical thrust of the engine.

b. Immediately choose one of the following methods of procedure:



(1) Throttle down and land straight ahead if the terrain permits. If this procedure is followed less damage will probably be done if the landing gear is retracted, unless there is a perfect field ahead.

(2) Retract landing gear and carefully build up flying speed and altitude until a safe landing can be effected. If this procedure is followed, operate the airplane in accordance with the instructions contained in this Technical Order.

(b) Propellers. - Feathering propellers not only permits the stopping of a disabled and vibrating engine, but also decreases the drag of the propeller and increases the performance of the airplane. It is estimated that a feathered propeller on a two-engine airplane increases the single engine ceiling 1500 feet over that which can be maintained with the useless propeller "windmilling," but that a braked propeller reduces the single engine ceiling approximately 1500 feet below the "windmilling" ceiling. When a propeller is unfeathered from the feathered position, the momentary effect is the same as though the useless propeller were braked and, in case the engine fails to rotate, this effect is permanent until the propeller can again be feathered. Hence, the single engine ceiling of the airplane during unfeathering and until the engine is operating is approximately 3000 feet lower than its ceiling would be with the useless propeller feathered.

## SECTION V

### POWER PLANT

#### 1. Engines.

##### a. General.

(1) This airplane is powered with two Pratt and Whitney R-1830-92. It is a fourteen cylinder, twin row, radial air-cooled engine having a 16:9 propeller reduction gear ratio and provisions for the installation of the Hamilton standard hydromatic full feathering propeller. The constant speed governor for obtaining constant speed operation with this propeller is mounted in a readily accessible location on the nose of the engine.

(2) The cylinders are constructed of cast aluminum-alloy heads, shrunk tightly upon steel barrels, and have a large number of deep, closely spaced, integral cooling fins. All cylinders are fitted with specially designed baffles which force the cooling air to pass between the fins so as to obtain the most efficient cooling possible. The intake and exhaust valve mechanisms such as the rocker arms, valve springs, and valves are contained in housings which are an in-

tegral part of the cylinder head. Constant lubrication of these parts is obtained by full force feed of engine oil under pressure.

(3) The crankcase is a solid, one-piece steel forging supported by large roller bearings located at the center and at each end of the crankshaft. The cylinders and crankshaft bearings are held in place by a three-section crankcase of aluminum alloy which is forged to give it exceptional strength. The engine is rendered free from any critical vibration periods over the entire operating range by virtue of specially designed dynamic balancing devices installed in the crankshaft.

(4) The master rods are steel forgings of two-piece construction and are fitted with specially processed silver bearings capable of withstanding high bearing loads for long periods.

(5) The blower or supercharger section is constructed from an aluminum-alloy housing containing a large dynamically balanced impeller mounted on a

steel shaft supported by ball bearings at each end. This shaft is driven 7.15 times the crankshaft speed. The blower section also is fitted with eight forged steel pedestals through which the engine is bolted to the engine mount.

(6) The rear section is an aluminum-alloy casting fitted with a number of mounting pads which are provided with drives for the various accessories, such as vacuum pumps, hydraulic pumps, oil pumps, fuel pumps, generator, starter, and tachometer. Two Scintilla magnetos are bolted to special mounting pads. The left magneto fires the rear spark plugs and the right magneto fires the front spark plugs. Both magnetos are timed to fire 25 degrees before top dead center and incorporate specially designed breaker cams which insure that all cylinders fire at exactly the same point before top center. This type of magneto is known as the "even-firing" type and is a considerable contribution toward obtaining a smooth succession of power impulses.

b. Ratings.	BHP	RPM	ALT	MAN. PRES
Normal Take-Off Rating <i>FULL THROTTLE</i>	1200	2700	S.L.	48.0 in.
Normal Maximum Rating for Continuous Operation <i>100%</i>	1050	2550	7500	40.0 in.
Maximum Power and RPM for Cruising <i>75%</i>	790	<i>2300</i> 2230	S.L. to 7500	33.0 in.

All ratings are based upon the use of 100-octane fuel. (See figure 29 for additional information.)

## 2. Starter.

a. General. - Each engine is equipped with a type C-21 combination electric inertia, direct-cranking starter.

b. Starter Switches. - The starting system consists of a double-throw selective safety switch and two momentary contact switches mounted on the right-hand electrical control panel. The starters are operated by moving the safety switch to the desired engine and pulling down on the starter and booster switches. All three switches will return to their original position when released.

## 3. Carburetors.

a. General. - This airplane is equipped with Bendix Stromberg metering injection aircraft carburetors. This carburetor is entirely different from the previous types of carburetors in that it does not have a vented float chamber, but instead, has a closed fuel system

from the fuel pump to the discharge nozzle. Fuel is prevented from leaking into the engine by the spring-controlled needle valve in the discharge nozzle which is closed when the nozzle fuel pressure is less than four pounds per square inch. Even though the fuel pressure is over four pounds per square inch (with the throttle closed and the engine standing still), the fuel can flow only at the lowest idling rate. When the idle cut-off is in use, it reduces the flow to considerably less than the idle flow. Understanding the construction and operation of this carburetor is made easier since it is subdivided into separate units, each of which has its individual duty and function. These units are: the throttle unit, automatic mixture control unit, regulator unit, fuel control unit, and the adapter.

b. Throttle Unit. - The throttle unit of the injection carburetor is quite similar to that used with the conventional float-type carburetors. It has a butterfly-type throttle valve, a large and small venturi provision for mounting an automatic mixture control unit and a flange for mounting the regulator mount. A manually operated valve to by-pass the automatic mixture control and make it inoperative is also included in the throttle body design. The suction at the throat of the small venturi is a measure of the amount of air entering the engine. This suction, when corrected by the automatic mixture control for changes in air density, becomes a measure of mass air flow and is applied to the air diaphragm of the regulator unit to regulate the fuel metering pressure (or head) across the fixed jets in the fuel control unit.

c. Automatic Mixture Control. - The automatic mixture control unit consists of a sealed metallic bellows operating a contoured valve. The bellows is filled with a measured amount of an inert gas to make it sensitive to temperature as well as to pressure changes. The valve, therefore, has a predetermined position for each air density encountered in flight.

d. Regulator Unit. - The regulator unit automatically adjusts the fuel pressure across the metering jets, resulting in a fuel flow in proportion to the mass air flow through the throttle body. The unit is made up of an air diaphragm, a fuel diaphragm, and a balanced fuel valve, all mounted on one stem supported on suitable guides. Fuel enters through a strainer, passes through the balanced valve to one side of the fuel diaphragm chamber, and then to the jets in the fuel control unit. A vapor separator is provided in the strainer chamber to prevent vapor entering the regulator.

e. Fuel Control Unit. - The fuel control unit, attached directly to the regulator, contains the metering jets, an economizer valve, an idle needle, and a manually operated mixture control and mixture selection valve. The economizer valve is operated by an air diaphragm and provides enrichment in proportion to the mass air flow through the carburetor. The idle



needle is mechanically connected to the throttle and controls the mixture throughout the idle range of speeds. The manual mixture control may be set in any one of the positions as noted in section III paragraph 2.

f. Emergency Setting. - This position makes the automatic mixture control unit inoperative, eliminating automatic compensation for altitude and temperature (recommended for emergency operation only).

g. Take-Off and Climb Setting. - This is the usual operating position, which automatically maintains the desired fuel air ratios at all engine speeds and loads, independent of changes in altitude, temperature, propeller pitch, or throttle position.

h. Cruise. - This position is a leaner setting than that used for take-off and climb and is suitable for cruising under favorable conditions. This setting may be too lean for good acceleration.

i. Idle Cut-Off. - This position is used for stopping the engines and while priming for starting.

j. Adapter. - An adapter with a constant pressure discharge nozzle is supplied with metered fuel direct from the fuel control unit. This fuel is sprayed, under pressure across the face of the supercharger.

k. Accelerating Pump. - The accelerating pump is operated by, and in proportion to the momentary changes in air pressure in the supercharger entrance. The accelerating pump is not connected with the throttle or throttle control, hence, when the engine is not running, no fuel is pumped from the carburetor when the throttle is moved, no matter how rapidly.

#### 4. Propellers.

a. General. - Each engine is equipped with a Hamilton standard hydromatic, quick feathering constant speed, controllable pitch propeller, eleven feet six inches in diameter. The full low pitch is 18 degrees, constant speed operating range and approximately 29 degrees, and the full feathered position is 88 degrees. All settings are taken at the 42-inch blade station.

b. Propeller Mechanism. - The centrifugal force acting on the blades, and engine oil under normal pressure acting on the forward face of the piston in the propeller hub, tend to cause the blades to go into low pitch. Engine oil, which has been boosted to a higher pressure by the constant speed governor pump

is used to overcome this centrifugal twisting moment when it is necessary to increase the pitch. When the feathering pump is put in operation, the oil pressure is increased, and the piston overcomes the twisting moment, increasing the pitch until the adjustable mechanical stops are reached, where the feathering pump is automatically stopped. About nine seconds are required for the entire feathering operation. When the feathering pump is started again and the blades are in the feathered position, the oil pressure increases to a point where it operates the distributor valve in the propeller hub, allowing the oil to pass to the dome on the forward side of the piston and unfeather the blades.

c. Propeller Governors. - The governors are of the flyball type, operating a pilot valve which opens and closes a port, through which oil is admitted to and released from the propeller cylinder. As the speed of the engine starts to increase, the flyballs move out against the governor spring, raising the pilot valve, which allows high pressure oil to pass to the cylinder, forcing the blades to a higher pitch. This prevents the engine from overspeeding. If the engine starts to slow down, the flyballs move in and drop the pilot valve which allows oil to drain from the propeller cylinder, moving the blades into a lower pitch and preventing the engine from slowing down. Engine oil at 75 pounds per square inch pressure is boosted to 200 pounds per square inch pressure by a small gear pump in the base of the governor. This high pressure oil works against the centrifugal twisting moment of the blades and the engine oil pressure on the forward face of the piston when forcing the blades into a higher pitch.

The feathering pump takes oil from the engine oil tank and delivers it to the propeller, causing the piston to move out to the feathered position; the pressure being approximately 400 pounds per square inch. The pressure required for unfeathering is approximately 600 pounds per square inch. The distributor valve in the propeller hub is always in the position for feathering until the oil pressure reaches 600 pounds which moves it to the unfeathering position.

Speed selection is obtained by moving the propeller pitch controls which are located on the control pedestal in the pilot's compartment. Operating the control compresses or releases the governor spring. The amount of compression of the governor spring determines the speed at which the governor will allow the engine to run. The more the spring is compressed, the faster the engine speed will be.



SECTION VIFLYING CHARACTERISTICS

1. A so called "stabilizer stall" is produced in C-47 (DC-3 type) airplanes if the airplane is slowed down below normal operating speed (70 mph indicated) at approximately 24,000 pounds gross weight and the nose is pulled up above the horizon. Icing conditions will increase the stalling speed, thereby aggravating the condition, which will then occur at higher speeds.
2. The term "stabilized stall" is actually a misnomer, since the condition is quite unstable, with a definite rolling and a slight pitching motion of the airplane. Although the wing tips are partially stalled, the ailerons are effective during the entire stall.
3. In the "stabilized stall" attitude, descent is rapid, approximately 1,800 feet per minute, and can continue indefinitely. Application of power does not aid in recovery.
4. "Stabilized stall" with single engine has the same characteristics as the two engine, and there is no noticeable yaw during descent.
5. The "stabilized stall" condition is not dangerous. Recovery is easily obtained by dropping the nose of the airplane four or five degrees below the horizon, and can be completed without excessive loss of altitude, provided the nose is dropped as soon as the stall condition develops. As the air speed increases above 70 mph, the buffeting begins to fade and ceases as the airplane regains normal flight. Like any other stall, however, this condition should not be attempted at low altitude, and should be avoided at any altitude except for necessary demonstration or training purposes.

SECTION VI  
WEIGHT DATA

1. <u>Weight in Pounds.</u>	<u>Overload</u>	<u>Normal</u>
Weight Empty (including radio, 517 pounds).		16,621
Useful Load.		
<u>a. Standard Cargo Arrangement.</u>		
Crew - 3 at 200 pounds each		600
Fuel - Normal (540 U.S. gallons - 450 Imperial gallons)		3,240
Fuel - Maximum (804 U.S. gallons - 670 Imperial gallons)	1,584	
Oil - Maximum (58 U.S. gallons - 48.4 Imperial gallons)		435
Cargo		5,000
Trapped Fuel and Oil		104
Gross Weight		26,000
<u>b. Passenger Arrangement (Alternate Load).</u>		
Crew - 3 at 200 pounds each		600
Fuel - Normal (540 U.S. gallons - 450 Imperial gallons)		3,240
Fuel - Maximum (804 U.S. gallons - 670 Imperial gallons)	1,584	
Oil - Maximum (58 U.S. gallons - 48.4 Imperial gallons)		435
Passengers - 28 at 200 pounds each		5,600
Trapped Fuel and Oil		104
Gross Weight		26,000
<u>c. Hospital Arrangement (Alternate Load).</u>		
Crew - 3 at 200 pounds each		600
Fuel - Normal (675 U.S. gallons - 562.5 Imperial gallons)		4,050
Fuel - Maximum (804 U.S. gallons - 670 Imperial gallons)	774	
Oil - Maximum (58 U.S. gallons - 48.4 Imperial gallons)		435
Litters and Blankets		594
Passengers, 18 at 200 pounds each		3,600
Trapped Fuel and Oil		104
Gross Weight		26,004
Maximum Loaded Weight, Safe Flight		26,004
Wing Loading, Normal Gross Weight (pounds per square foot)		26.32
Power Loading, Normal Gross Weight (pounds per HP)		12.4

A loading chart is located on the cabin side of the lavatory door for the purpose of weight distribution and limits.

SECTION VIII

CURVES

TAKE-OFF DISTANCE TO CLEAR 50-FOOT OBSTACLE

Prepared Runways

Example: Airplane Gross Weight: 26,500 pounds  
 Airport Elevation: 4000 feet above sea level  
 Prepared Runways

to intersect the 4000-foot vertical line on the "Altitude" scale; the nearest slanted curved line to this intersection shows that the required take-off distance to clear a 50-foot obstacle will be 2400 feet.

Solution: Take-off distance to clear 50-foot obstacle.

To find the take-off distance from a sod runway follow the same procedure as outlined above, the only exception being to follow the line vertically to the sod field curve. Under the same conditions as outlined above, the take-off distance from a sod field should be 3400 feet.

Enter chart (figure 17) at 26,500 on "Take-Off Gross Weight" scale; rise vertically to intersect line labeled "Prepared Runway;" proceed horizontally to the left

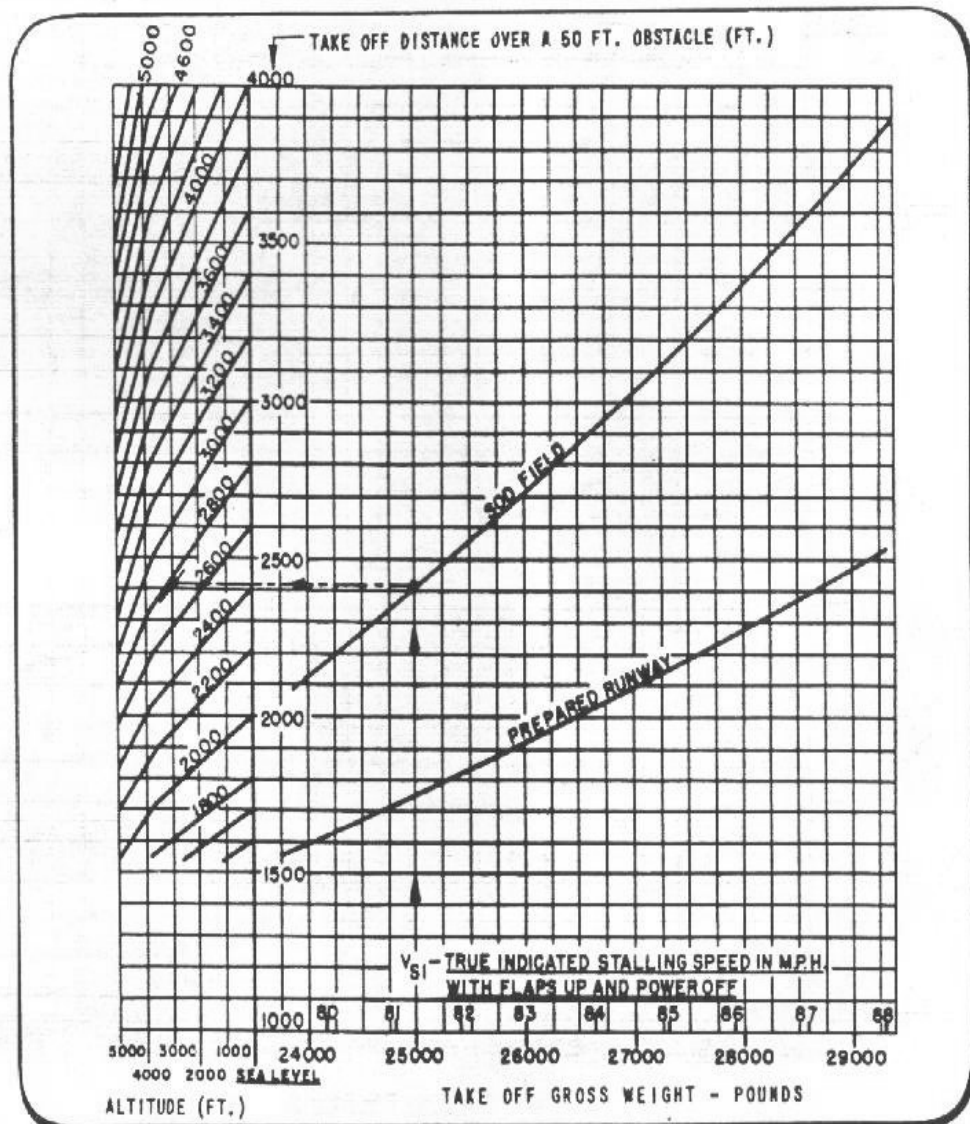


Figure 17 - Take-Off Performance Chart

USE OF RATED POWER CEILINGS CHART

In using the Rated Power Ceilings Chart, first determine the gross weight of the airplane. Then move vertically upward from the gross weight point obtained, to intersect the proper curve for the condition wanted, i.e., one engine out, service ceiling. Move horizontally to the left from this point to obtain the altitude.

Example: (Gross Weight 21,000 pounds)

Altitude (Single Engine Flight) - 14,000 feet

Altitude (Twin Engine Flight) - 22,025 feet

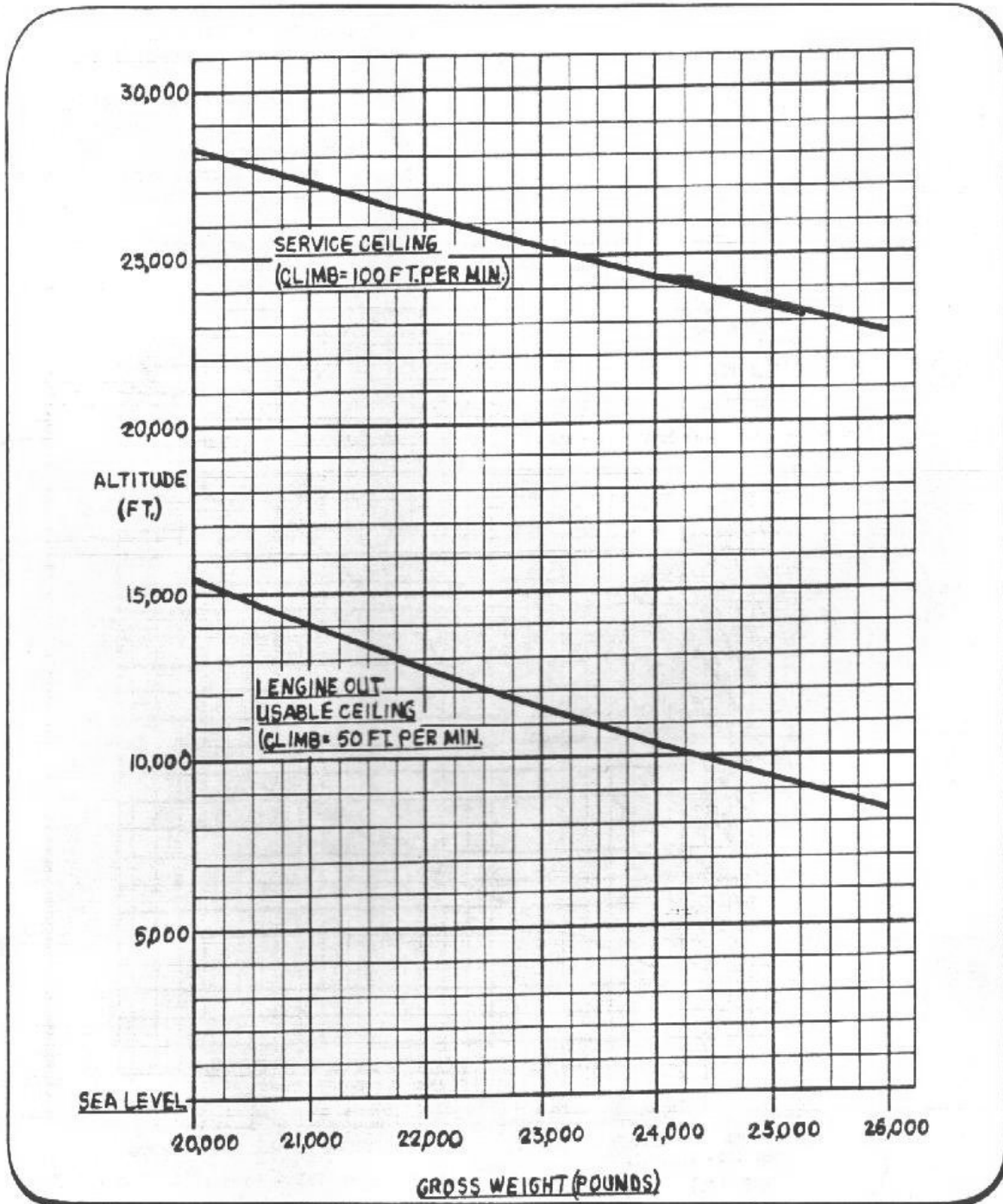


Figure 18 - Rated Power Ceilings Chart



**USE OF CRUISING CHARTS FOR LEVEL FLIGHT**

The following figures are cruising charts for level flight at gross weights of 20,000 pounds, 24,000 pounds, and 29,000 pounds respectively. In using charts, move up the "Standard Temperature" line until the "Density Altitude" (indicated altitude) line is reached. Then move along the "Pressure Altitude" line until the "Outside Air Temperature" line is reached. Move vertically up the "True Air Speed" line (indicated air speed corrected, figure 22) and move horizontally to the right on the "Outside Air Temperature" at the same time. The intersection of these two lines will give the proper horsepower rating for the foregoing conditions.

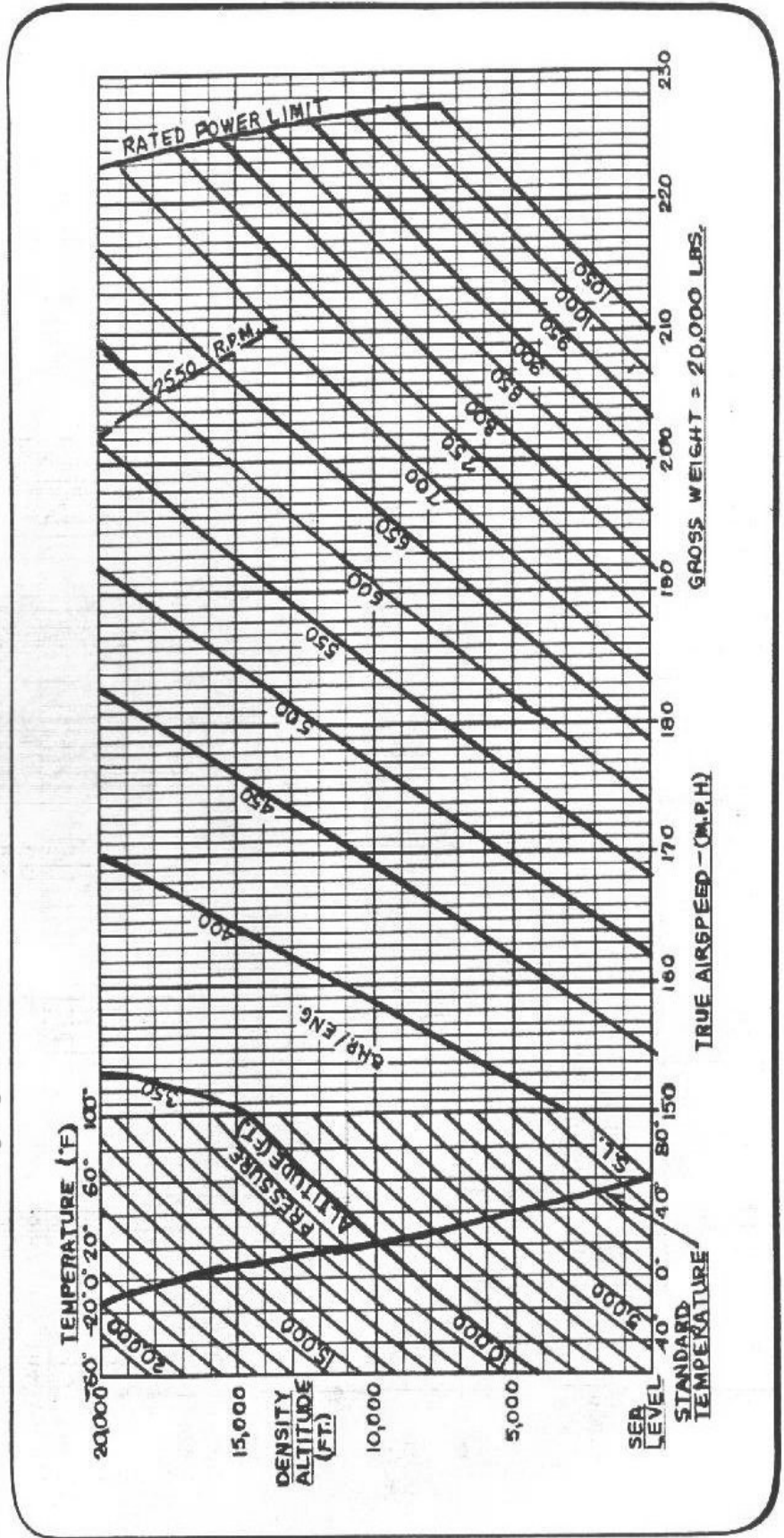


Figure 10 - Cruising Chart for Level Flight - Gross Weight - 20,000 Pounds

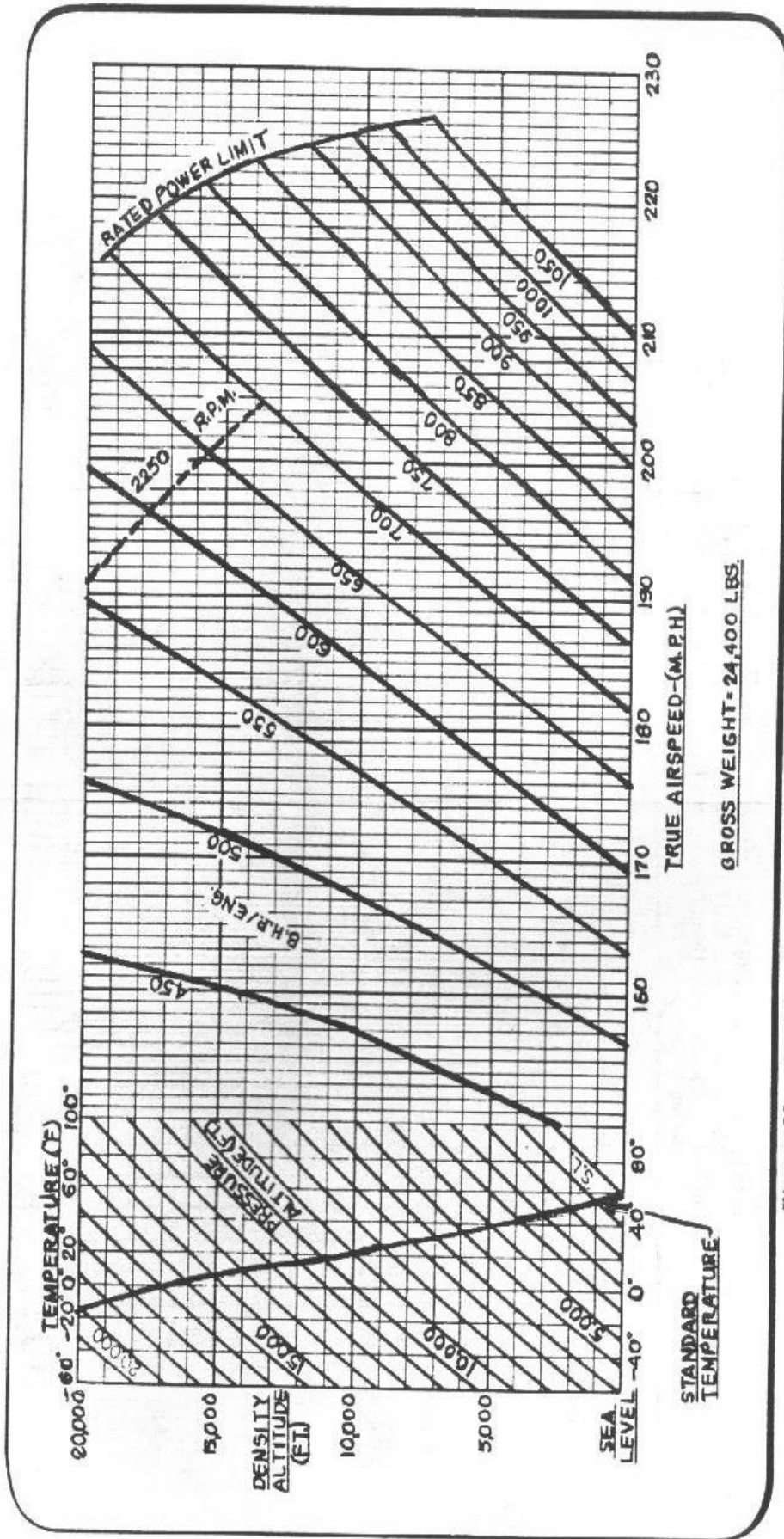


Figure 20 - Cruising Chart for Level Flight - Gross Weight - 24,000 Pounds



USE OF AIR SPEED CORRECTION CHART

The dash line represents the following example:

Move upward along the "Standard Temperature" line to "Pressure Altitude" (8000 feet). Move along "Pressure Altitude" line to vertical line corresponding to outside temperature (60°). Then move horizontally to "Indicated Air Speed" (150 mph). At this point read down for true air speed (180 mph).

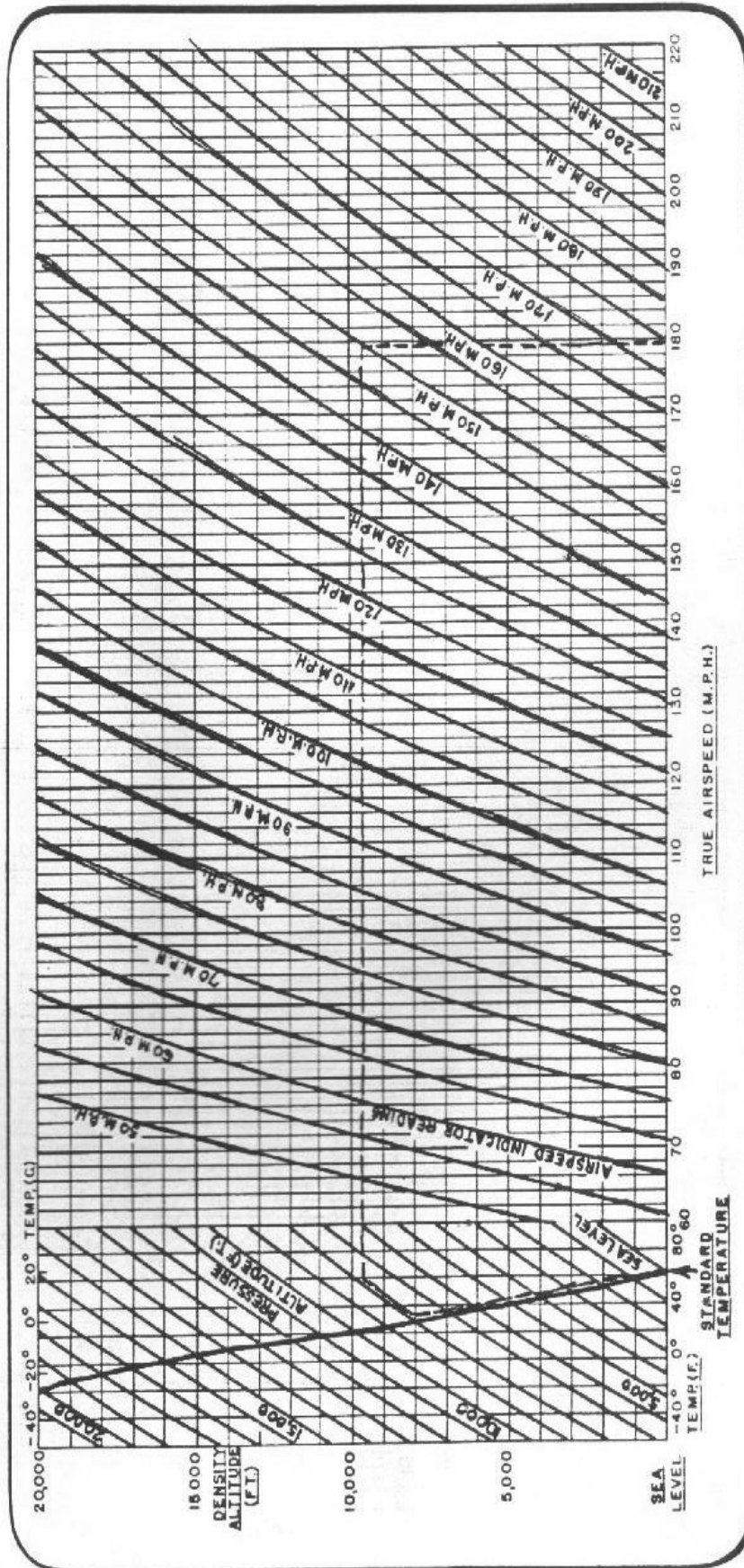


Figure 22 - Air Speed Correction Chart



USE OF CRUISING POWER CHART

The Cruising Power Chart can be utilized as guide for operation when economy is a principal requirement.

The solid horizontal lines of constant BHP, RPM, and maximum BMEP at part throttle extend from sea level to the highest altitudes at which that BMEP can be obtained with full throttle. These constant speed lines then break and at higher altitudes become a part of the "Standard Altitude Operating" curve, with decreasing horsepower and with the BMEP less than the maximum value.

The upper boundary lines are the maximum permissible BHP for cruising, and the maximum permissible RPM for cruising. Below that altitude at which maximum BMEP is obtained, the maximum horsepower line is at full throttle increasing RPM and decreasing BMEP terminating at the maximum allowable RPM.

Manifold pressures required are plotted as solid lines below the full throttle portion of the curve. For accurate use the manifold pressure should be corrected for a variation in carburetor air temperature from standard by referring to the instructions on the chart, and interpolating the readings from the "Temperature Variation" line.

**EXAMPLE:** 650 BHP is obtained with 140 BMEP between sea level and 10,500 feet at 2000 RPM with manifold pressure varied from 32 inches Hg at 400 feet to 29 inches Hg at 10,500 feet by throttle adjustments if the airplane is cruising between these altitudes. If this same speed (2000 RPM) is maintained beyond 10,500 feet, 650 BHP cannot be obtained. If 650 BHP is desired for higher altitudes, it is available up to 15,900 feet by gradually increasing engine speed from 2000 to 2250 RPM at full throttle.

USE OF CRUISING FUEL CONSUMPTION CHART

Enter the chart along the "RPM" line and move horizontally to the right until reaching the intersection of the "Brake Horsepower" line. This will give the number of gallons per hour (two engine fuel consumption) that is consumed.

Example: RPM - 1950 Gas consumption  
BHP - 475 70 U.S. gallons (58.3 Imperial gallons) per hour

USE OF POWER CHART

The Power Chart can be utilized as a guide in obtaining the maximum output of power. In many cases, the curves show only rounded manifold pressure values in steps. It affords means of selecting the appropriate combinations of rpm and manifold pressure for any altitude and power within the capacities of the engine.

Enter the chart at the proper altitude reading and move upward until reaching the "RPM" line. The intersection of the "Altitude" line with the "Manifold Pressure" curve will give the full throttle power at this rpm and altitude. The horsepower being developed at standard temperatures may be determined by moving horizontally to the left until reaching the "Brake Horsepower" line.

Temperature variation may be compensated for by referring to the instructions on the chart, and interpolating the readings from the "Temperature Variation" line.

Example: Altitude 10,000 feet  
RPM 1,700  
Manifold Pressure 27 inches Hg

The above values will give a full throttle power of 500 brake horsepower being developed by the engine.

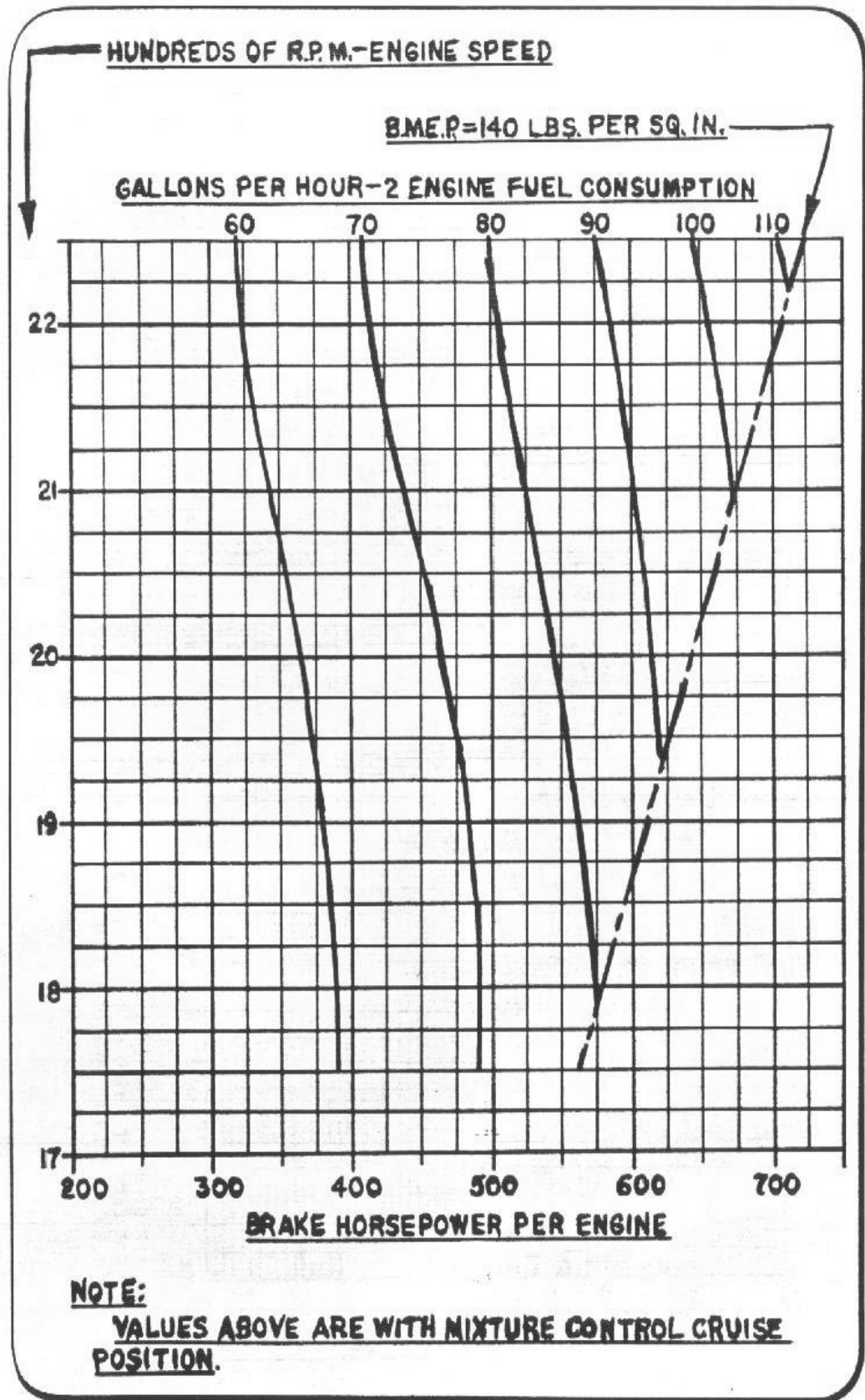


Figure 24 - Cruising Fuel Consumption Chart

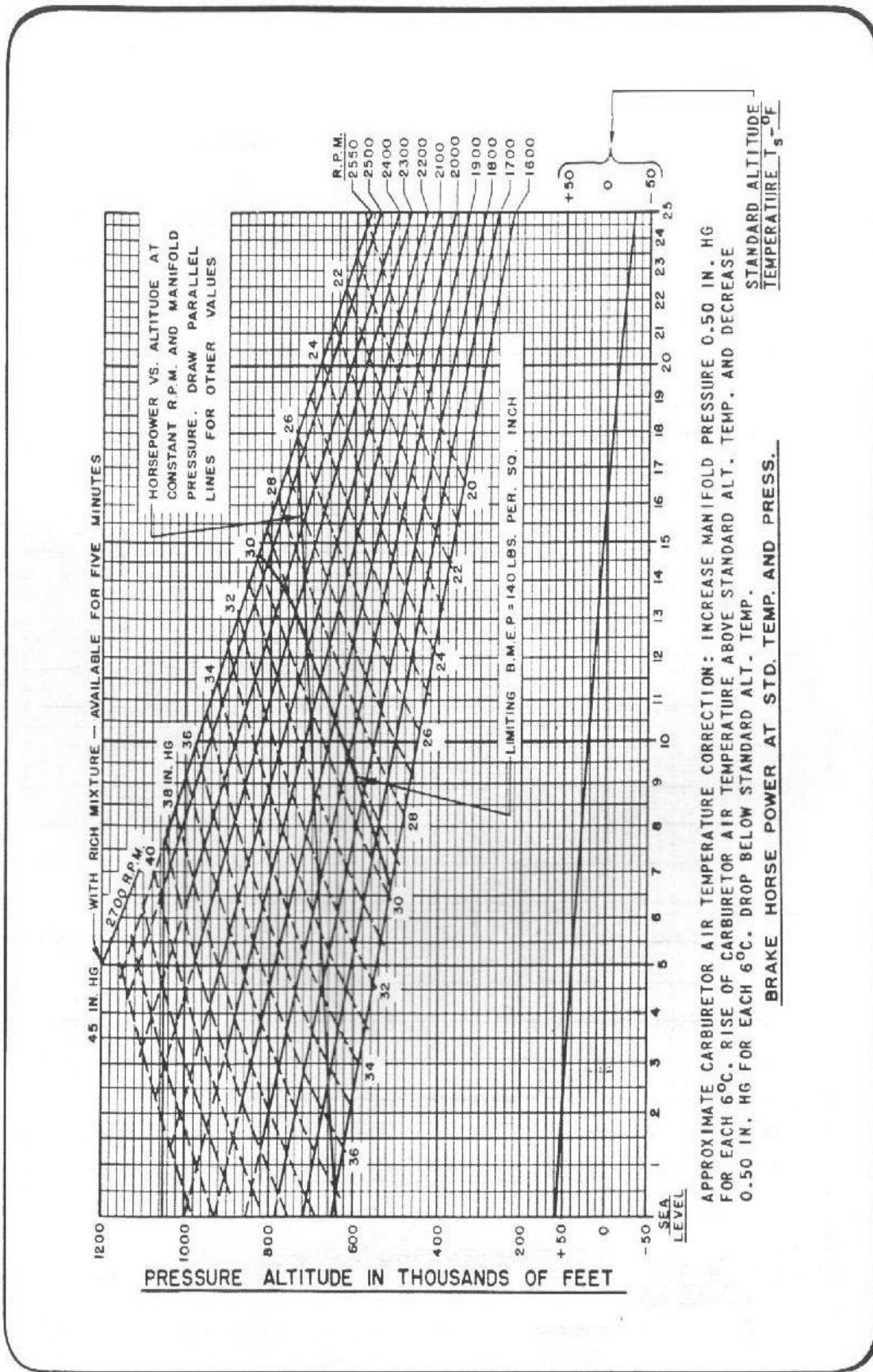


Figure 25 - Power Chart

USE OF AUTO-RICH FUEL CONSUMPTION CHART

Enter the chart along the "RPM" line and move horizontally to the right until reaching the intersection of the "Brake Horsepower" line. This will give the number of gallons per hour (two engine fuel consumption) that is consumed.

Example:

RPM - 2100  
BHP - 600

Gas consumption  
100 U.S. gallons  
(83.3 Imperial gallons)  
per hour

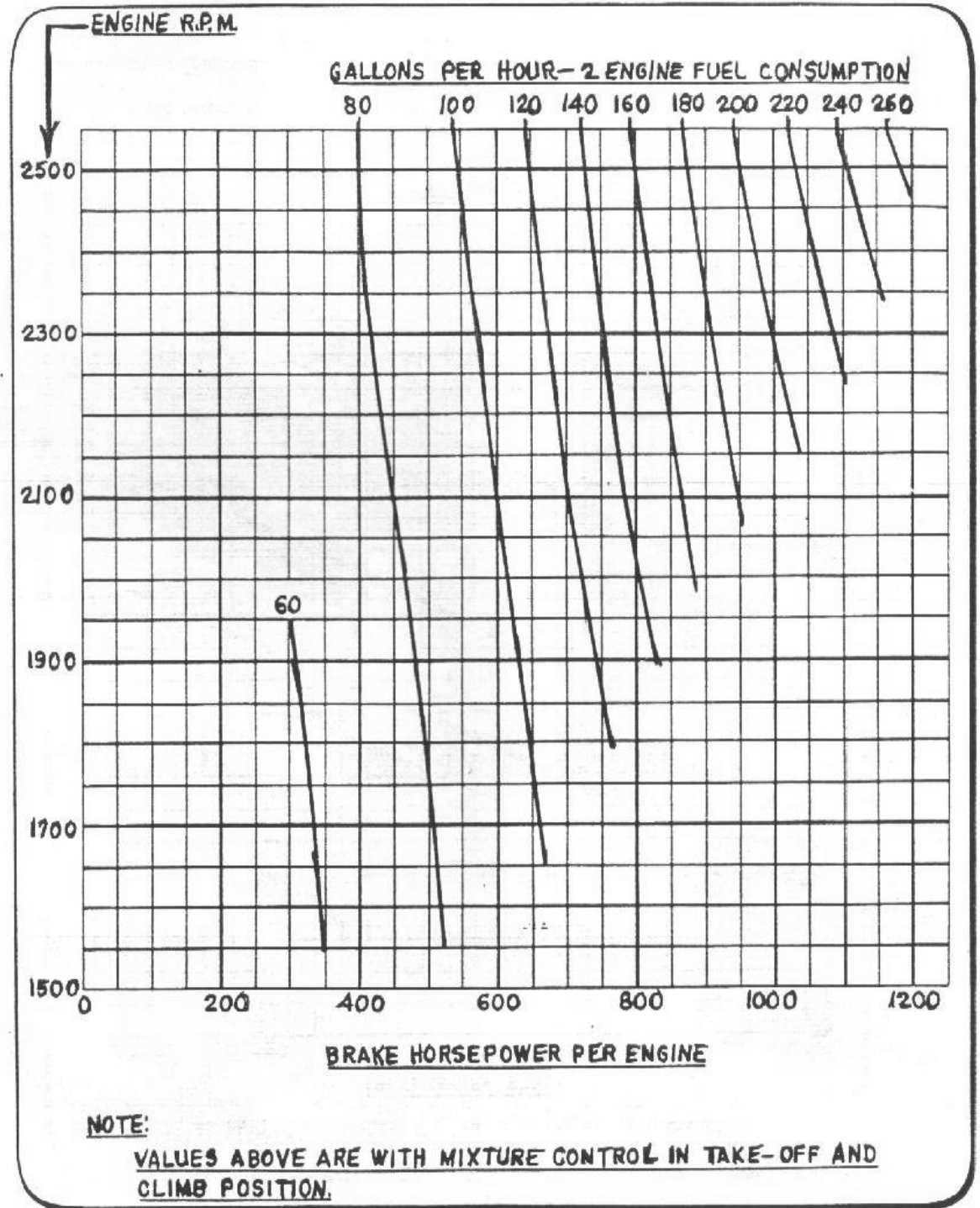


Figure 26 - Auto Rich Fuel Consumption Chart



STALLING SPEED

(Gear Up or Gear Down)

From this chart the stalling speed may be determined in mph (air speed indicator reading) for gross weights from 20,000 pounds to 26,500 pounds. Four landing flap positions are given; flaps up, flaps down 15 degrees, flaps down 30 degrees, and flaps down 45 degrees.

No correction for altitude or temperature is necessary since the indicated air speed changes with these conditions.

Example: Determine the stalling speed for the following conditions:

Gross Weight            24,500 pounds  
Flaps Down                30 degrees

Solution: Enter the chart at 24,500 pounds on the gross weight scale. Rise vertically to intersect the flaps down 30 degrees curve. Proceed horizontally to the left and read 71.5 mph air speed indicator reading on the stalling speed scale.

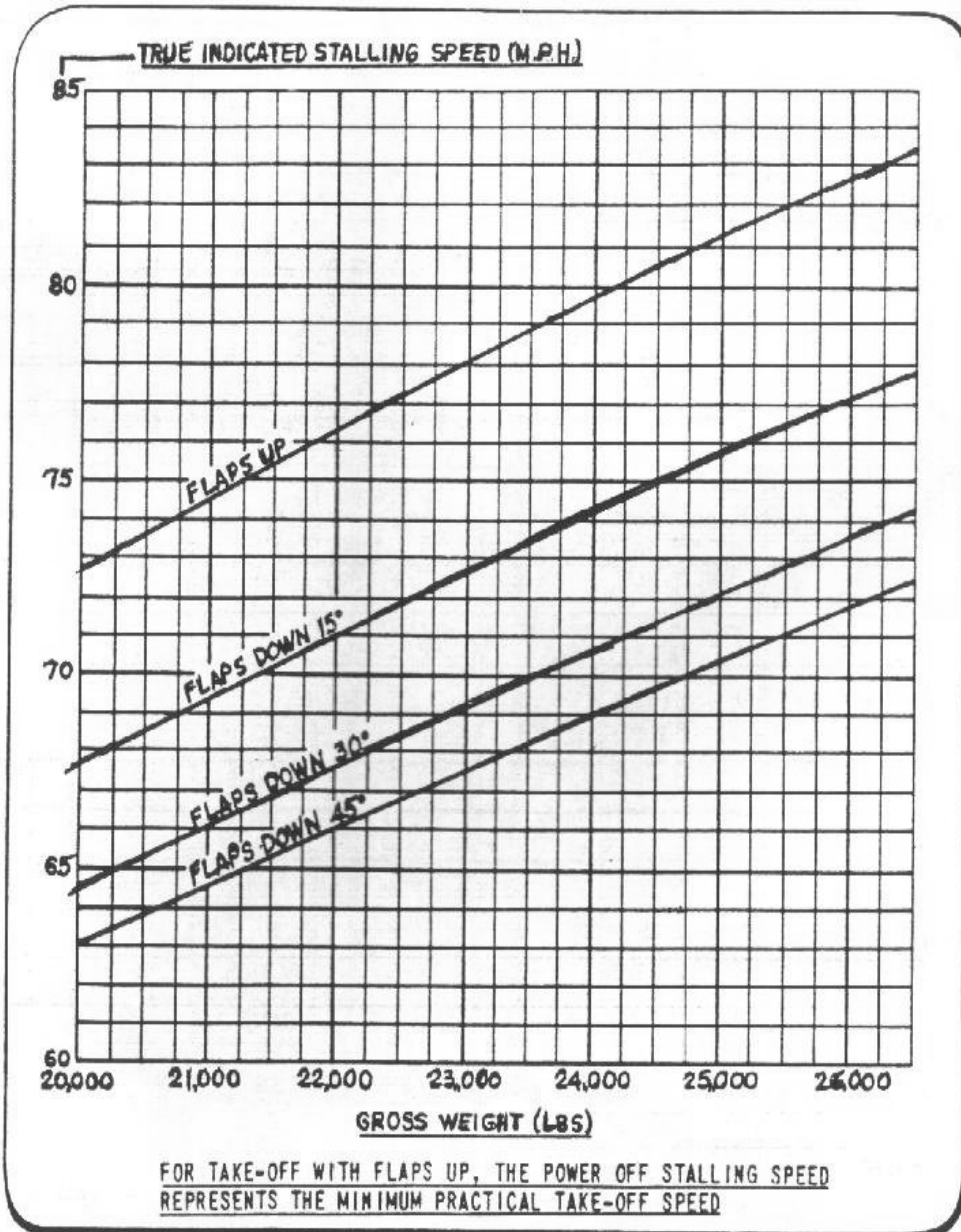


Figure 27 - Stalling Speeds Chart

LANDING DISTANCE: TO CLEAR 50-FOOT OBSTACLE

Chart gives distance to come to rest after gliding over an obstacle 50 feet high at a speed 15 percent greater than the flap down stalling speed.

Landing flaps are full down until the airplane comes to rest. The landing run is shortened, however, if the flaps are retracted as soon as the wheels touch the ground. This permits greater braking power.

If temperature at landing place is above standard, landing distance will be increased over that read from the chart, approximately two percent for each  $-12.2^{\circ} \text{C}$  ( $10^{\circ} \text{F}$ ) increase in temperature.

**Example:** Instantaneous gross weight 20,400 pounds.  
Landing field 4500 feet above sea level.  
Sod runway.  
Outside air temperature  $50^{\circ}$  above standard

**Solution:** Entering landing gross weight scale at 20,400 pounds. Rise vertically to sloping line labeled sod runway, and proceed horizontally to left edge of chart.

Reenter chart on altitude of field scale (lower left corner) at 4500 feet. Rise vertically until horizontal line just drawn is intersected. Read landing distance for standard conditions on sloping scale as 1960 feet. Since temperature is  $15^{\circ}$  above standard, the landing distance increased by three percent, the final answer is 2020 feet.

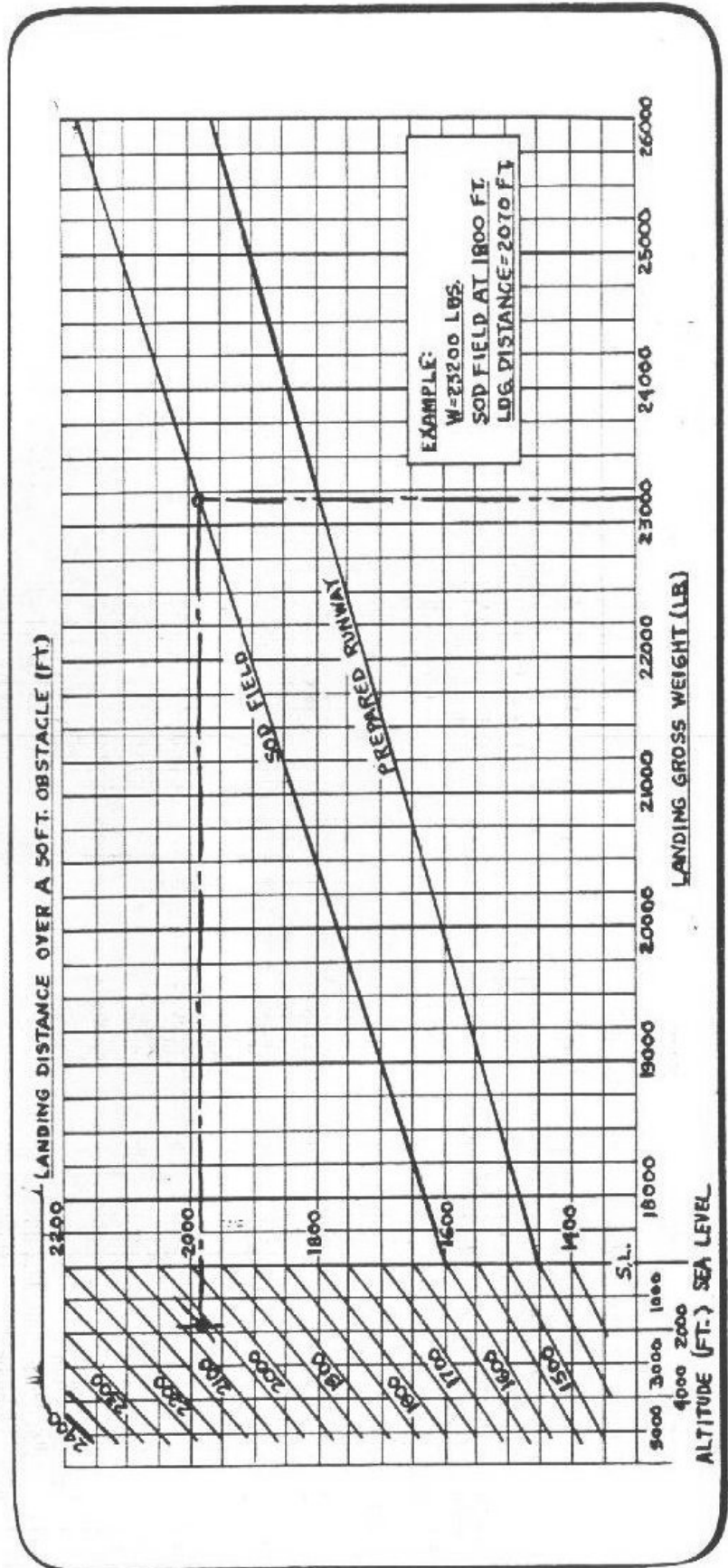


Figure 28 - Landing Performance Chart

ENGINE: Pratt & Whitney R-1830-92

MAX. PERMISSIBLE ENGINE OVER SPEED: 3060 R.P.M.

CONDITION	FUEL PRESSURE LB/IN. <sup>2</sup>	OIL PRESSURE LB/IN. <sup>2</sup>	OIL TEMP °C	COOLANT TEMP °C
DESIRED	12-14	75-90	50-70	—
MAXIMUM	16	95	95	—
MINIMUM	12	60	—	—
IDLING	7	15	—	—

MAX. ALLOWABLE OIL CONSUMPTION AT:  
 NORMAL RATED POWER 18 QTS./HR.  
 MAXIMUM CRUISING 11 QTS./HR.  
 MINIMUM SPECIFIC FUEL FLOW 6 QTS./HR.

FUEL GRADE 100 OCTANE

OPERATING CONDITION	HORSE POWER	R.P.M.	MAN. PRESS. (IN. HG)	PRESSURE ALTITUDE (IN FEET)	BLOWER CONTROL POSITION	USE LOW BLOWER BELOW	MIXTURE CONTROL POSITION	MIN. F/A RATIO	FUEL FLOW GAL/HR	MAX. CYL. HD TEMP °C	REMARKS
TAKE-OFF	1200	2700	48.0	Sea Level	—	—	Auto Rich	—	143	260	5 minutes only
MILITARY RATED POWER											
Ⓢ NORMAL RATED POWER (100%)	1050	2550	40.0	7,500	—	—	Auto Rich	—	114	232	
MAX. CRUISING (75%)	790	2230	33.0	7,500	—	—	Auto Rich	—	74	232	
DESIRED CRUISE (67%)	700	2230	30.0	7,500	—	—	Auto Lean	—	63	232	
DESIRED CRUISE (60%)	630	2150	28.0	7,500	—	—	Auto Lean	—	49	232	
CRUISE FOR MIN. SPECIFIC FUEL FLOW	550 500 450	1700 1600 1500	30.0 29.0 29.0	7,500 7,000 6,500	— — —	— — —	Auto Lean	— — —	41 37 34	232	

Ⓢ REFER TO T.O. NO. 00-10 FOR DEFINITION OF EACH OPERATING CONDITION Ⓢ MAXIMUM PERMISSIBLE CONTINUOUS HORSE POWER

Figure 29 - Specific Operating Instructions

USE OF PERMISSIBLE SPEEDS AND LOAD FACTORS CHART

The Permissible Speeds and Load Factors Chart (figure 30) is provided so that the pilot may readily determine the maximum speed and load factors for various gross weight conditions. The charted points are limit factors; the design load factors being 50 percent higher.

In using this chart it is first necessary to know the gross weight of the airplane. When this is determined, enter the chart at the correct gross weight (bottom of chart - reading horizontally) and move vertically until reaching the "Design Level Speed" curve. Then move along the horizontal line of the graph, until reaching the "Indicated Air Speed" line on the left-hand side of the chart. This will give the IAS NOT to be exceeded for the given gross weight for level flight.

Using the same procedure, after first determining the gross weight point, enter the chart and move vertically until reaching the "Placard Maximum Speed" curve. Then move horizontally to the left until reaching the "Indicated Air Speed" line. This point will give the IAS NOT to be exceeded in a glide or dive.

The high and low angle of attack curves can be used in conjunction with an accelerometer (if installed), to insure that the load factors are not exceeded in flight.

A maximum gross weight landing load of 26,000 pounds should NEVER be exceeded because of possible damage to the brakes through excessive wear (limit landing load factor - 3.10).

The symbols shown off the curves, are the actual calculated points.

Example:(Normal Maximum Gross Weight 26,000 pounds)

Design Level Speed, Not to Exceed	207	IAS
Placard Maximum Speed, Not to Exceed	255	IAS
(Limit Gust L.F.), Low Angle (Wing) of Attack	2.275	Load Factor
(Limit Gust L.F.), High Angle (Wing) of Attack	2.86	Load Factor

(Maximum Overload Condition 29,000 pounds)

Design Level Speed, Not to Exceed	187	IAS
Placard Maximum Speed, Not to Exceed	210	IAS
(Limit Gust L.F.), Low Angle (Wing) of Attack	1.94	Load Factor
(Limit Gust L.F.), High Angle (Wing) of Attack	2.50	Load Factor



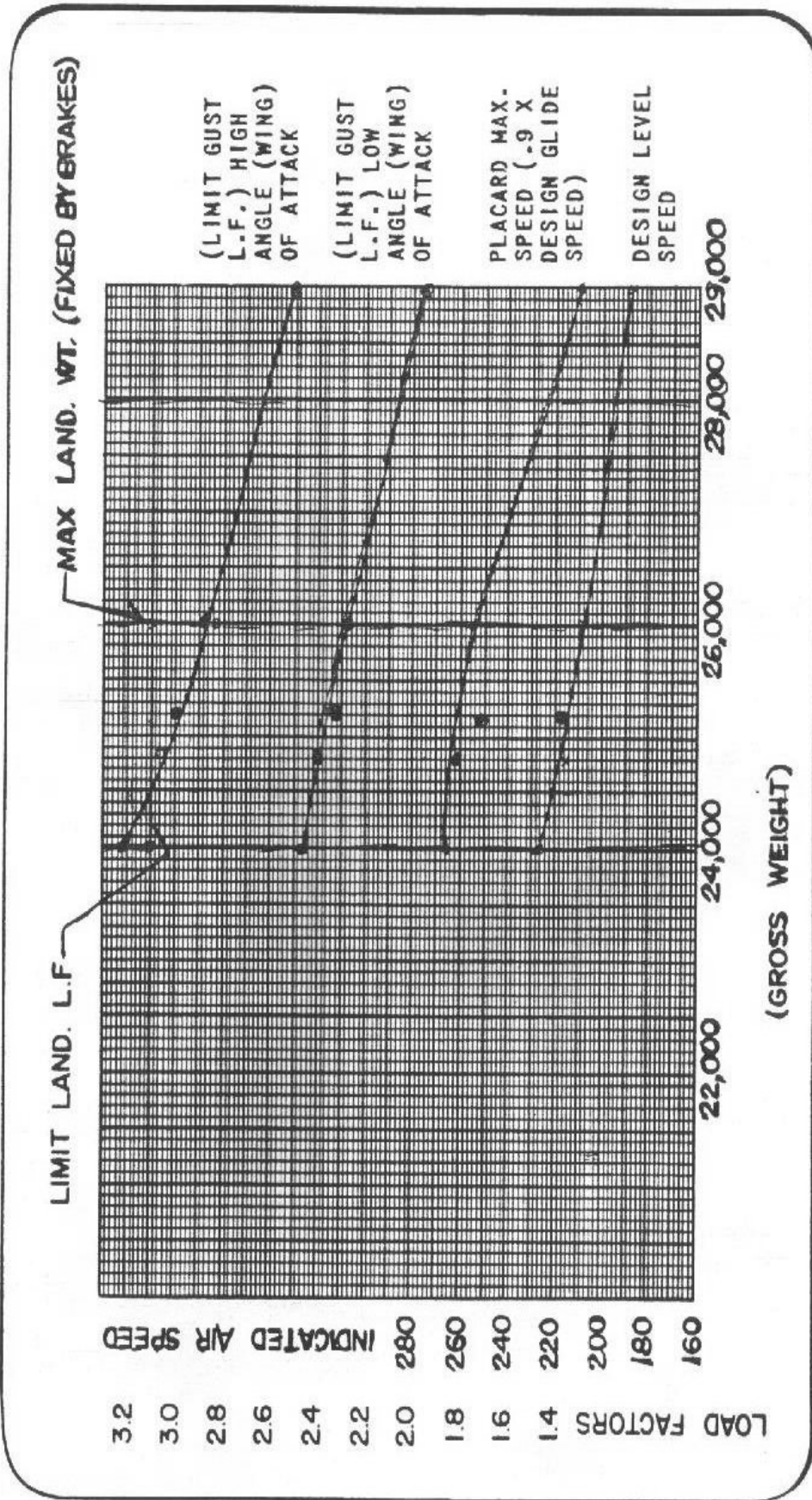
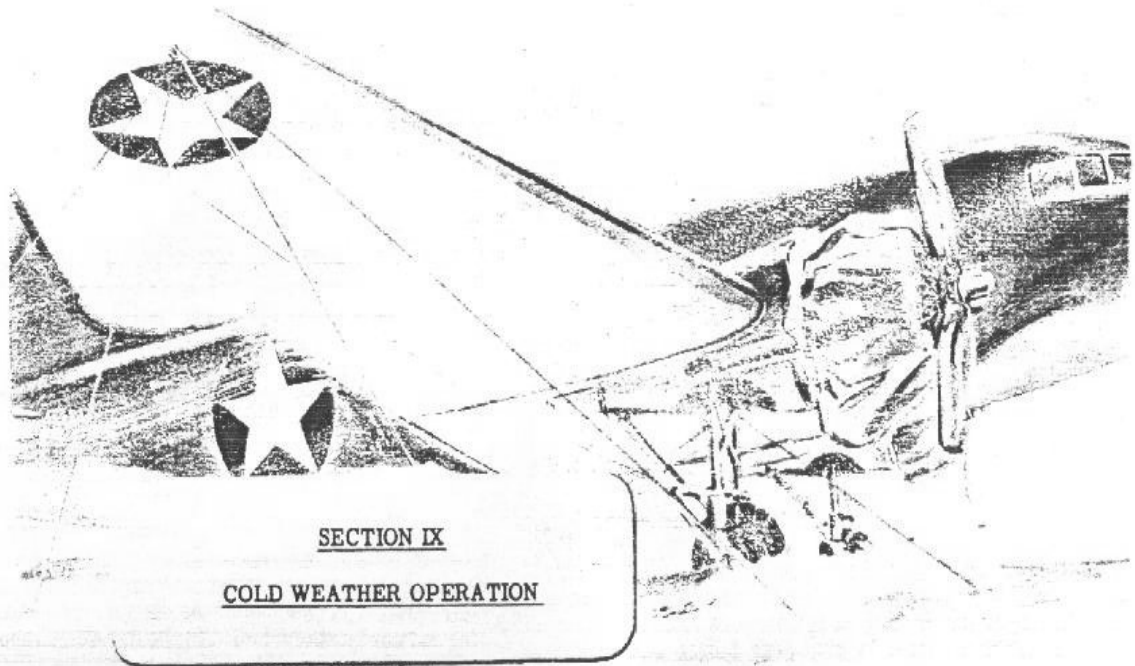


Figure 30 - Permissible Speeds and Load Factors Chart



SECTION IX  
COLD WEATHER OPERATION

1. Operation and Handling.

a. Engine Oil Dilution System.

(1) Controls and Indicators. - The oil dilution system provides a method of diluting or thinning the engine oil with gasoline at the end of each engine run in order to facilitate starting the engine in cold weather.

The system consists of four electric solenoid operated oil-dilution valves, each located on the front of its respective engine fire wall, the necessary piping (identified by a pointed red band), the necessary electric wiring and two double throw switches on the pilot's electrical panel. (See section II, figure 28-231.) Two dilution valves may be operated simultaneously.

The engine oil should be diluted prior to stopping the engines when there is a possibility of the engine oil temperature dropping below approximately  $5^{\circ}\text{C}$  ( $41^{\circ}\text{F}$ ) during the period the engine will be inoperative.

(2) To Dilute Oil. - Proceed as follows:

(a) Maintain the speed of each engine at 800 rpm. (If an engine speed in excess 800 rpm is maintained, the oil temperature will exceed the maximum temperature limit of  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) set for the diluting period. Also fuel vapor blown from the breather outlets to the exhaust stacks by the propeller blast creates a fire hazard.)

**NOTE:** It is impossible to dilute the engine oil unless the engine is running.

(b) Maintain the oil temperature of each engine below  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) during dilution procedure. The ideal temperature is  $40^{\circ}\text{C}$  ( $104^{\circ}\text{F}$ ).

If the oil temperature exceeds  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) the gasoline will evaporate as rapidly as it is introduced into the oil and will leave the oil with its original viscosity. Again, this vaporizing fuel exhausting from the breather outlets creates a dangerous fire hazard. If the temperature exceeds  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) when the airplane is landed, the engines must be stopped and the oil allowed to cool to approximately  $35^{\circ}\text{C}$  ( $95^{\circ}\text{F}$ ) before the engines are started again to accomplish the oil dilution.

(c) Hold the oil dilution switch in the "ON" position for four minutes plus the time required for the propellers to stop rotating (the engines must be stopped at the end of the four-minute period by moving the mixture control to the "IDLE CUT-OFF" position).

The fuel pressure should show a drop from the normal pressure of approximately 14 pounds per square inch to approximately four or five pounds per square inch during oil dilution. If a sharp decrease in fuel pressure is not noted, check the oil dilution electrical circuits, the oil dilution valves and lastly the pressure gages for the source of the trouble.

The electric booster pumps need not be running during the dilution period.

When the engines are started subsequent to engine oil dilution, the normal starting procedure should be followed.

b. Propeller Oil Dilution. - When operating in cold climates with oil dilution equipment installed on airplanes which are equipped with hydromatic propellers, the propeller control will be slowly moved from extreme increase to extreme decrease rpm several times during the period of dilution. This operation will permit the filling of the dome with diluted oil and prevent sluggish response of propeller when starting the engine.

c. Preparing The Airplane for Flight.

(1) Inspect all exposed hinges on flaps, elevators, ailerons, rudders, trim tabs, cargo, and doors for presence of ice or frozen accumulations, and remove all accumulations observed. Clear all obstructions of foreign matter from openings between fixed and movable surfaces, from landing gear hinges and brakes, and from around doors.

(2) Operate all controllable trim or control tabs through complete range of travel three or four times.

(3) Operate ailerons, elevators, and rudders through complete travel three or four times noting forces required. If forces necessary to operate are excessive, check system for cause.

(4) If the airplane has remained in extreme low temperatures for an extended period of time, check air pressures in hydraulic accumulators, surge valves and tanks, in landing gear shock struts, and in tires. Add air whenever necessary to obtain required operating pressure.

(5) Slowly operate all hydraulic mechanisms exclusive of the landing gear retracting system using the accumulators if installed on the airplanes. Refill accumulators and maintain pressure by using hand pumps. After the engines have been started, and the hydraulic fluid has been warmed, repeat this procedure using the engine pump for pressure.

(6) Slowly depress brake pedals several times. If the parking brake operates hydraulically, it should also be applied and released two or three times. Apply foot brakes several times just prior to take-off and in flight just before landing, if the hydraulic system is functioning.

(7) Check special installations, parts or systems for mechanical operation, and check any other parts or operations peculiar to the airplanes affected, and which experience has indicated are liable to be affected by extended low temperature exposure.

(8) Check all tires for freezing to the ground and break them loose if that condition exists before starting the engines or attempting to taxi the airplanes.

(9) Engine rpm should be kept low until the hydraulic fluid is warm to prevent damage to the hydraulic pumps and systems.

d. Portable Ground Heaters.

(1) When operating under freezing conditions and if available, use type D-1, portable heater or heaters as the weather conditions may require to preheat the engines and cabins prior to the first flight.

(2) It requires approximately 15 minutes to heat up the engines at  $-17.8^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ) and approximately 30 minutes at  $-34.4^{\circ}\text{C}$  ( $30^{\circ}\text{F}$ ). Each heater is normally equipped with three flexible warm air ducts.

(3) One heater may be used in light freezing weather to heat two engines and the cabin at a time. Extreme cold weather conditions might require that the entire output of one heater be directed into each engine and one into the cabin. This heater weighs approximately 210 pounds and is easily handled by one man.

**Caution** Whatever method is used for preheating the engine, extreme care must be taken to prevent accidental ignition of the gas fumes from the engine breathers due to vaporization of the gasoline in the oil.

e. Cold Weather Starting of Engines.

(1) When the engines are to be started for warm-up, or to be repeatedly started and stopped for ground test purposes or "alert," engines will be primed and the oil dilution system operated in accordance with the instructions given in paragraph a. When extreme ice and snow conditions exist, all screens should be removed from the carburetor air induction systems, except the screens at the mouth of each carburetor. These screens should be 1/4-inch mesh, approximately .032-inch diameter wire. The screens should be of corrosion-resisting steel, Specification No. AN-QQ-W-423.

(2) During cold weather operation (below  $0^{\circ}\text{C}$ ,  $32^{\circ}\text{F}$ ) drain the oil pressure gage line and refill with instrument oil, AAF Specification No. 2-27.

**Warning** In warming a cold engine in extremely cold weather, start with cowl flaps closed. Do not run the engines to more than 900 rpm until oil has reached a temperature of  $40^{\circ}\text{C}$  ( $104^{\circ}\text{F}$ ).

f. Batteries. - Energizers or battery carts are generally used for cold weather starting, as this is more practicable than heating the batteries. Batteries should be maintained at not less than  $-12.2^{\circ}\text{C}$  ( $-10^{\circ}\text{F}$ ). Lower voltage at extremely low temperatures cause malfunctioning of all electrical equipment.

**NOTE:** To safeguard the batteries, remove them from the airplane and store them in a heated location when the airplane is idle overnight.

**g. Protective Covers.** - Airplane protective covers, consisting of paulins with ropes for securing to the airplane will be used on the wings, tail surfaces, and fuselage to provide protection against frost and ice accumulation. If available install propeller blade covers, Specification No. X-43B10132. Engines and compartment enclosures should be covered to prevent frost accumulation. In extreme cold weather, a certain amount of frost will form under the covers which is apt to affect the moving parts of the airplane. Considerable time is lost by having to move the airplanes into the hangars to overcome this condition, and even, so, the water remaining on the airplane as a result of this action must be removed before moving the airplane outdoors for flight. For airplanes that are moored out in the open, a portable hand-operated heater, when available, is to be used to remove the frost condition. If frost is present on any of the airplane flight surfaces, it must be removed by brushing or flushing prior to take-off.

**h. Frost or Ice Remover.** - When it is necessary to remove frost or ice from areas of the airplane, melt a small area of the ice-covered surface at a time using hot water, then flush this area with denatured alcohol before the hot water freezes. Pay particular attention to the hinges and controls. Alcohol is used for cleaning frost off windows and windshields.

**i. Mooring.** - If due to extreme cold weather, mooring stakes cannot be driven into the ground, use a pick or sharp instrument and dig a hole deep enough (approximately eight inches deep by eight inches square) and freeze deeply notched stakes, having the mooring rope tied to it, crosswise in the hole by filling it with water. The mooring rope may also be coiled in the hole and frozen. When mooring in the open, if possible, head the airplane into the wind, before tying down.

**j. Communication Equipment.** - The following communication equipment is adversely affected by extreme cold weather operation:

(1) **Dynamotor.** - The increased viscosity of bearing lubricants may prevent the dynamotor from starting and result in blown fuses. If this occurs the grease should be removed and oil substituted as a lubricant.

(2) **Operating Controls, Hand Switches, etc.** Stiffness of operation may occur. Oil should be removed in order to prevent drag and binding.

(3) **Storage Batteries.** - Batteries should be kept charged above 1.290 specific gravity.

(4) **Microphones.** - The hand microphone is unsatisfactory for use in cold weather. Moisture collects and freezes in the small holes of the microphone cap. Throat type microphones should be used for all cold weather operations.

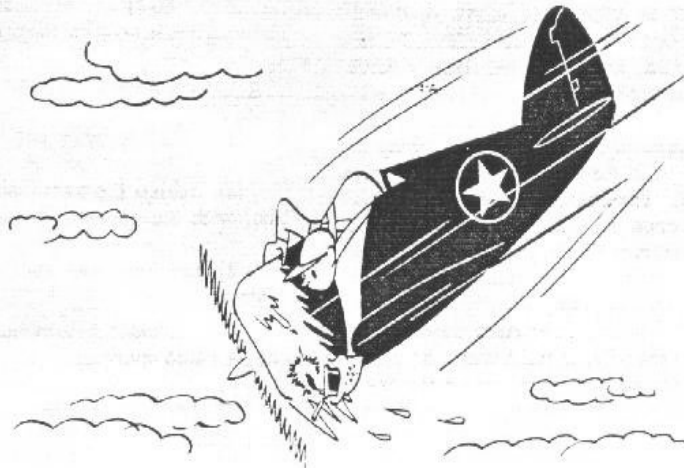
(5) **Transmitter.** - In certain type transmitters, frequency shift occurs with wide changes in temperature. Consequently the transmitter must be returned and checked until a relatively stable temperature is reached.

(6) **Antenna.** - Icing is prevalent on all types of antenna. The whip antenna is most satisfactory in this respect and should be used instead of vee type for radio compasses.

(7) **Plugs.** - Cracking occurs on type PL-54. No remedy can be effected.

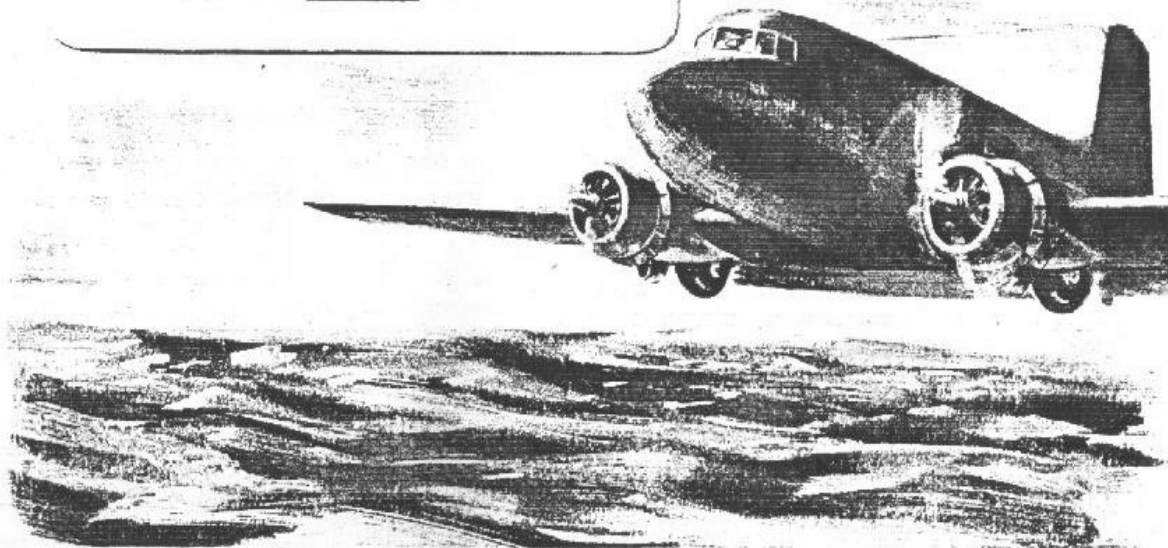
(8) **Antenna Shock Mount.** - The rubber type shock mounts becomes very brittle and breaks in extreme cold weather. A compression type spring can be used for replacement.

**NOTE:** For additional information on cold weather operation, see T. O. No. 01-40NC-2, Handbook of Erection and Maintenance Instructions for the C-47 Transport Airplane.





SECTION X  
FORCED DESCENT OF LAND PLANES AT SEA  
DITCHING



1. General.

The following notes, which may not apply to this specific airplane in all cases, have been prepared by the British for the general guidance of all members of airplane crews in the event of a forced sea landing, which is called "Ditching." The life rafts referred to as "Dinghys" are installed, complete with inflation bottles in the forward baggage compartments.

2. Preparation for Ditching.

a. If the pilot is doubtful of being able to reach shore, preparation for ditching must begin immediately, particularly in regard to the radio procedure.

b. If height cannot be maintained above 1000 feet the crew should move to their stations in order that the pilot can readjust, trim, and lower his flaps without the crew moving about the airplane.

c. The pilot's command to prepare for ditching is "Dinghy, dinghy, prepare for ditching." It must be given by the pilot only. The command will be acknowledged by the entire crew on the interphone system with the answer "Navigator ditching" or "Radio operator ditching," whichever is appropriate. The crew should also have a prearranged call-light ditching signal. The letter "D" in code, repeated three times is appropriate. The pilot will normally warn the radio operator in this manner and the members of the crew nearest the radio operator should also give him verbal warning. The preparation for ditching is thus begun

on a coordinated basis and the pilot is assured that his crew are aware of the situation, and, if they have practiced the drill, they know what to do and do it.

d. The pilot's duty is to coordinate the work of his crew, but each crew member should act on the pilot's command, "Dinghy, dinghy, prepare for ditching," without further orders being necessary, other than the pilot's final command to the radio operator to move to his ditching station and the final warning of the impending impact.

3. The Navigator.

a. The navigator should have a constant knowledge of the wind speed, direction, drift, and the fixed position of the airplane. He should always know the fuel consumption in relation to his estimated time of arrival.

b. At the pilot's command the navigator will:

- (1) Calculate his position.
- (2) Advise the radio operator of the drift position, with the course, height, and speed maintained.
- (3) Receive fixes and bearings from radio operator.
- (4) Calculate estimated position of ditching and advise radio operator.
- (5) Inform the pilot of surface, wind speed, and direction.

(6) Make out air and life raft release pigeon messages.

(7) Destroy secret papers and place charts (with latest position marked thereon) in satchel.

#### 4. Radio Operator.

a. On the pilot's command, "Dinghy, dinghy prepare for ditching," the radio operator will:

(1) If on "GROUP" frequency make the first signal on that frequency and then change over to the allotted "MFDF" section.

(2) Turn "IFF" to emergency.

(3) According to the situation, use one of the three priority calls:

(a) S.O.S. I am in immediate need of assistance. May Day (by radio telephone).

(b) I may require assistance.

(c) I may be forced to land without further signal.

(4) Give a time and position to the signal. It is better to make one of the appropriate distress signals than to remain silent. A distress call can always be cancelled when no longer applicable and in fact this must be done.

(5) Transmit course, height, and ground speed maintained.

(6) Advise navigator of fixes or bearings.

(7) Get estimated position of ditching from navigator.

(8) Transmit estimated position of ditching.

(9) Clamp down key on pilot's command and move to ditching station.

(10) Destroy secret papers.

(11) Where possible use the trailing antenna as an altimeter.

#### 5. Pilot's Responsibilities.

a. To be sure that the cargo doors are opened, cargo and loose equipment dumped and the doors closed again.

NOTE: Be sure that when equipment is dumped it does not hit the empennage or carry away the IFF antenna.

b. To Determine Whether or Not to Dump Fuel. - The crew member who has been detailed in the previous

drill opens the valves on the pilot's order. After the fuel is dumped it is imperative that the valves be closed again to retain the buoyancy of the tanks. Fuel valves take time to open and close and fuel can seldom be dumped faster than 100 gallons per minute.

c. Make sure that the crew member detailed in the drill assists pilot to secure his shoulder harness.

d. Release pilot's upper escape hatch.

e. Check that landing gear is "UP."

f. Lower flaps as required.

g. To Order the Radio Operator to His Ditching Station. - It is important that he remain at the set as long as possible.

h. Warn the crew when ditching is imminent.

i. To switch on the landing lights and upper identification lights (if this does not cause reflections which upset vision). It is important to remember that although the surface may be seen in the beam of the landing lights, judgment of height may not be correct.

#### 6. Making the Airplane as Seaworthy as Possible.

a. Not only does dumping the fuel lighten the airplane and so reduce the speed at which the airplane may be ditched, but also the empty fuel tanks are a considerable contribution to flotation.

b. The security of all lower and side hatches must be checked. Side escape hatches may have to be used in ditching but only upper escape hatches can be regarded as ideal, since they must be opened before ditching. This is necessary because the hatches may become jammed on impact and also because it is essential for the crew to be free to leave the airplane without delay after ditching.

c. All bulkhead doors must be closed to hinder the flow of water from bow to stern.

d. Close all camera hatches and flare chutes.

#### 7. Crew Preparations to Insure Safety On and After Impact.

a. All the actions taken to make the airplane seaworthy also come within this category.

b. It is vitally important that the crew should be braced for the impact. There are two ideal ditching stations:

(1) In a sitting position with head braced against a solid structure such as at the rear of a spar, or bulkhead. If the head comes above a spar being used as a ditching station, it is very important that the head should be clasped in the hands to avoid it being forced



back and injured. In this position the body can withstand forces which are far greater than those expected in ditching with the exception of forces expected when the airplane dives straight in.

(2) The second but less satisfactory ditching station is to lie on the floor with the head to the rear and the feet braced against a solid structure. It is necessary to have the knees bent to avoid injury as far as possible, but the limiting factor of this ditching station is the liability of the legs to fracture.

c. Straps are not normally required at ditching stations unless there is a lack of suitable positions in the airplane, in which case the crew member may have to remain in his seat. Loss of life may occur due to failure to get clear of the airplane so that straps must not be used unless virtually necessary.

d. It is vitally necessary that the pilot be secured by shoulder harness and it is considered that the embarrassment caused by having harness done up during ditching is far less serious than the consequence of not being secured.

e. All upper hatches should be opened before ditching to facilitate the rapid exit of the crew and also to insure that the hatches do not become jammed on impact, due to being left closed. It should, however, be borne in mind that open hatches cause drag and therefore, if the airplane is being flown at reduced power these upper hatches should not be opened until at least 1000 feet is reached.

f. In night ditching, all bright internal lights should be put out and only the amber lights used. This will accustom the eyes to the external darkness.

g. All lights should be left on after ditching to facilitate search, in the event of the airplane floating for a period.

h. Life jackets must be worn at all times with the leg straps secured. Where there are small upper ditching hatches, jackets should not be inflated until immediately after leaving the hatch. In most cases it is safe to inflate the jacket with one or two breaths before ditching.

i. Parachute harnesses should be removed before ditching in all cases where practicable.

j. Helmets should be retained for the sake of protection of the head against cold when in the life raft. The leads should be tucked firmly within the life jacket below the V of the neck, at the top tie.

#### 8. Judging Wind and Surface Conditions.

a. At least an elementary understanding of sea conditions must be gained to obtain full advantage from the notes on handling, which follow this section.

b. Calm Sea. - With this type of sea, there may be little or no wind, so that it is essential to ditch with the lowest indicated air speed possible. Such a sea is deceptive with regard to judgment of height, particularly if the surface is glassy. If there are ripples upon the surface judgment of height is improved.

c. Waves always move with the wind except close inshore and in fast flowing estuaries. Waves are the direct result of the wind which creates them and maintains them.

d. "Swell" is an undulating movement of the surface caused by past or distant disturbance by action of the wind. It does not necessarily move with the wind and it has no breaking crests. If the wind is blowing across the swell a cross sea is created with the waves (which are moving downwind) running on the swell. In these conditions the pilot must choose that direction along the swell which will make the approach as near to the wind as possible.

#### 9. Ditching Characteristics.

a. If the airplane alights tail down in a three-pointer attitude (as it should) there will be a primary slight impact as the rear of the airplane strikes. This will be followed by a severe impact with violent deceleration in most cases.

b. If the alighting has been made too fast a bounce will occur, providing the fuselage is sufficiently strong. As the airplane comes to rest the nose will bury, but if the alighting has been carried out correctly, the effect of the nose burying will be minimized and the structure may not collapse.

c. If the airplane bounces in a short, moderate or calm sea, the control column should be held back. In the average short sea the tail should touch the crest of a wave and as soon as it does the nose should be kept up as much as possible. This should cause the forebody to touch down approximately under the center of gravity on the next wave.

**Warning** The open sea always appears from the air to be much more calm than is the case.

#### 10. Wind Speed and Direction.

a. In the absence of any fixed mark (land, lightship, etc ), or floating object not under way, the pilot can only judge motion relative to the motion of the waves.

b. Waves, as distinct from swell, move downwind and the line of the wind can be taken to be at right angles to the lines of the wave crests. Doubt may exist as to which way the wind blows along the line.

c. If there is sufficient wind, waves break and they break downwind. This can readily be observed from a low height. If the airplane is flown at right angles to the breaking waves the direction of drift will be apparent.

d. If there is enough wind to blow the spray off the wave crests, the direction in which the spray moves is reliable.

e. Wind direction may be obtained by dropping a smoke float. The smoke from ships is also a useful guide. Smoke naturally drifts with the wind and if this drift could be observed the direction would be indicated. But do not make the mistake of supposing that the wind direction is along the trail of the smoke. This trail is the resultant of the wind speed and direction and the ship's forward motion. Therefore, the wind direction is somewhere between the forward path of the ship and the smoke trail. Only when the wind is blowing in a similar direction to the forward motion of the ship will the smoke be a reliable indication of direction. It will be from astern.

f. If low enough, it is possible to calculate the direction of the wind by observing the sails of surface craft. A reasonable indication of speed can also be gained by observing the set of the sails.

g. Where the surface is not broken up, it is possible to watch gusts rippling the surface in great sweeps, which indicate the wind direction.

#### 11. Drill During Final Approach.

a. The pilot should keep his radio operator at the radio set as long as possible and allow him only a safe margin of time to take up his ditching station.

b. The crew must see to it that the radio operator's ditching station is not occupied and is clear of obstacles.

c. The pilot will warn the radio operator to move to his ditching station by call light, by interphone, or by shouting.

d. The radio operator for his part can be fairly certain that the order will come when he feels the flaps finally being lowered.

e. The radio operator will immediately clamp down the key and move to the ditching station at the pilot's command, fully realizing that he has been left at the set only as long as it is safe and if he does not move quickly he may be caught standing up at impact. This may prove fatal.

f. The pilot will maintain intercommunication with the crew up until the last moment and warn them of the impending impact. It is not reasonable to expect the crew to remain braced for long periods. If they are not in communication with the pilot the temptation to get up and see how things are progressing may end in their being caught away from their ditching station with consequent injury. A casualty in ditching is a grave handicap to the rest of the crew, who may scarcely be able to save themselves.

#### 12. Drill During Ditching.

a. The crew must not relax or release themselves in their ditching stations until the airplane has come to rest.

b. The first impact of the tail can be mistaken for the shock against which they are on guard, but it will be followed by a greater shock as the nose strikes the water after a correct three-point tail-down ditching.

NOTE: Serious casualties have occurred in crews who have not taken up proper ditching stations or where they have relaxed before the final impact. Also, some crews have thought that they knew better ditching stations than those laid down in the official drill. This also has resulted in casualties. It is pointed out that these drills are the result of the experience of a great many previous ditchings and are drawn up accordingly.

#### 13. Handling Landplanes in Ditching.

a. Use of Flaps. - The flaps should be lowered to reduce the speed at which the airplane can approach and touch down. It is better to use a medium setting and not to lower them fully because little, if any, further reduction of speed is obtainable by so doing, while the rate of descent is increased and the airplane approaches more nose down. A steep nose down descent is dangerous if the sea is met sooner than expected and also more height is required for flattening out from such an attitude.

b. Approach Speed. - Assuming that symmetrical power is not available the normal glide approach speed should be used. This will insure control and some margin of speed after flattening out to allow the pilot to choose the best point for ditching on the swell.

c. Touch Down. - Apart from choosing the best point at which to ditch, the pilot should hold off until he loses all excess speed above the stall and so strikes the sea at the normal three-point landing attitude. The best point for ditching is towards an oncoming swell top.

d. Approach In a Swell. - As the sea is approached drift should be taken off by sideslipping and the airplane ditched on the upslope of the swell.

e. Across Wind Along a Swell. - As the sea is approached, drift should be taken off by sideslipping and the airplane ditched on the upslope of the swell.

f. Use of Engines. - If only one engine is available a little power should be used to flatten the approach, but the engine should not be used to such an extent that the airplane cannot be turned against it right down to the stall, with a margin of rudder power in hand. On no account should the engine be opened up during the final stages of ditching. The power that can be used will depend on the characteristics of the airplane.



#### 14. Retention of Fuel for Ditching.

The value of power in ditching is so great that the pilot should always ditch before the fuel is quite exhausted, when it is certain that shore cannot be reached.

#### 15. Altimeter.

The aneroid altimeter is quite unreliable as an indicator of close approach to the sea. The trailing antenna can be used, the radio operator signalling the pilot when the current drops as the weight hits the sea. An alternative method is to engage the antenna with an insulated hook held in the hand, when the impact of the weight on the sea will be felt. This drill can only be carried out where a suitable station is adjacent to the radio operator.

#### 16. Drill After Airplane Has Come To Rest.

a. The crew must not release themselves until the airplane comes to rest.

NOTE: There are two critical periods in ditching.

(1) The actual handling of the airplane on the water. This is the sole responsibility of the pilot.

(2) The abandonment of the airplane in an orderly manner after ditching in the very shortest possible time. An untrained crew cannot be expected to complete this operation in a training fuselage in a hangar; nor can an untrained crew be expected to carry out an efficient drill in the dark in a fuselage rapidly filling with water. Practice makes perfect. A large number of crews owe their rescue by surface craft to previous practice in abandonment of the airplane.

b. As soon as the airplane comes to rest, rise from the ditching stations and collect the equipment detailed in the drill. Leave by the hatch assigned in the drill and in the correct order, carrying that equipment allocated to each crew member.

c. On emerging inflate the life jacket if not already done. Do not be surprised to find that waves may be breaking over the airplane. If they are large it is possible to be swept off. If the airplane has a life line attached to the inside of the hatch, make use of it, otherwise hold on to the outside of the hatch and await a favorable moment to board the life raft, but by doing so take care not to block the escape hatch or to hinder the tempo of the drill to any great extent.

d. The men detailed to remove the life rafts from the stowage should see that the necessary cordage does not entangle during inflation. They should also place the life rafts in the water in order to hasten the boarding.

e. If a life raft should inflate upside down, an effort should be made to right it from the wing if the

airplane is not sinking too rapidly; otherwise one (and only one) of the crew should jump into the sea and right it. There are two methods of righting life rafts:

(1) If there are handling patches on the bottom of the life rafts grasp them with both hands. Then haul on these patches with the knees on the buoyancy chamber. Now while still hauling on the handling patches lean back and prepare to become submerged for a moment. Even the largest life raft will turn over.

(2) In the absence of handling patches place the toe of the foot on the bottom of the ladder, grasp the two nearest stabilizing pockets. Lean back and haul on the pockets while pressing with the foot on the ladder.

f. Do not jump on an inverted life raft, as doing so expels the air trapped beneath it and makes righting more difficult.

g. If there is a painter which attaches the life rafts to the airplane, it is made light in order that it will break if the airplane sinks while the life raft is still attached. There is a floating knife attached to the life raft near the point where the painter is made fast. This knife is to be used to cut life raft free.

#### 17. Boarding the Life Rafts.

a. If the ditching has been made into the wind the life raft should float toward the empennage and the boarding will not be difficult.

b. If a crosswind ditching has been made the airplane will tend to swing into the wind. If the life raft is on the upwind side of the airplane, there is danger of its becoming wedged beneath the wing as the airplane rolls and swings into the wind. On the other hand, if the life raft is on the downwind side there is a danger of its getting beneath the fuselage or empennage, which may be thrashing up and down as the airplane weathercocks into the wind. Look out for jagged edges which may puncture the life raft.

c. Do not jump into life rafts. By so doing they may become damaged and the whole crew endangered.

d. If boarding from the sea, use the rope ladder, or the tail line if provided. When using the ladder grasp the ratlines (which run across the life raft) with one hand and the bottom rung of the ladder with the other pushing it down into the water as far as it will go to assist in inserting the foot. Then grasp the ratline with both hands and pull, at the same time pressing downward with the foot.

e. One man already in the life raft can be of great assistance to those in the water.

f. To avoid the consequences of exposure it is important not to get wetter than absolutely necessary. Wet clothing must not be taken off. It is far warmer with wet clothes on than off. In hot weather this may not apply, but the body should be covered against the sun.

g. On every life raft there is a heaving line which may be used for aiding crews to reach the life raft.

h. All the above actions concerning the boarding of life rafts are comparatively simple if the life jacket is fully inflated. If this jacket has been partly inflated by mouth it is important to see that the mouth valve is closed before using the CO<sub>2</sub> bottle. A non-swimmer can feel quite confident in a fully inflated jacket providing the leg straps are secure.

#### 18. Aboard the Life Rafts.

a. Once aboard, it is the duty of the man detailed in the drill to check whether there are any leaks and stop them up with the repair material provided.

b. Once every one is aboard, the pilot should call the roll, give the order to cast off and then the crew should paddle away from the airplane. If the airplane floats, keep nearby to increase the chance of being spotted. But do not remain fast to the airplane if there is any chance of the life raft being punctured or in rough weather where the life raft is likely to be damaged by the rise and fall of the airplane.

c. Start bailing as soon as possible.



APPENDIX IU. S. A. - BRITISH GLOSSARY OF NOMENCLATURE

U. S. A.	British	U. S. A.	British
Accumulator (hydraulic)	Should not be confused with electrical accumulator or battery	Lock washer	Spring washer
Anti-friction bearings	Ball and roller bearings	Manifold pressure	Boost
Battery (electrical)	Electrical accumulator	Oil pan	Sump
Blade connecting rod	Plain connecting rod	Pad	Sometimes used for raised machined surface for mounting accessories, etc
Block test	Bench test under engine's own power	Palnut	Type of locknut
Bombardier or Bomber	Bomb-aimer	Panel, wing - center of inboard panel	Center section
Box-end wrench	Circular-ended wrench (for hexagon)	Outboard panel	Outer plane
Cap screw	Setscrew or screw	Pilot	Spigot
Check valve (hydraulic)	Non-return valve	Piston pin	Gudgeon pin
Clevis	Fork joint or knuckle joint	Reticule (gun sight, etc)	Graticule
Closed spanner - wrench with internal lugs or surface lugs	Ring spanner	Round head screw	Cup head screw
Copilot	Second Pilot	Screen	Filter
Cotter pin	Split pin	Setscrew	Grub screw
Crock (used in heat-treatment)	Earthenware jar	Ship	Aircraft
Cylinder (hydraulic)	Jack	Slushing compound	Corrosion inhibitor
Dump valve	Jettison valve	Socket wrench	Box spanner
Fillister head screw	Cheese head screw	Spanner	C-spanner
Flat head screw	Countersunk head screw	Spanner wrench	Ring spanner
Flight indicator	Artificial horizon	Stabilizer - Horizontal Vertical	Tail plane Fin
Gall	To fret or score	Stack	Manifold (inlet or exhaust)
Gasoline (gas)	Petrol	Sylphon	Aneroid
Gross Weight	All up weight	Tachometer	Engine speed indicator
Ground (electrical)	Earth	Tag	Label
Green run	Endurance test	Test club	Test fan
Gyro horizon	Artificial horizon	Tube (radio)	Valve
Gyro pilot	Automatic pilot	Turn indicator	Direction indicator
Kerosene	Paraffin	Valve (fuel or oil)	Cock
Knuckle pin (used on radial engines)	Wrist pin or anchor pin	Weight empty	Tare