FLIGHT MANUAL

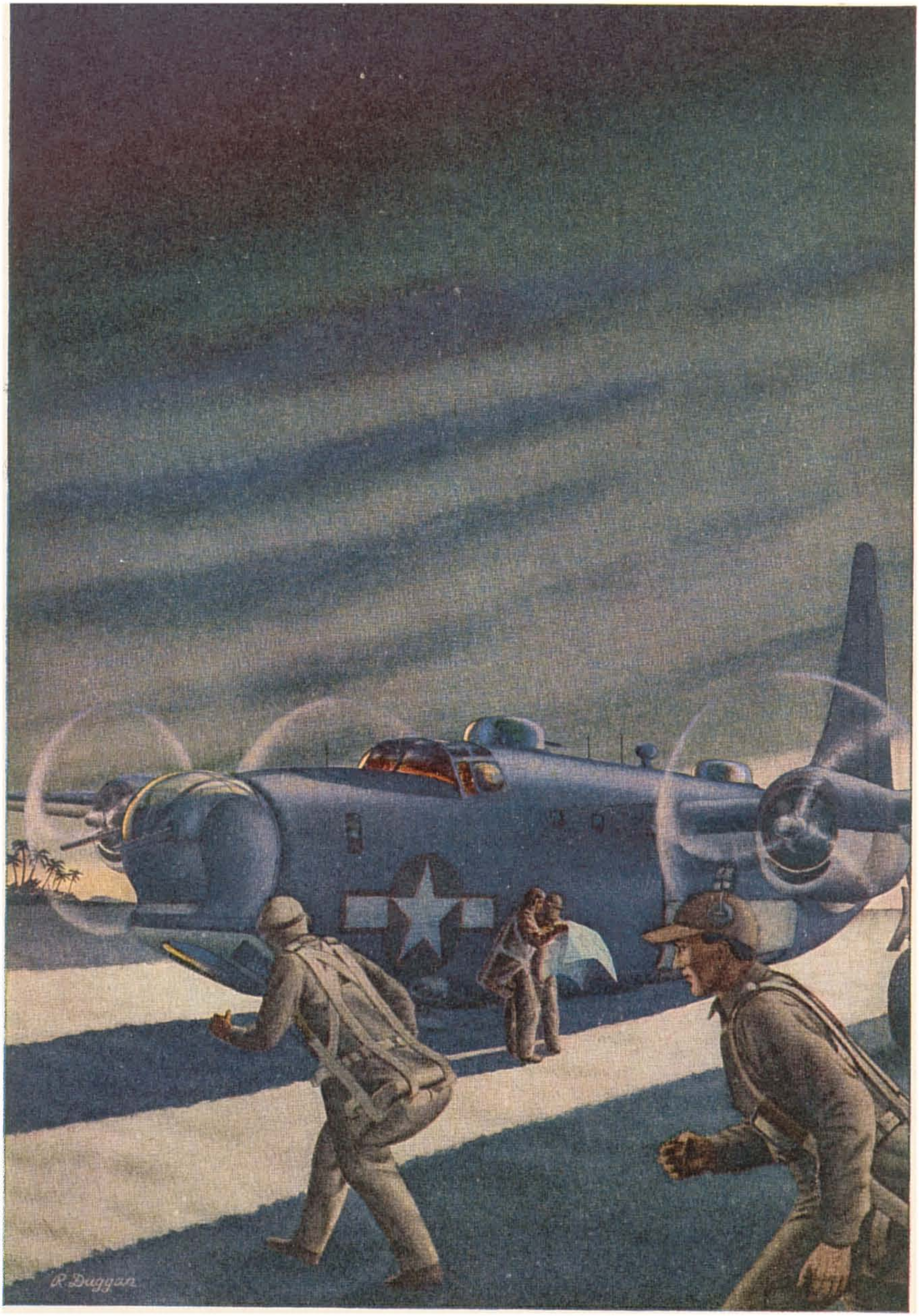
PB4Y-2 BOMBARDMENT AIRPLANE

PREPARED BY

SERVICE DEPARTMENT

OF

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO, CALIFORNIA
U. S. A.


R. Duggan

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FOREWORD

The information in this PB4Y-2 Flight manual will serve to give you, the pilot, a review of the operations of the various systems in the airplane. The extra time you give to familiarize yourself with the operating systems may prove to be a valuable asset when a difficult situation arises.

Your PB4Y-2 airplane, like any other well designed equipment, requires intelligent handling. A thorough knowledge of essential facts, gained by review, will help you in all of your operations.

G. A. P.

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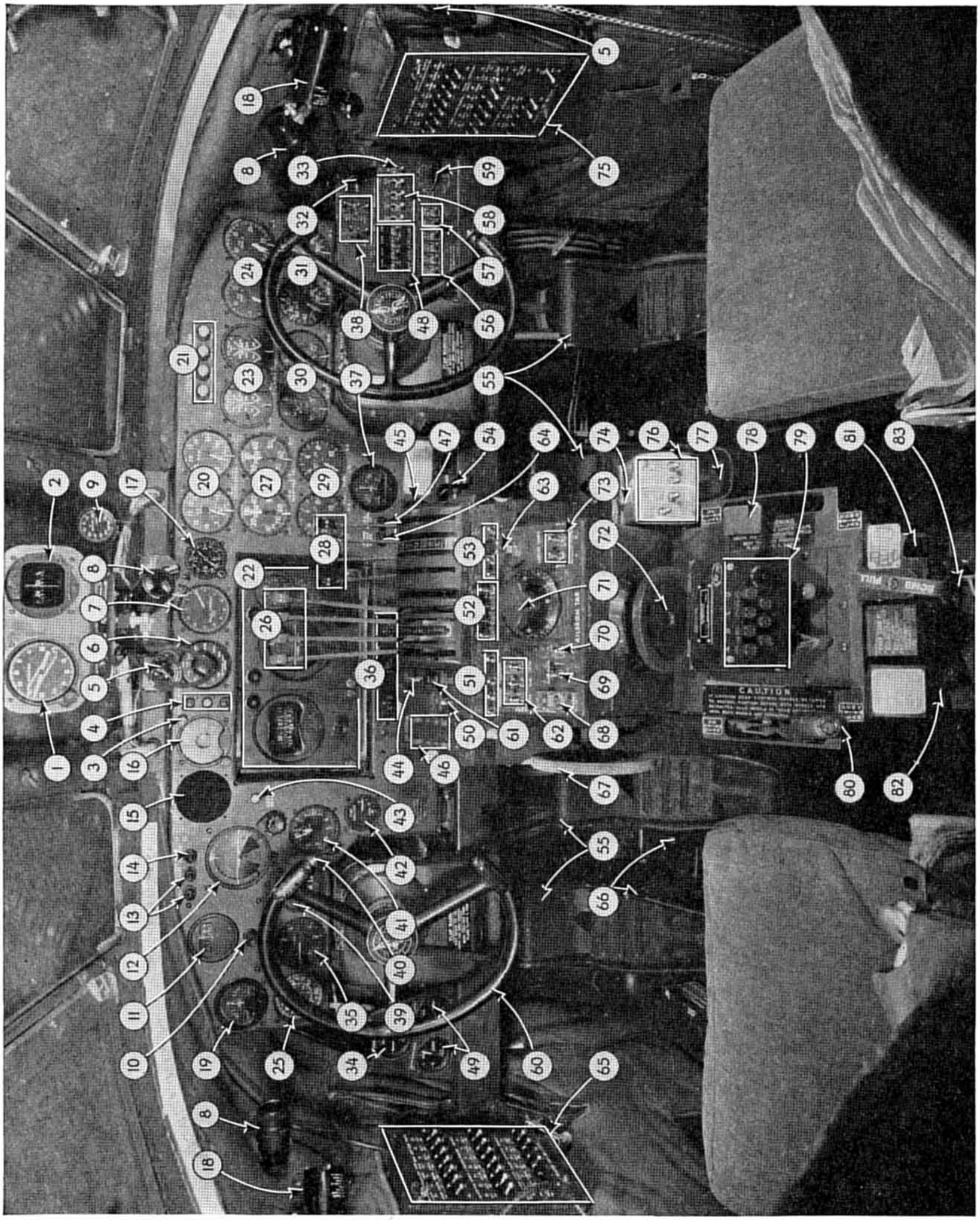
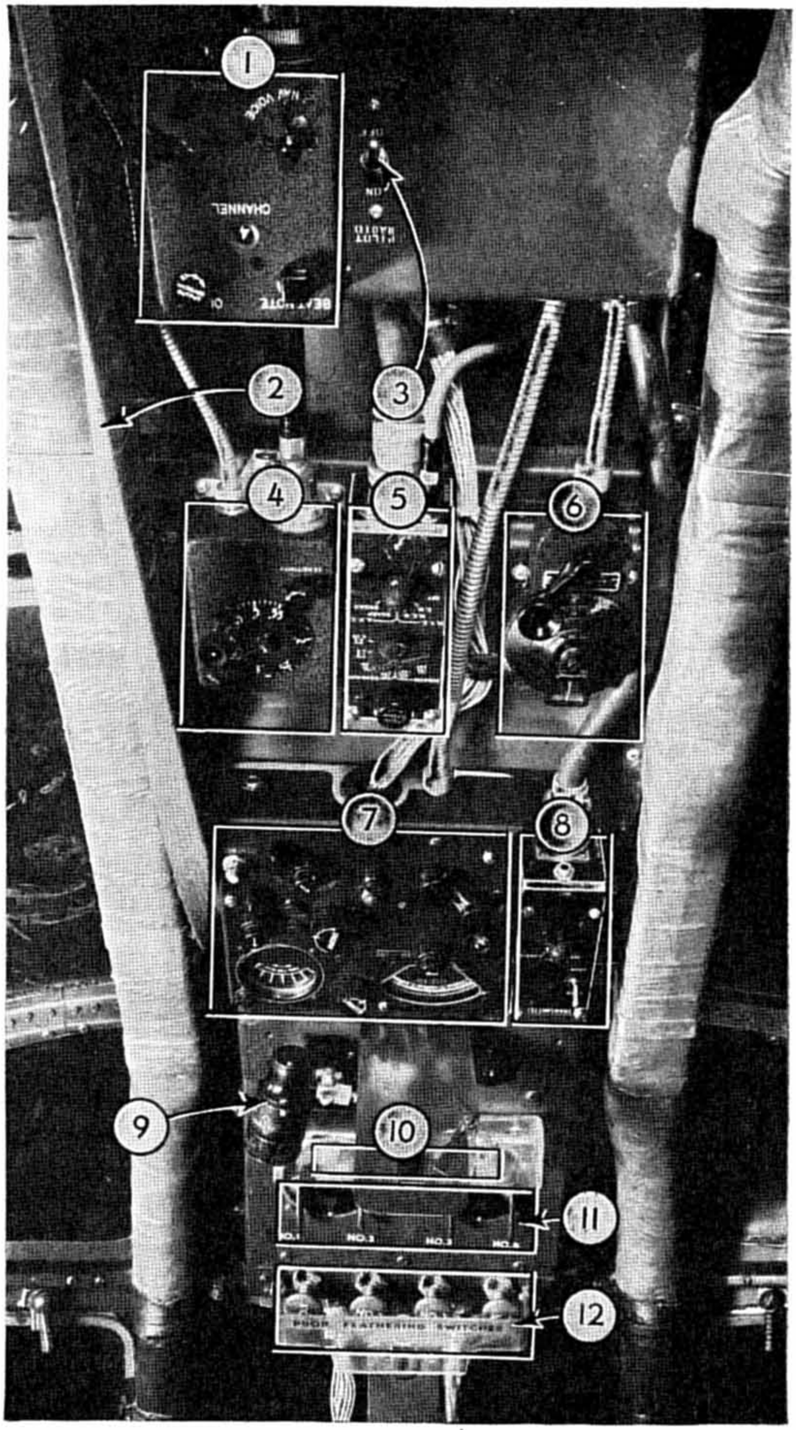


Figure 1—Location of Controls—Flight Compartment

LEGEND FOR FIGURE 1

1. Direction Indicator
2. Magnetic Compass
3. Radio Altimeter
4. Radio Altimeter Indicating Lights
5. Instrument Panel Light Rheostat Switch
6. Radio Altimeter Limit Switch
7. Radio Compass
8. Ultra-Violet Instrument Panel Light
9. Free Air Temperature Indicator
10. Gyro Indicator Caging Control
11. Gyro Indicator
12. Gyro Horizon
13. Bomb Door Indicating Lights
14. Bomb Release Indicating Light
15. ZA Indicator
16. Radio Altimeter
17. Clock
18. Map Reading and Trouble Light
19. Pilot's Directional Indicator
20. Tachometers
21. Propeller Limit Indicating Lights
22. Automatic Pilot
23. Head Temperature Gauges
24. Fuel Pressure Gauges
25. Air Speed Indicator
26. Throttle Levers
27. Manifold Pressure Gauges
28. Mixture Control Levers
29. Fuel Flow Indicators
30. Oil Temperature Indicators
31. Oil Pressure Gauges
32. Carburetor Air Control Handle
33. Bomb Bay Booster Pump Switch
34. Hydraulic System Pressure Gauge
35. Rate of Climb Indicator
36. Automatic Pilot Trim Indicators
37. Pilot's Directional Indicator
38. Oil Dilution Switches
39. Turn and Bank Indicator
40. Microphone Button
41. Altimeter
42. Flap Position Indicator
43. Marker Beacon Indicator Light
44. Pitot Heat Switch
45. Automatic Pilot Oil Pressure Gauge
46. Fast Feathering Pump Circuit Breaker Reset
47. A.S.G. Antenna Nacelle Position Indicator
48. Cowl Flap Switches
49. Brake Pressure Gauges
50. Hydraulic Booster Pump Switch
51. Anti-Icing and Cabin Heat Switches
52. Propeller Governor Switches
53. Supercharger Switches
54. Throttle Lock Control Knob
55. Brake Pedals
56. Starter Switches
57. Primer Switches
58. Booster Pump Switches
59. Propeller Anti-Icing Switch
60. Pilot's Control Wheel
61. CO Indicator Warning Light
62. External Light Switches
63. Automatic Pilot Control
64. Landing Gear Position Indicator Lights
65. Pilot's Power Panel
66. Rudder Pedal Adjustment
67. Elevator Tab Control
68. Alarm Bell
69. A.C. Power Switch
70. Pilot's Directional Indicator Switch
71. Rubber Tab Control
72. Aileron Tab Control
73. Landing Light Switches
74. Recognition Light Keying Button
75. Copilot's Power Panel
76. Recognition Light Switches
77. Rudder Pedal
78. Wing Flap Control Handle
79. V.H.F. Control Head
80. Landing Gear Control Handle
81. Controls Lock
82. Parking Brake
83. Emergency Bomb Release



1. A.R.R.-2 Radio Receiver Control Head
2. Control Lock Strap
3. Pilot's Radio Power Master Switch
4. ARC-5 Command Set Control Head
5. ARB Command Receiver Control Head
6. ARB Command Receiver Control Head
7. Radio Compass Control Head
8. ATB Transmitter Control Head
9. Ultra-Violet Instrument Light
10. Master Bar Switch
11. Ignition Switches
12. Fast Feathering Switches

Figure 2—Overhead Controls

CHAPTER I
FLIGHT PROCEDURE

HOW TO FLY THE PB4Y-2 AIRPLANE

THE operation of any airplane, single or multi engine, requires certain functions to be performed in a definite sequence. This sequence is necessary either as a precaution against injury to personnel, or to prevent equipment damage which might be incurred by using an incorrect procedure, or to create a definite condition upon which a subsequent action depends.

Pilots and plane captains can learn the entire PB4Y-2 operation in detail by referring to the illustrated step-by-step guide herein as it applies to the operation of controls from the time the crew first approaches the airplane until it has returned to the field from a flight.

Fundamentally, the PB4Y-2 is not a stranger. Its prototype has demonstrated a tremendous capacity to perform difficult missions. Changes in design and equipment location have occurred because of new demands on capacity.

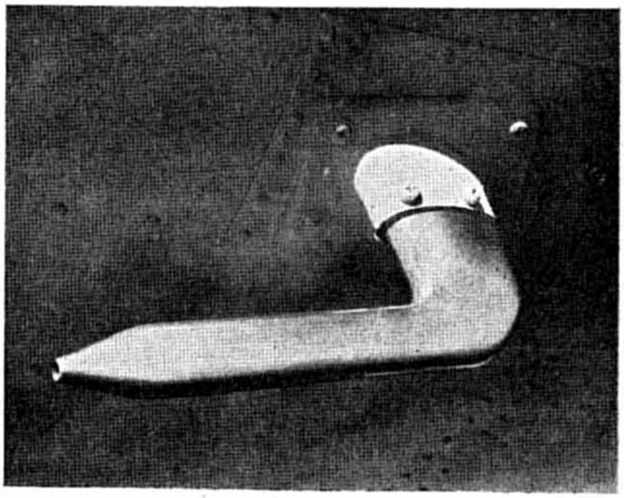
The various functional systems are described later in this manual. It is important that you **KNOW YOUR AIRPLANE.** A large bomber is a highly complicated piece of equipment, but a study of the functions of the several systems will clarify the doubt and mystery which accompany unfamiliarity. A little time devoted to fundamentals will pay amazing dividends—at a time when most needed. Competence inspires confidence, and, what is more important, may be the means of converting an impending misfortune into a successful outcome. *Use good judgment and common sense!*

BEFORE STARTING ENGINES

1—Pilot

CHECK PITOT COVER REMOVAL

Upon approaching the airplane the wise pilot makes certain that the cover on the pitot head has been removed. He knows that this cover cannot be removed in the air and that with it *on* the airspeed indicator is inoperative. An airplane of this size cannot be operated safely by guessing airspeeds.



2—Plane Captain

OPEN BOMB BAY DOORS

The plane captain opens the bomb bay doors at a small access door on the right side of the fuselage. There is no lock—just push in on the small access disc to release the spring latch on the door. The handle extension is first pulled outboard and then moved aft to operate the auxiliary bomb bay door valve. Retract the handle extension and the access door will close.

3—Pilot

FORM F WEIGHT AND BALANCE

It is the duty of the pilot to inspect the Form F and to determine if any malfunctions noted on the previous flight have been corrected. The weight and balance report should be inspected for approval at this time.

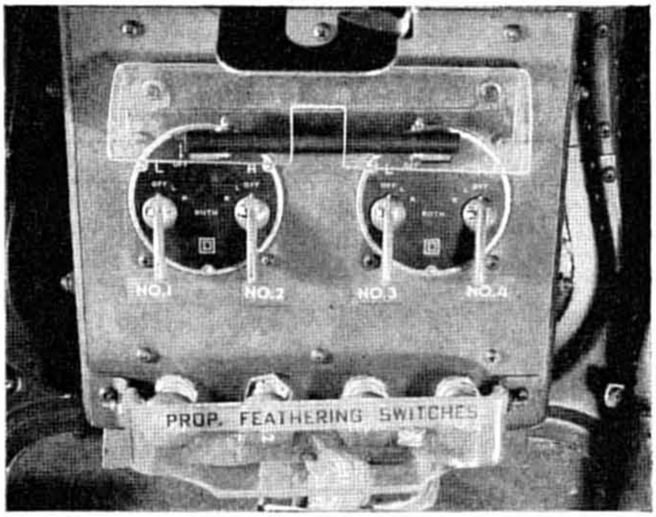
4—Plane Captain

PLANE CAPTAIN'S REPORT

When properly completed, this report should state the amount of fuel and oil aboard, the number of crew and parachutes aboard, and any discrepancies noted on preflight inspection.

With the ship open, pilots enter first and go to the flight compartment. The plane captain then enters.

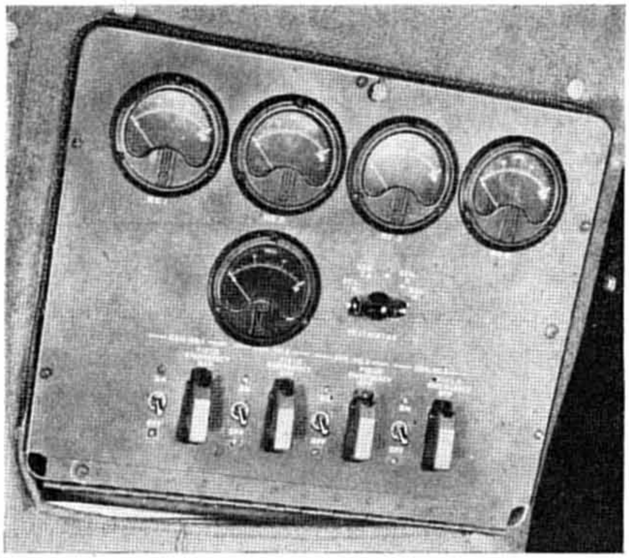
5—Pilot



MASTER SWITCH AND IGNITION SWITCHES OFF

The first act of any pilot on taking his seat is to definitely see that the master emergency switch bar and the ignition switches are *off*. This is for the safety of the plane captain or any of the ground crew who may approach the propellers. Kick back would result in serious injury.

6—Plane Captain



GENERATOR SWITCHES OFF

Switches on the generator switch panel, located on the left cabin wall behind the pilot, are turned *off* to prevent damage to the voltage regulators before engines are brought up to speed for taxiing and subsequent operations.

7—Pilot

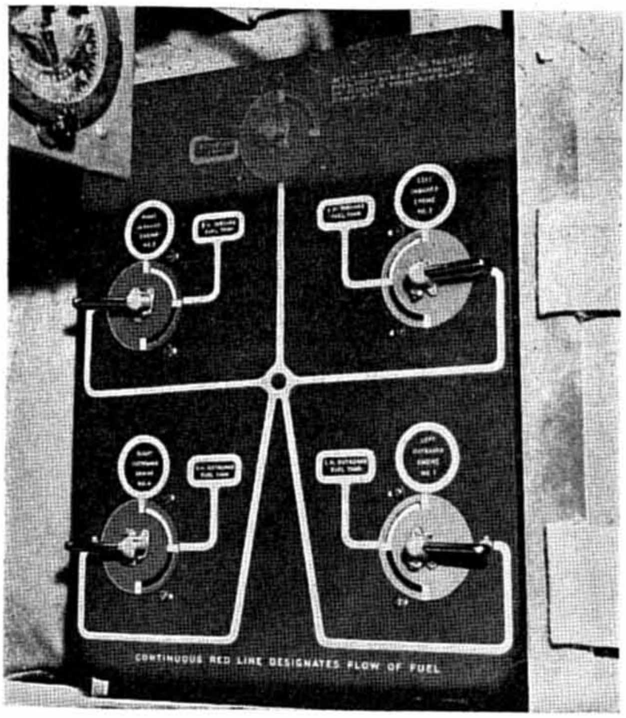
ADJUST SEATS

As the fuel and oil levels are being determined, the pilot and copilot in their seats, adjust them for maximum comfort by means of the levers which permit adjustment fore and aft, up and down, and tilt.

8—Pilot

ADJUST RUDDER PEDALS

With the seats adjusted for comfort, the rudder pedal adjustment for proper length is the next step. Each pedal adjustment ratchet is located between the pedals. Adjustment is accomplished by pushing the ratchet lever away from the pedal with the toe and moving the pedal fore or aft to the proper postion. Be sure the latch is fully re-engaged and be sure that the pedals are adjusted for the same length when the system is in neutral.

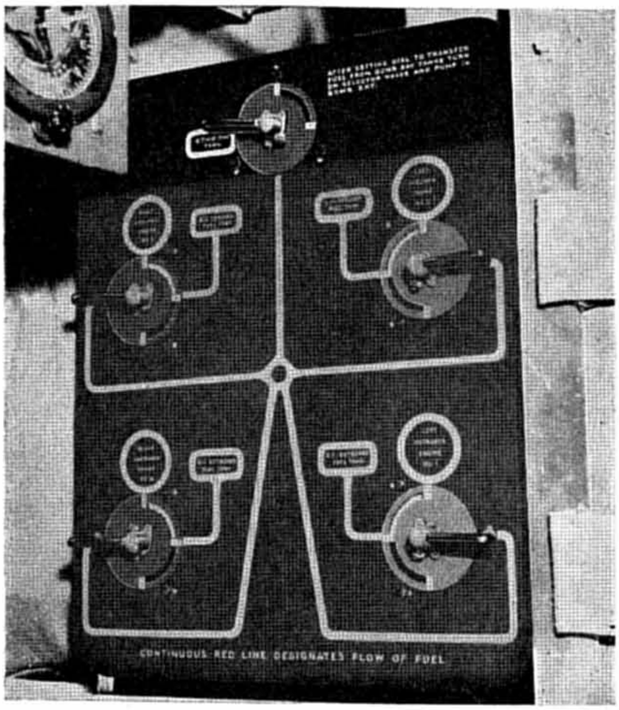


9—Plane Captain

MAIN FUEL VALVES—TANK TO ENGINE

The plane captain will turn *on* the four fuel selector valves, one for each engine. The red line seen through the valve disc, which rotates with the handle, indicates connection of an engine to a correspondingly marked fuel tank or to the cross-feed connection to which all tank units and engines may be interconnected. These valves are located on the fuel selector panel which is on the forward face of the bulkhead at station 4.1, right side, at the rear of the flight compartment.

10—Plane Captain



BOMB BAY FUEL VALVE OFF

The auxiliary bomb bay fuel system is shut off at the valve located at the top center of the main panel.

11—Pilot

RELEASE CONTROLS LOCK

The strap which holds the locking lever up in the *locked* position is removed and stowed securely in the overhead. It is wise to check the locking lever in the *full down* position to make sure it has dropped all the way and the lock is released.

12—Pilot—Plane Captain

CHECK SURFACE CONTROLS

(Pilot's Section)

With the controls lock released, check each movement of the rudder, elevator, and ailerons, with each movement of the control wheel and rudder pedals.

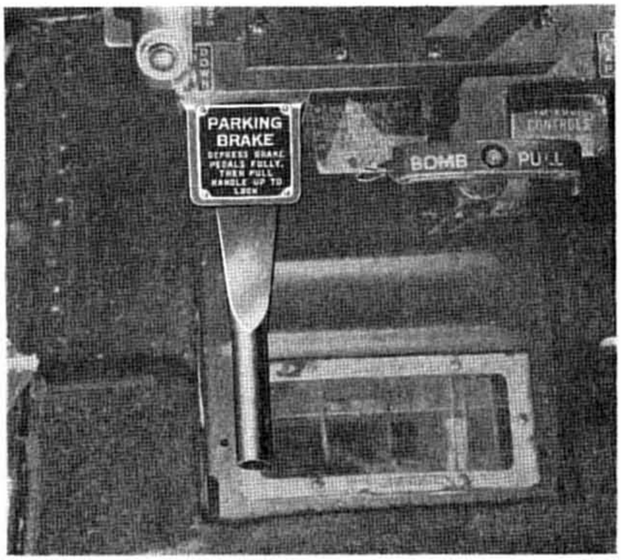
(Plane Captain's Section)

As the pilot exercises each control for freedom of movement and complete travel, the copilot or the plane captain should check the direction of movement of that control surface visually and call it out to the pilot. Check the tab action on the aileron, elevator, and rudder systems to eliminate the possibility of adverse tab action. These checks might seem superfluous but the direction of movement of control surfaces has been found to be reversed after rerigging.

13—Pilot

SET PARKING BRAKES

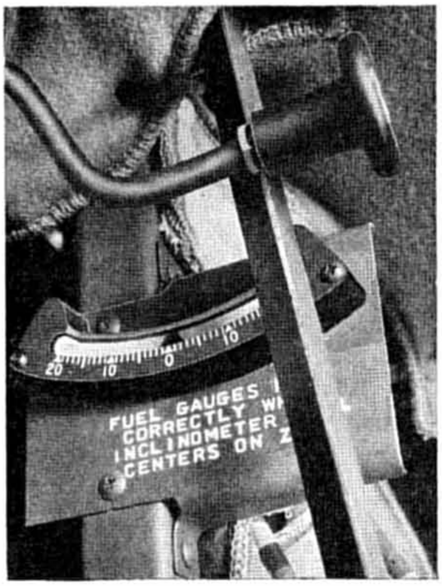
The parking brakes are set by pressing brake pedals fully and lifting lever in *up* position to lock. Press brake pedals to unlock.

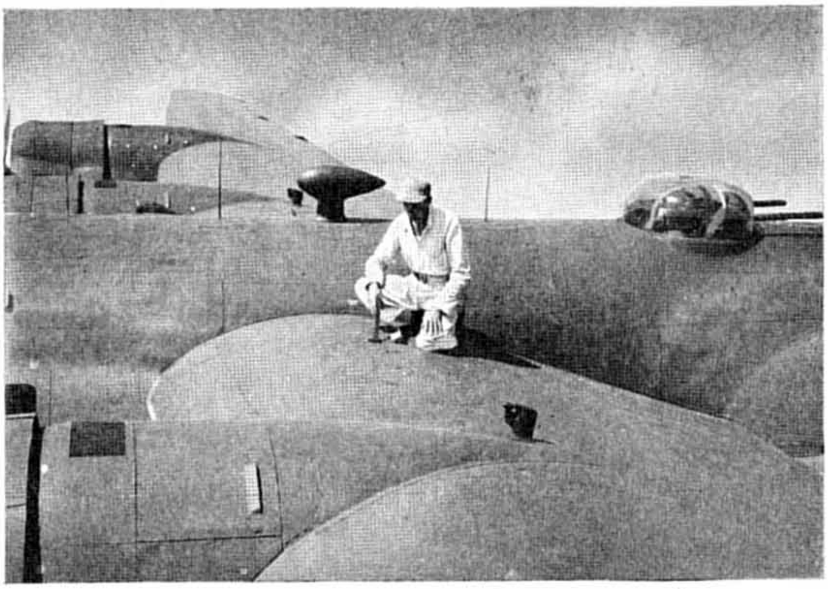


14—Plane Captain

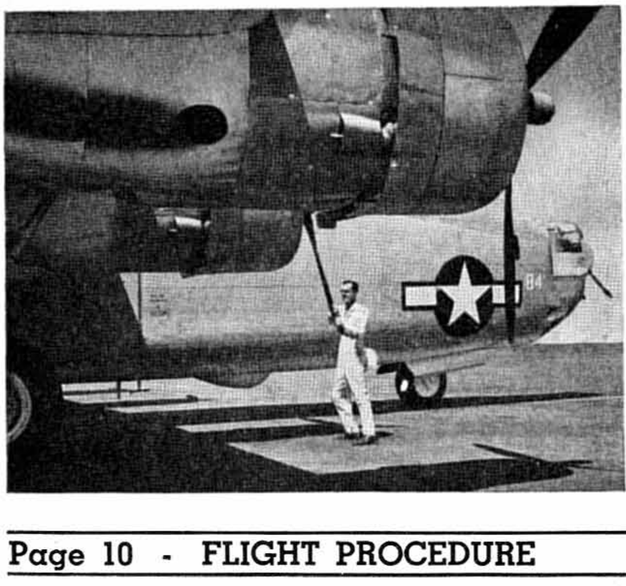
CHECK INCLINOMETER; FUEL AND OIL LEVELS

The inclinometer, located on the left side of the hatch at the rear of the flight compartment, must read *neutral* for an accurate check of the fuel levels. If he has not already done so, the plane captain will check the fuel levels in the main tanks located in the wing and the oil levels in the reservoir of the four nacelles. The most accurate readings can be made with a dip stick. The boiler type fuel sight gauge may also be used to determine quantities of fuel in the main wing tanks. Bomb bay fuel cells can be checked for content by reading the gauges mounted on top of each cell.





15—Plane Captain



PULL PROPELLERS THROUGH

Before beginning the actual starting sequence, each propeller must be pulled through by hand to check the free turning of the engine and to clear any oil or fuel which may have accumulated in the combustion chambers which, if present would result in a damaged engine. The plane captain must pull each propeller through six blades which completes two full revolutions, or one complete cycle. Even with the ignition switch checked in the *off* position the engineer should be constantly aware of the possibility of a broken ground wire which would cause a kick back. Keep clear of the propeller plane of rotation while the propeller is being pulled through. Do not become careless; the ignition switch *off* can be just like the famous unloaded gun.

16—Plane Captain

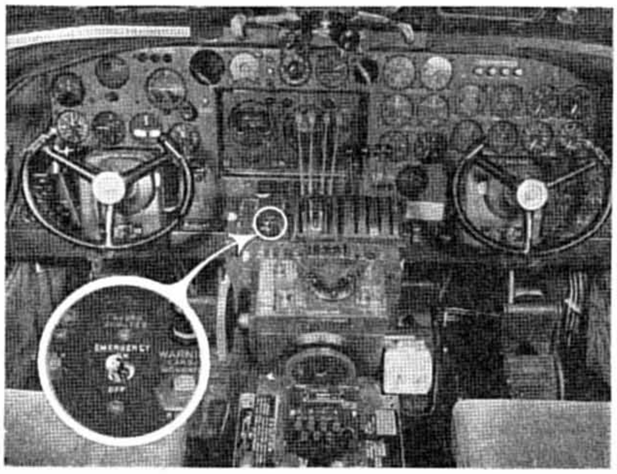
REMOVE WHEEL CHOCKS

Wheel chocks are removed at this time to obviate danger to ground personnel who would otherwise have to remove chocks after the engines have been started. If chocks are mandatory, place them 2 to 4 inches ahead of the tire to avoid the wheel creeping onto the chock.

17—Pilot

HYDRAULIC SWITCH OFF

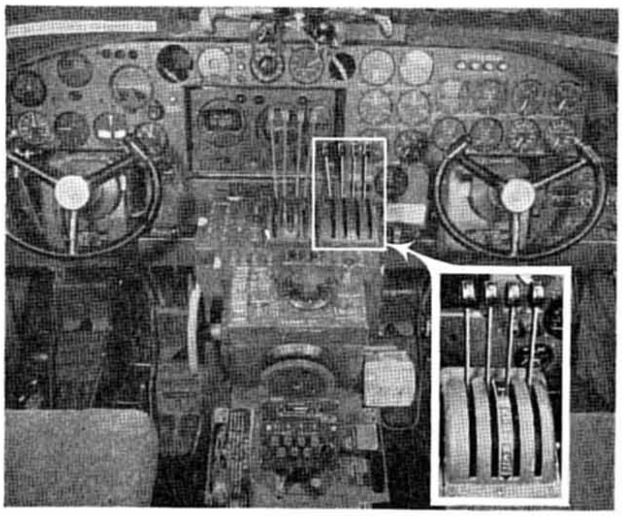
The auxiliary hydraulic pump switch is checked to the *off* position to prevent arcing at the remote solenoid switches when the ship's batteries are subsequently tested; also to reserve usage of the ship's batteries until No. 3 engine is started and its generator is connected to the line. This is important when battery carts are not available.

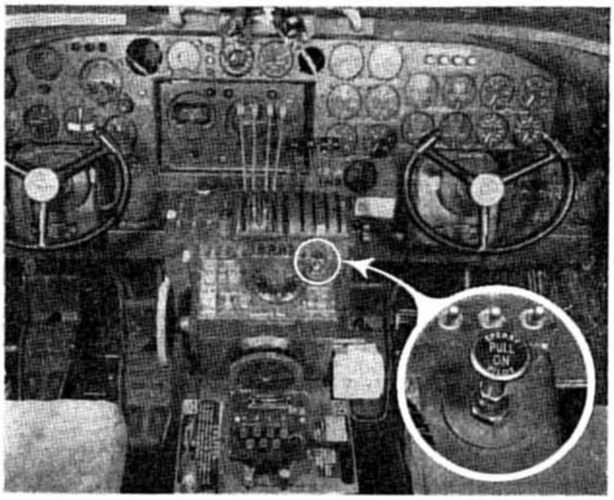


18—Pilot

MIXTURE—IDLE CUT OFF

The mixture control levers are placed in *idle cut off* position. If they are in any other position with the fuel system *on* the induction sections will become flooded. This will create a fire hazard and make starting difficult.

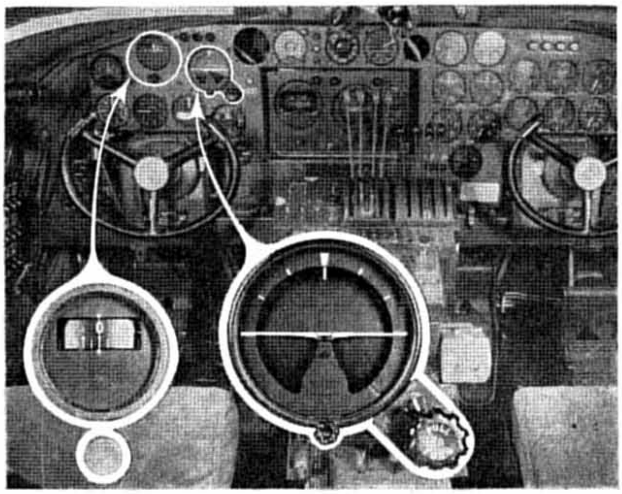




19—Pilot

AUTO PILOT OFF

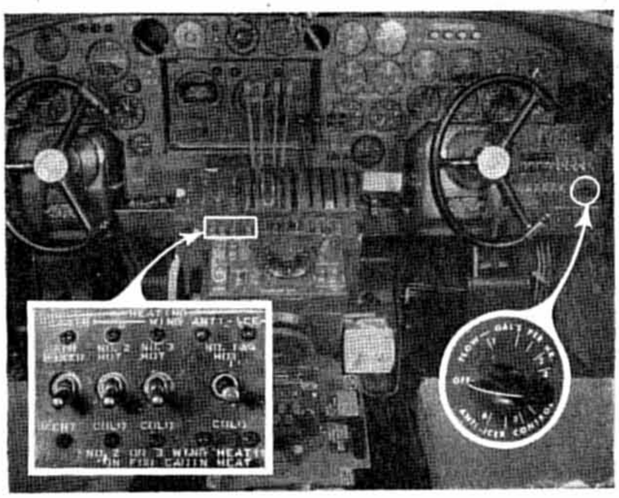
The automatic pilot is turned *off* to disengage it from the control system.



20—Pilot

GYROS UNCAGED

The pilot makes certain that the gyros are uncaged unless the airplane is equipped with a Jack and Heintz flight indicator. In this event the instrument will be caged for the first five minutes after engines No. 1 and No. 2 are started.

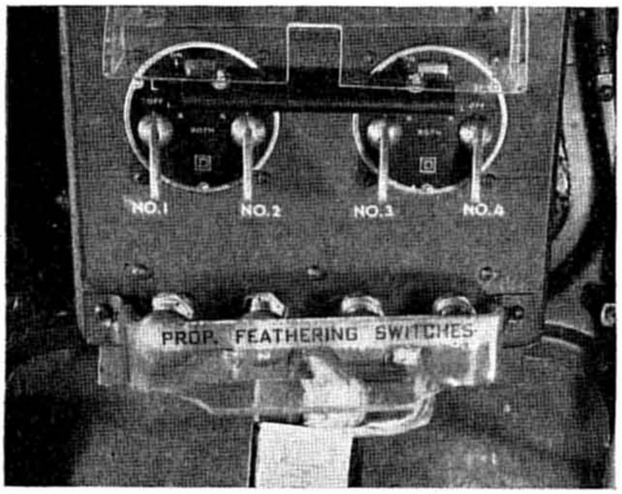


21—Pilot

ANTI-ICERS—WING HEAT AND PROPELLER—OFF

All four heat control switches on the pedestal switch panel are turned to the *aft* or *cold* position. This prevents excessive heat in the wing during engine operations on the ground. See that the propeller anti-icer system is *off*. Rheostat control is at the lower outboard corner of the panel to the right of the copilot's control column for propeller anti-icing. Wing anti-icer switches are located on the left center of the pilots' pedestal.

22—Pilot



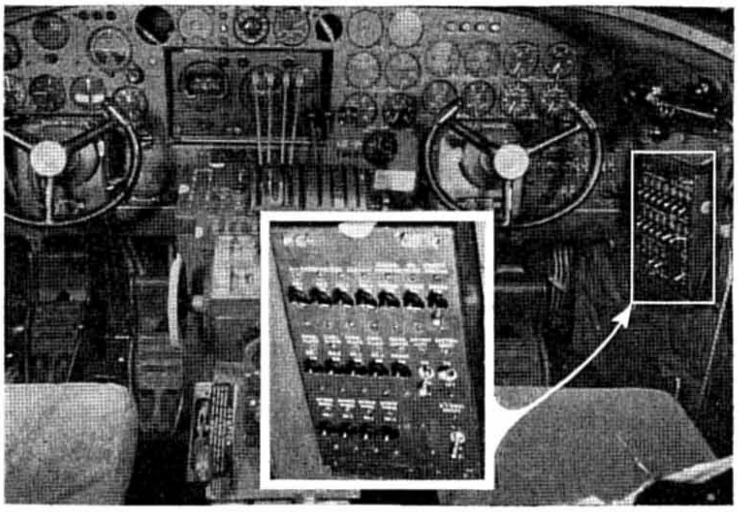
MASTER EMERGENCY SWITCH—ON

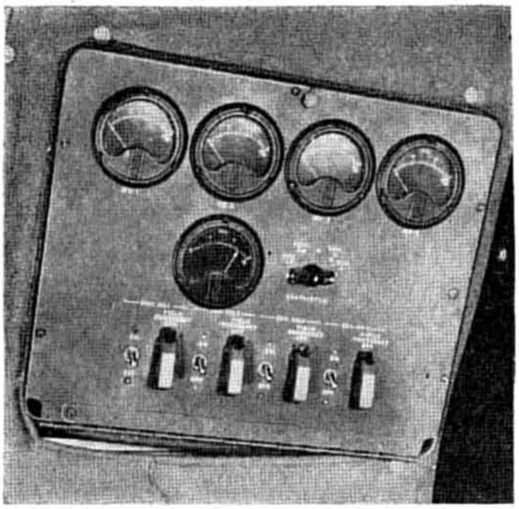
The master emergency switch bar, on the ignition switch panel, will be turned to the *on* position. This allows the battery circuits to be checked by the plane captain because the master switch bar control and the battery switches are in series in the remote control battery circuit.

23—Pilot—Plane Captain

MAIN BATTERY SWITCHES ON

As the copilot turns first one, then the other of the ship's battery switches to *on* (one at a time), the plane captain verifies that the polarity of each battery is correct as he reads its voltage on the ship's voltmeter. Correct polarity is essential to the operation of some equipment. Be sure the battery switches are turned *off* again after this test, if a battery cart is to be used. If a battery cart is not available leave the battery switches *on*.

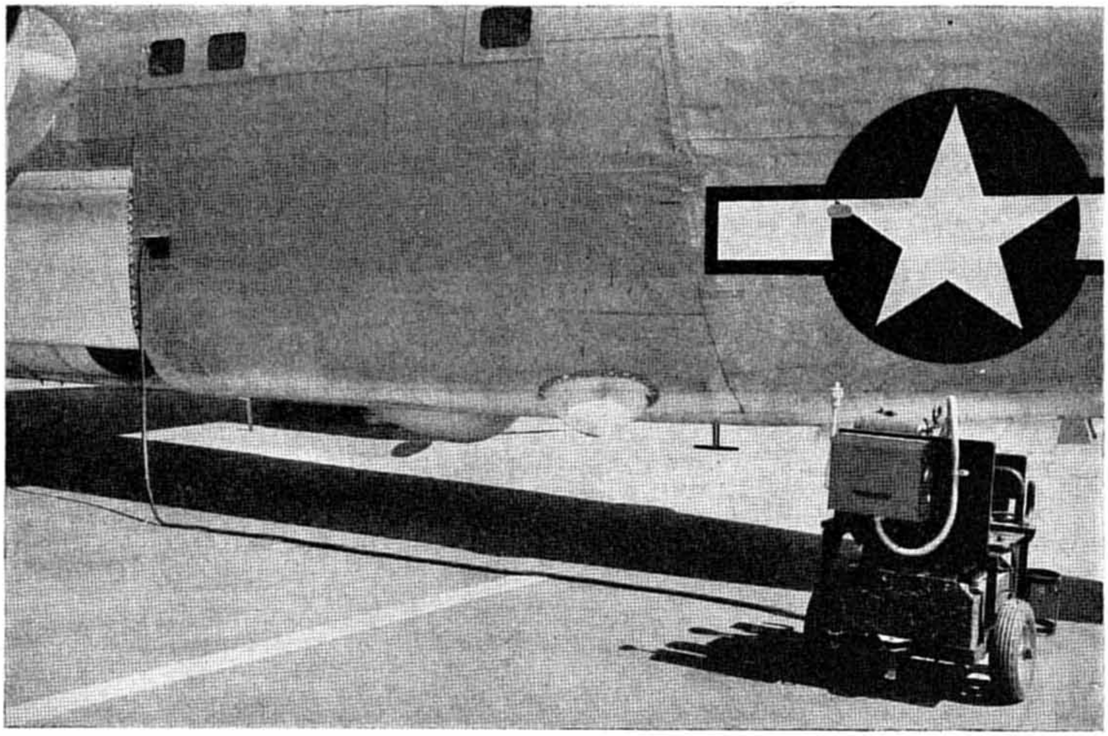




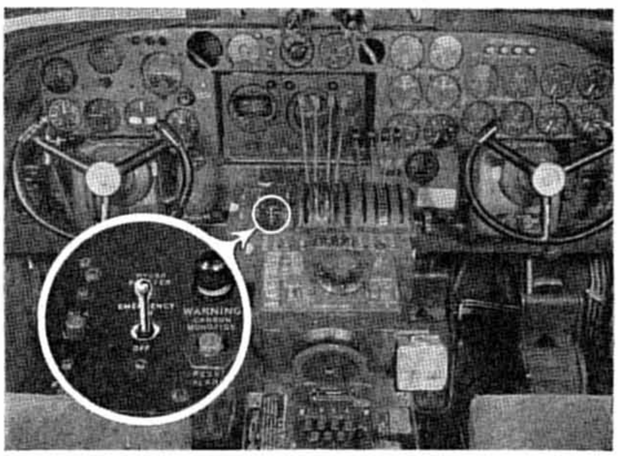
24—Pilot—Plane Captain

BATTERY CART ON, CHECK VOLTAGE, POLARITY

A battery cart should always be used when available, not only for starting, but also for prerun preparation such as opening cowl flaps, checking the governors, etc. Make certain airplane battery switches are turned *off;* and connect the battery cart at this time. The plane captain checks the battery cart polarity and voltage at the airplane generator panel. If the circuit is not energized, look for an open switch or fuse on the battery cart.



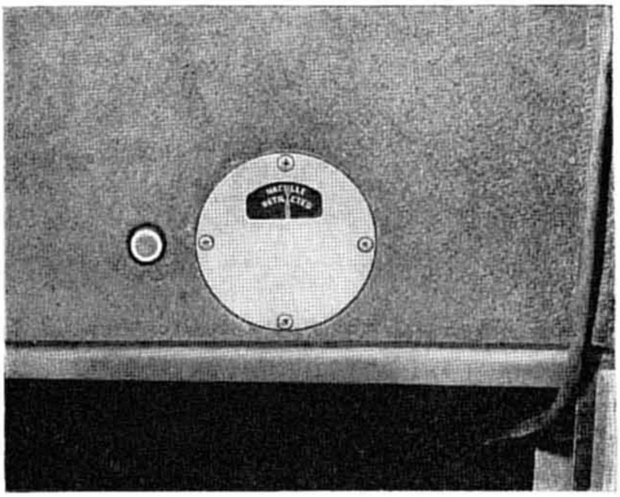
25—Pilot



HYDRAULIC SWITCH ON

If a battery cart is to be used the auxiliary hydraulic pump is turned *on* to insure adequate hydraulic pressure in the accumulators which are the source of brake pressure. If a battery cart is not available the hydraulic switch should be turned *on* immediately after the No. 3 engine has been started and the No. 3 generator turned *on.*

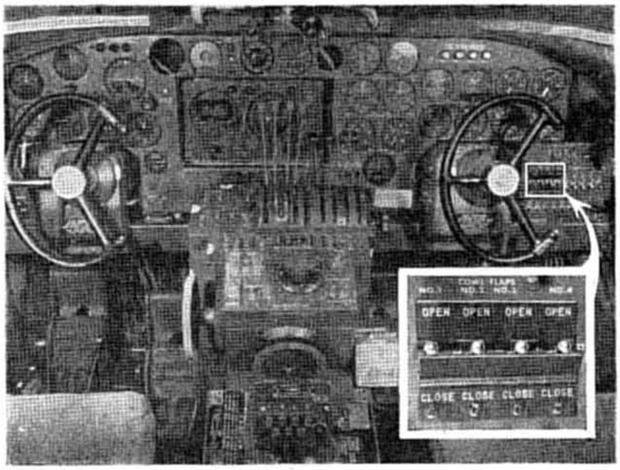
26—Plane Captain



CHECK RADAR HOUSING RETRACTED

Observe the indicator to be certain that the radar housing is retracted. The indicator is located on the flight deck just forward of the main entrance hatch. The radar housing is extended and retracted manually and the crank for this operation is stowed under the navigator's table.

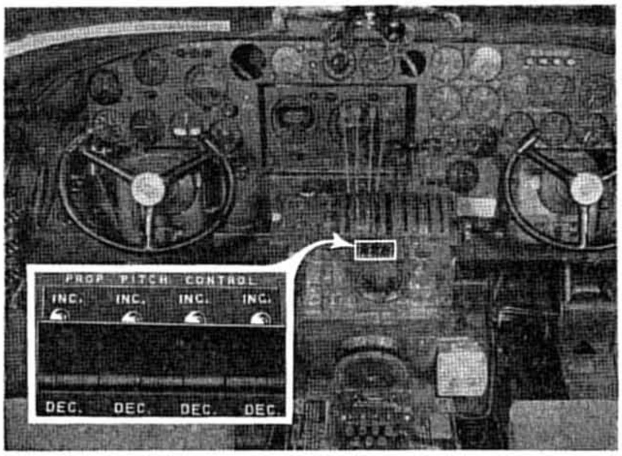
27—Pilot



COWL FLAPS OPEN

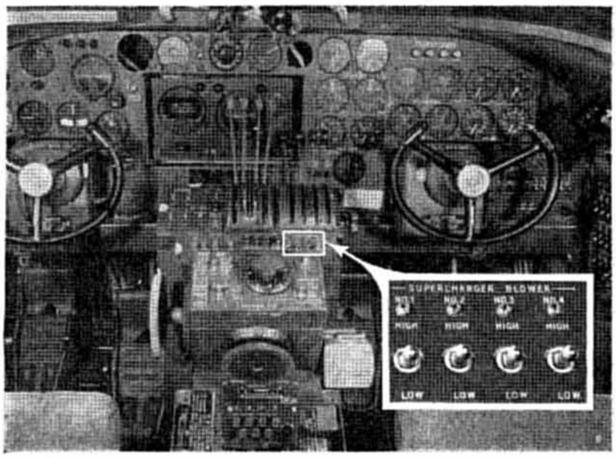
Cowl flaps are opened for starting to prevent excessive temperatures. Cowl flap switches are located on the panel to the right of the copilot's control column. To operate place them in the open position and hold until the cowl flaps are fully open.

28—Pilot



PROPELLERS TO HIGH R.P.M.

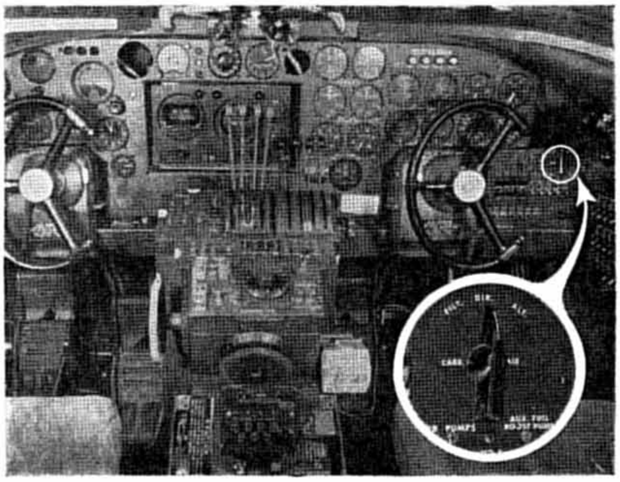
High r.p.m. is desirable to reduce torque loads and to make starting easier. The propellers are set for high r.p.m. by moving the switch bar in the center of the pedestal switch panel to the *inc.* position; hold until the four indicator lights on the instrument panel in front of the copilot flash *on.* The propellers will have reached their limit of travel only when oil pressure in the dome has forced the piston to its limiting position. This condition is indicated on the tachometers.



29—Pilot

SUPERCHARGERS TO LOW BLOWER POSITION

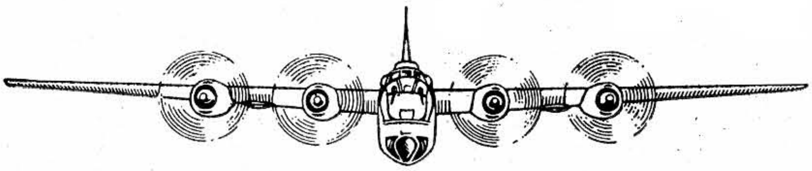
The four switches controlling the blower gear shift mechanism are located on the pedestal panel to the right of the propeller governor switches. These are placed in the low position to prevent excessive torque loads when the engines are started.



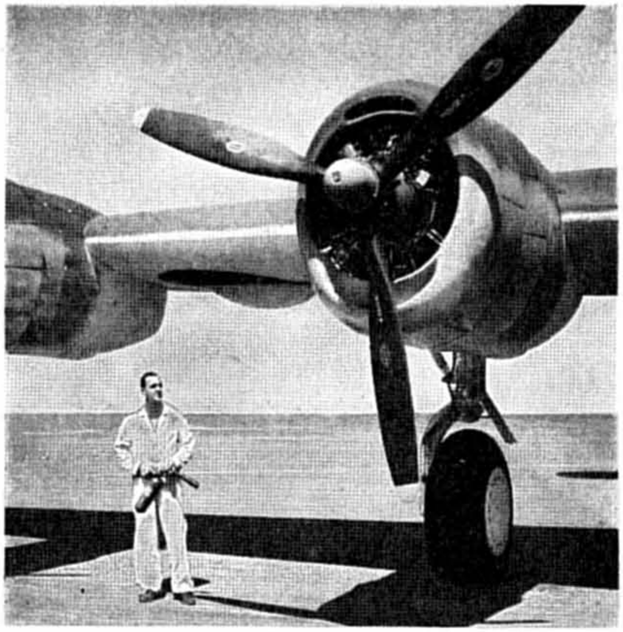
30—Pilot

CARBURETOR AIR FILTER—AS REQUIRED

Under normal atmospheric conditions the carburetor air filter selector will be placed in the *direct* position. This provides air induction without heat or filter action. Dust conditions at any altitude require filter action in the air induction system. Filtering is accomplished by turning the selector handle to the *filter* position. This will effect a drop in manifold pressure of approximately 2″ Hg which should be considered when operating in all ranges of power. The *alternate* position is used only when icing conditions prevail in the carburetor.



31—Plane Captain



STAND FIRE GUARD

The plane captain or the ground mechanic always stands by the starting engine with a portable fire extinguisher. A flooded induction system can result in a fire, which, if not extinguished immediately, might otherwise be very serious. *All propellers must be clear during the entire starting procedure.*

32—Pilot

IGNITION ON

All four ignition switches overhead, are turned to the *both on* positions.

33—Pilot

TURN A.C. POWER ON

The alternating current or inverter power switch located on the left rear of the pedestal is turned *on* to either No. 1 or No. 2 inverter; check both by listening. These inverters furnish alternating current for the electrically operated engine instruments and for radio equipment. During any flight use one inverter only. Consider the other inverter as spare equipment rather than for optional operation.

34—Pilot

BOOSTER PUMPS ON

The four fuel booster pump switches are located on the switch panel to the right of the copilot's control column. When it is necessary to start an engine on ship's battery power, every effort should be made to conserve this power for the starting of the first engine (No. 3). Turn on only No. 3 pump and watch for the rise in fuel pressure. Booster pump pressure is required for priming the engines in order to force fuel through the carburetor, when the electric priming solenoids are open; as the engine driven pumps are not operating until the engine starts. Booster pumps are further required on take-off, on landing, and at altitudes after the fuel pressure has dropped 2 lbs. Booster pumps maintain a sufficient pressure to insure a positive flow of fuel at all times.

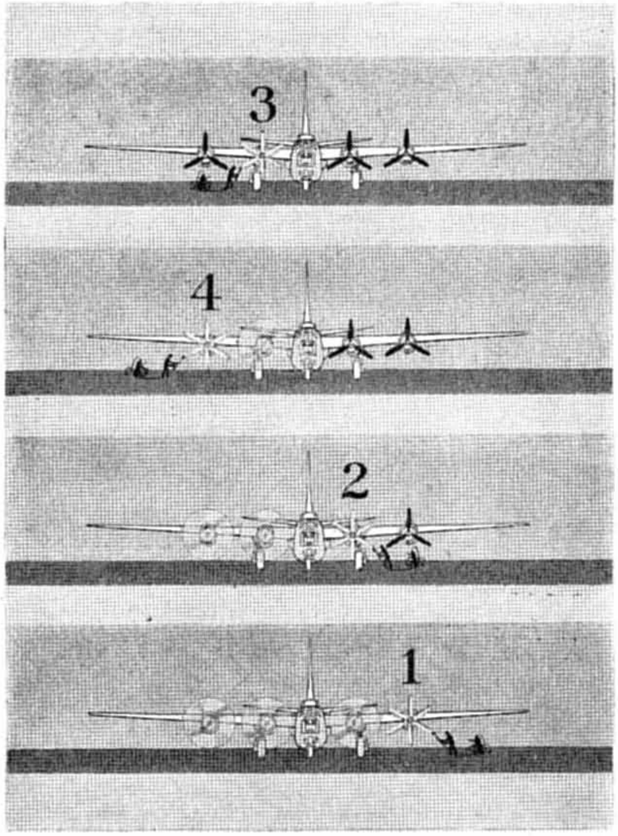
35—Pilot

NOW THE ENGINES CAN BE STARTED

When the engines are started electrically the sequence is 3, 4, 2, and 1. This is from inboard to outboard so that the fire guard does not have to walk through, or toward, a moving propeller when standing by with the portable fire extinguisher. The No. 3 engine is started first because the hydraulic pump is mounted on it.

When the engines are started manually the sequence is 1, 2, 3, and 4. This keeps the running engines constantly in front of the fire guard as he moves from one manual starter position on the right side of each nacelle to another.

The copilot, who usually controls engine starting, checks visually to see that all personnel and obstructions are clear of the propellers, calls *all clear* and is check answered *all clear* by the fire guard.



36—Pilot

THROTTLES ⅓ OPEN; ACCELERATE: PRIME

First open No. 3 throttle to the ⅓ open position. The starter energizing, meshing, and the priming switches are on the bottom row of the panel to the right of the copilot's control column. While the No. 3 starter is being energized, the copilot also primes the No. 3 engine. Each engine in turn is started in this manner. To prime, press the switch intermittently. This drives fuel into the engine combustion chamber in spurts and priming is much more effectively accomplished than by holding the switch on for a fixed interval. Priming depends upon the temperature of the engine and of the outside air. The maximum time allowable for energizing Jack and Heintz starters is 20 seconds on 24V and 10 seconds on 28V. When no outside power is available and it is necessary to start the first engine on ship's batteries the maximum of 20 seconds should still be observed. However, when this engine has warmed up, increase the engine r.p.m. until its generator indicates a charge of 28V on the generator panel. This insures easier starting for the other three engines with 28V available. Now the maximum time allowable for energizing No. 4, 2, and 1 starters is 10 seconds.

37—Pilot

MESH STARTER

With the engine primed and the starter energized, the copilot now moves the meshing switch to the mesh position and holds it there until the engine starts. Release immediately upon engine starting. After starter acceleration and meshing with the engine, continuous direct cranking must not exceed 30 seconds. If the engine does not start after 30 seconds of cranking, the starter and meshing must be allowed to cool for one minute before attempting to start the engine again.

38—Pilot

MIXTURES TO AUTO RICH

After the engine definitely fires on the priming charge, move the mixture control from *idle cut off* to *auto rich*. When moving the mixture controls, set them by feeling the operation of the ball check. Use this as the true indication of proper setting, rather than the marks on the quadrant. When the mixture control is moved from idle cut off, fuel under booster pump pressure flows to the carburetor jets. Therefore, if the engine does not start immediately, the mixture control will be returned to idle cut off to prevent flooding of the entire induction system. Oil pressure *must* come up in 30 seconds to prevent damage to engine.

39—Pilot

CHECK OIL PRESSURE

Just as soon as an engine starts firing it is imperative to observe that oil pressure is being indicated. If oil pressure does not build up within a maximum of 30 seconds, shut the engine down immediately.

40—Pilot

BOOSTER PUMPS OFF

After all four engines have been started and all oil pressures are registering, turn *off* the booster pumps. Observe the fuel pressure developed by the engine pump alone. Leave all fuel booster pumps *off* during the remainder of the ground operations; they will not be needed until take-off.

41—Plane Captain

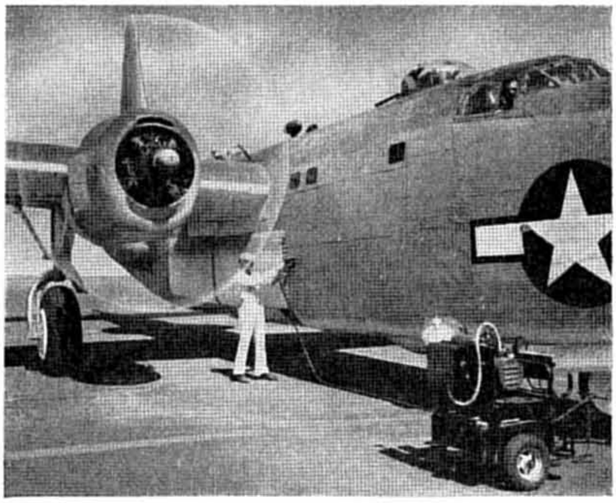
NO. 3 GENERATOR—ON

When necessary to start engines on ship's batteries, as soon as No. 3 engine is started, and warmed up sufficiently, run engine at 1200 r.p.m. and turn on No. 3 generator. This will supply electrical power needed to start remaining engines.

42—Pilot—Plane Captain

BEFORE TAXIING

Check all other instruments for proper operation. For convenience they are listed with reference numbers as illustrated in figure 1. Oil pressure (39), oil temperature (38), cylinder head temperature (35), fuel pressure (36), free air temperature (6), tachometer (21), manifold pressure (34), hydraulic pressure (28), *wheels locked down* light (40), radar housing retracted light (41), clock (20), magnetic compass (5). The altimeter (26) is set for proper barometric reading as obtained by radio from flight operations control tower. Obtain the prevailing barometric pressure and set altimeter by turning the adjustment below the face of the dial. Limits of tolerance permit so much variance that no other definite readings need be considered at this time except those given in the text on preceding pages. Before taxiing away from the line the pilot again checks the propellers for high r.p.m. by moving the propeller governor switch bar to *inc.* (high r.p.m.). When the propeller governors are in the full extreme positions, either high or low r.p.m., the four governor limit indicator lights above the copilot's control column are illuminated.



43—Plane Captain

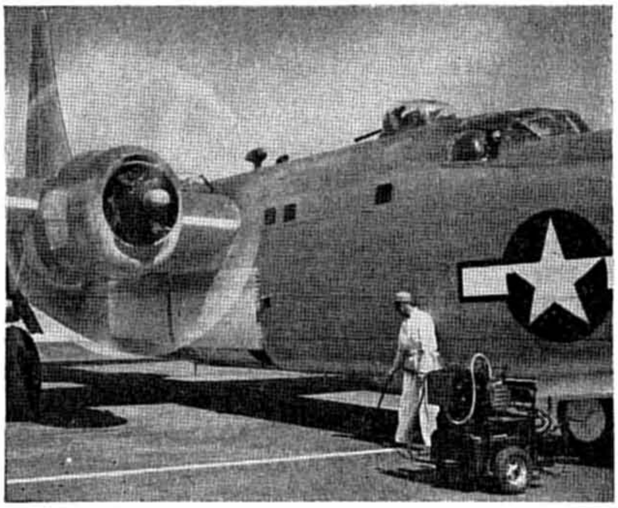
REMOVE BATTERY CART

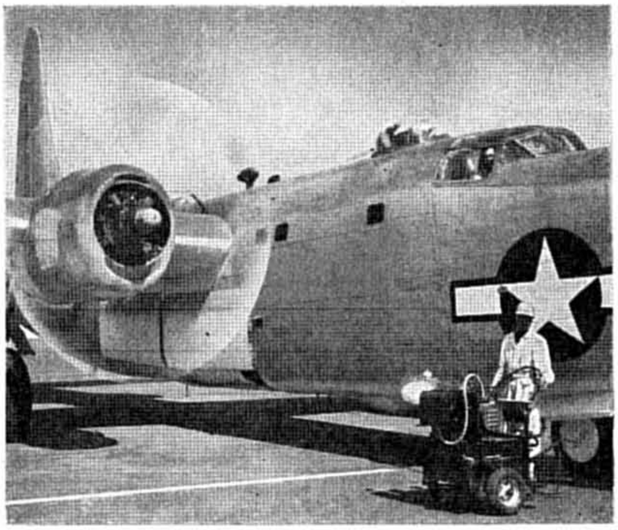
Before re-entering the airplane, make sure the battery cart has been disconnected and removed, entirely clear of the airplane.

Left —Removing Battery Cart Plug

Lower Left —Removing Battery Cart Cord

Lower Right—Winding Battery Cart Line on Cart

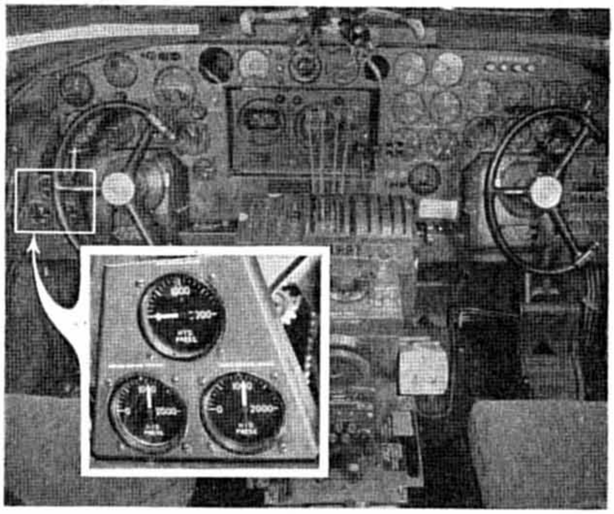




44—Pilot

CHECK BRAKE PRESSURE

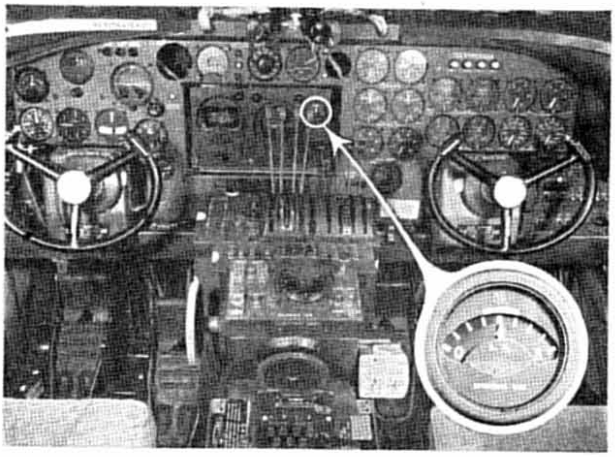
The two brake pressure gauges are located left of the pilot's control column on the instrument panel. They register the pressure in each of the two accumulator systems. They should read between 970 and 1140 p.s.i. The normal top limit is 1050 p.s.i. on the engine pump, but if the auxiliary hydraulic pump is operating, it cuts out at 75 p.s.i. higher, or at 1125.



45—Pilot

CHECK VACUUM PRESSURES

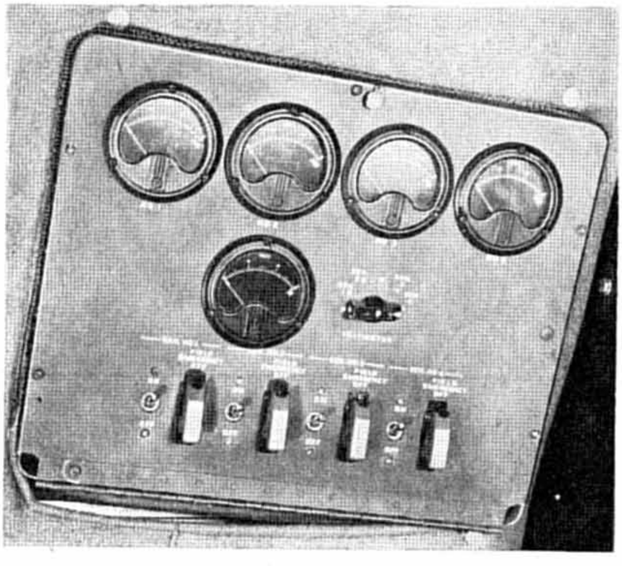
There are two vacuum pumps, one on engine No. 1 and one on engine No. 2. While the engines are warming up, vacuum operation is observed on the vacuum gauge located on the automatic pilot. No selection of vacuum pumps is provided as both operate together on a common line. Check valves are provided in each line in case of failure of one of the pumps.

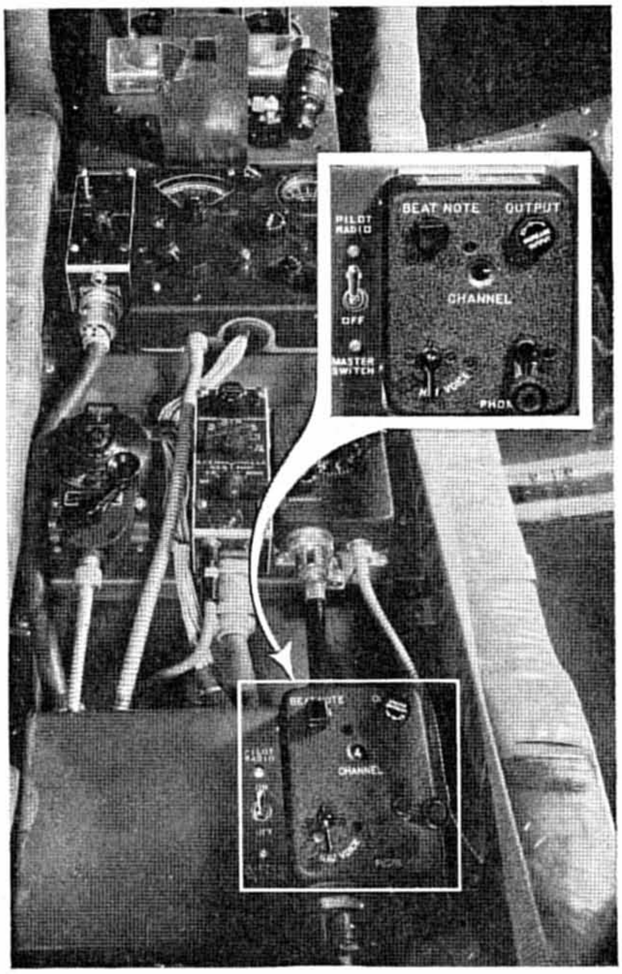


46—Plane Captain

ALL GENERATORS ON

The generators on engines No. 1, 2 and 4 may also be turned *on* at this time in order to equalize the loads and to prepare for checking generator output during the run-up.





47—Pilot

RADIO ON

The pilot turns *on* the master radio power switch. This is located overhead, on the center line where the windshield ducts separate.

48—Pilot

TAXIING

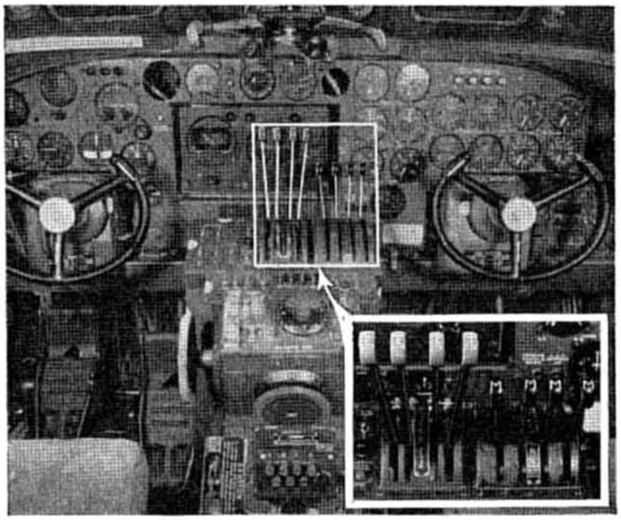
Unless there is some specific reason or local order, the pilot releases the parking brakes and taxies the airplane to the head of the runway for final run-up and prepares for take-off so that he can leave immediately thereafter. Then, too, planes warming up on the line are a definite hazard.

Taxiing is too often a carelessly executed maneuver. It should be executed in a broad sweep using the power of outboard engines and *not* brakes to make the turn. Sharp turns should be definitely avoided. They exert severe strain on the landing gear and on the tires. It is a simple matter to turn and steer the PB4Y-2 with the outboard engines. The nose wheel is limited to 45° either side of the center line. Turns which involve a greater angle than this bring the nose mechanism up against the stops and can cause failure. The stresses exerted by such a maneuver, particularly if done violently, are extremely severe. In designing an airplane, engineers expect pilots to exercise a reasonable amount of good judgment.

Always taxi at slow speed and maintain direction with outboard engines and rudder. When it is necessary to use the brakes, apply them gently and your airplane, will always be under control. On arriving at the head of the runway or designated warm-up area, make sure the nose wheel is in alignment. Stop the airplane and set the parking brakes.

ENGINE RUN-UP

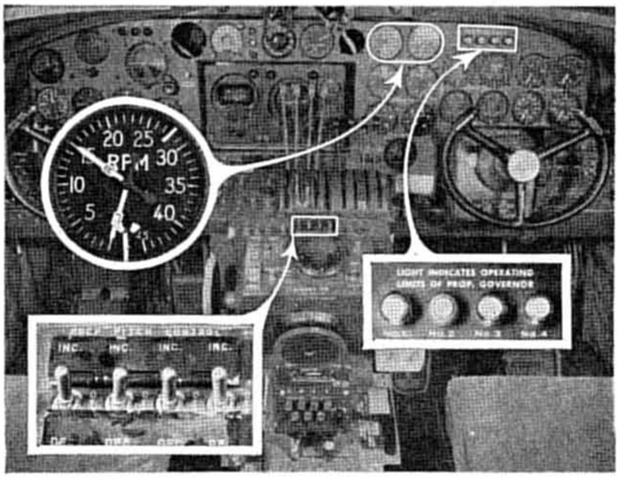
49—Pilot



SET POWER FOR RUN-UP CHECKS

With the mixtures in *auto rich*, set the throttles to 1500 r.p.m. then check instruments for proper readings.

50—Pilot

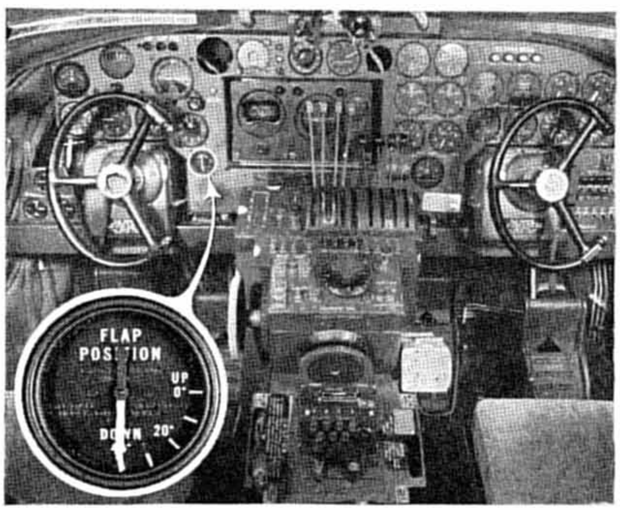


EXERCISE PROPELLERS

Exercise the propellers throughout their entire range by moving the governor switches to *dec.* (low r.p., high pitch position). At the low r.p.m. position, the tachometer will drop to approximately 1200 r.p.m. Then, move the switches to inc. (high r.p.m., low pitch position). *Leave them in this position for the run-up and take-off.* The propeller governor indicator lights will come *on* when the propeller governors reach the limits of travel.

In cold weather it is necessary to repeat this procedure 2 or 3 times to insure a circulation of warm oil.

51—Pilot



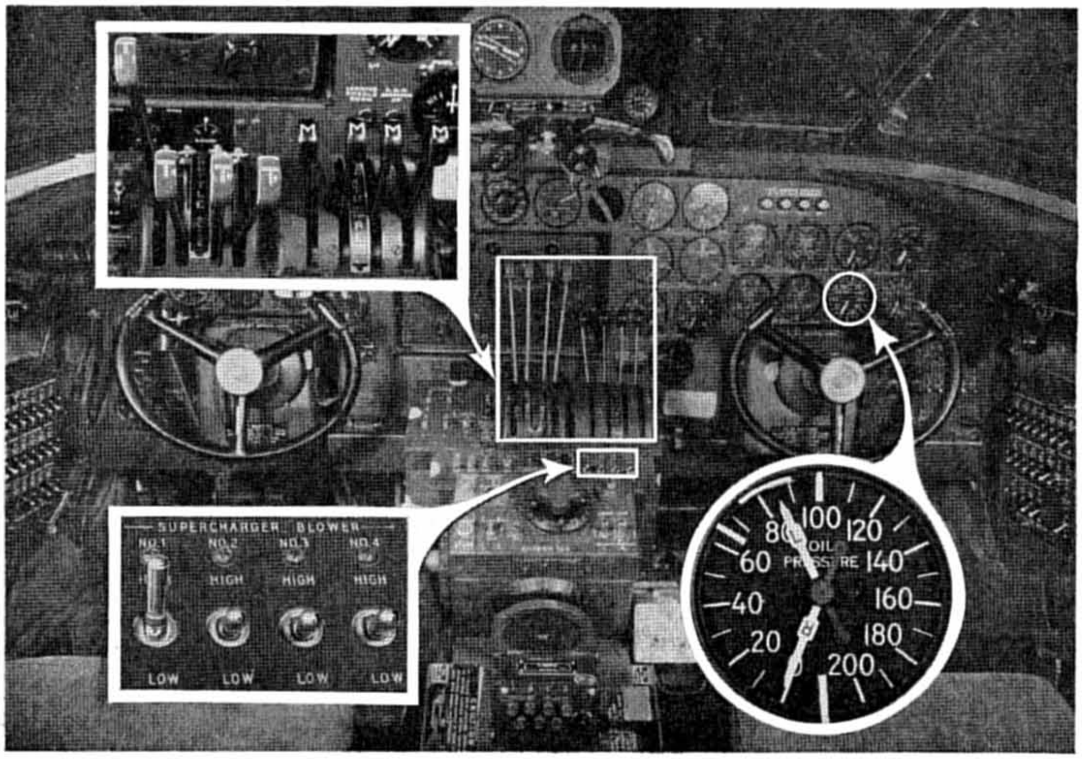
OPERATE WING FLAPS

While the pilot has been exercising the propellers, the copilot runs the wing flaps fully down to 40° and up again. The flap operating lever is on the right side of the pedestal. The flap position indicator is to the right of the pilot's control column.

EXERCISE SUPERCHARGER BLOWERS

The internal supercharger blowers are now exercised, one at a time, by remotely operating the two-speed blower mechanism. This is done with switches on the pedestal switch panel, marked *supercharger blower*. The desired condition to shift is when an oil pressure of at least 40 p.s.i. is obtained by increasing engine speed to 1500 r.p.m., to insure operation of the clutch mechanism.

While watching the oil pressure gauge for a fluctuation, move the switches to *high* position, one at a time. A change in oil pressure of ten to twenty pounds indicates operation of the blower from low stage to high stage. Then advance the throttles one at a time, to 2300 r.p.m. and immediately return the blower switches to low position, one at a time. The manifold pressure should show a drop of approximately 1″ Hg and oil pressure will fluctuate slightly. *Leave the blowers in the low speed position for take-off.* If these indications are not observed, allow a two-minute clutch cooling interval at 1000 r.p.m. before repeating the procedure.

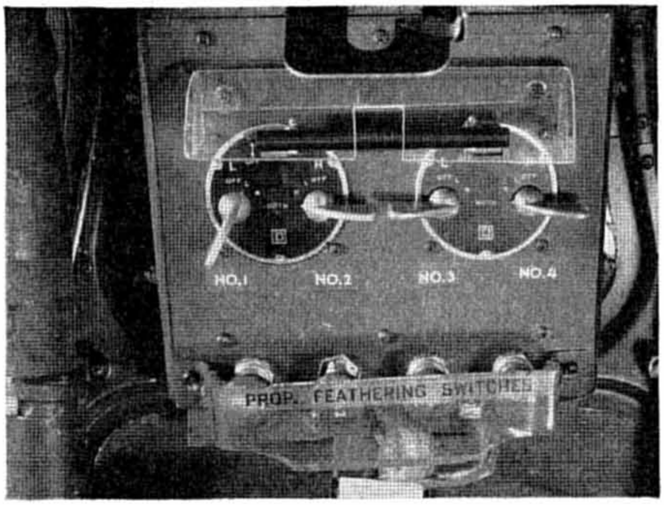


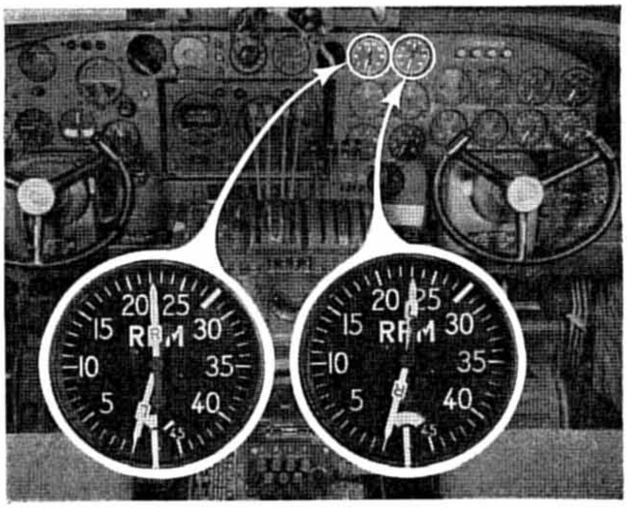
53—Pilot

CHECK MAGNETOS

Test the magnetos on one engine at a time by opening its throttle to 2300 r.p.m. Move the magneto switch from *both* to *left*, then to *both*, then to *right* magneto, and back to *both*. Watch for a drop in r.p.m.; 50 to 75 is allowable. Since the drop may be imperceptible, roughness of operation is a better indication.

Operation on one magneto for check purposes should be done at no higher than 30 to 31″ Hg. Higher power output may cause damage from detonation or preignition.

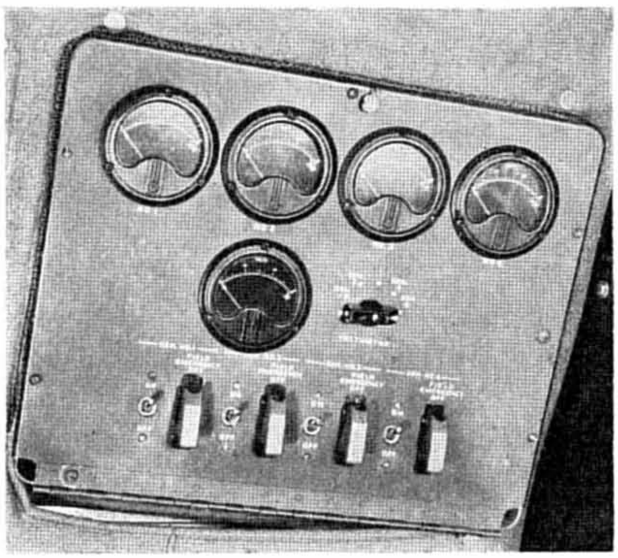




54—Plane Captain

CHECK GENERATORS

At the same time that the pilot is checking the magnetos at 2300 r.p.m., the plane captain can also observe the generator output as indicated on the ammeters.

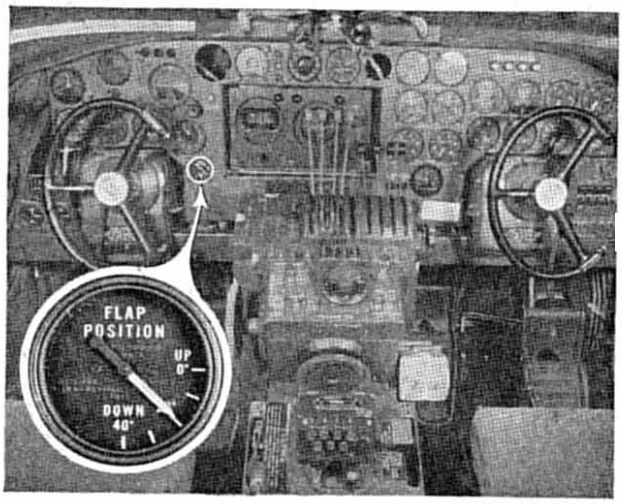


55—Plane Captain

CLOSE DOORS AND HATCHES

When the last crew member enters the airplane the plane captain pulls inboard on the handle of the bomb bay door auxiliary valve located immediately forward of the bomb bay bulkhead on the right side under the flight deck. This closes the bomb bay doors. Other exits should then be inspected for *closed* and *latched*.

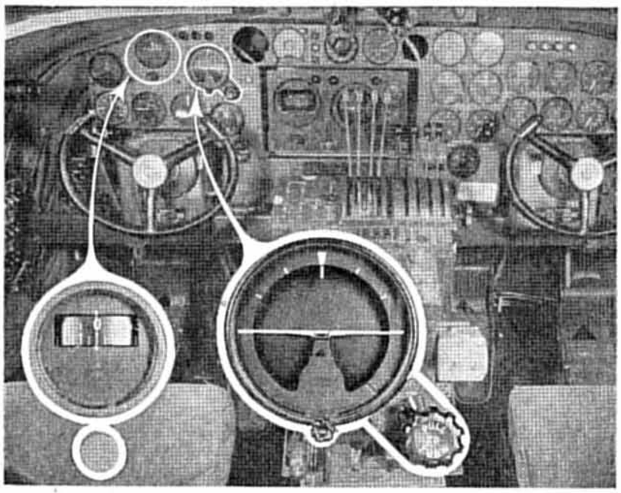
56—Pilot



EXTEND WING FLAPS

Upon direction from the pilot, the copilot extends the wing flaps to the 20° down position, depending on take-off conditions. Flaps extended 20° is the setting for maximum take-off lift. To stop the flaps in any position before *full down*, return the operating lever to neutral manually. In the extreme positions the lever returns automatically to neutral.

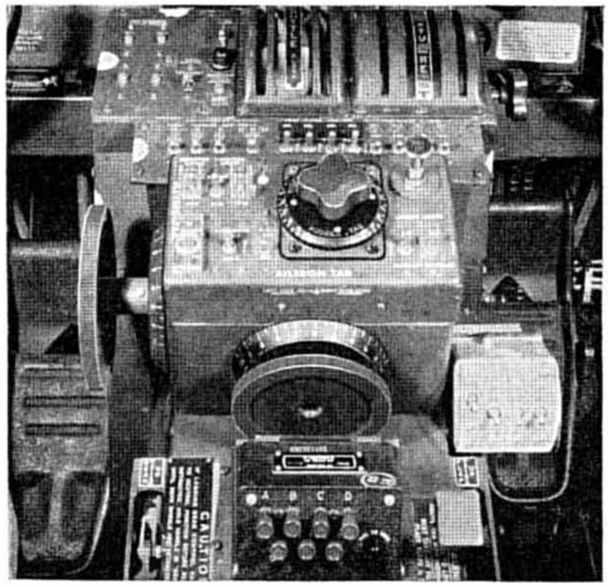
57—Pilot



SET DIRECTIONAL GYRO

The pilot will set the directional gyro to correspond to the magnetic compass, and the flight indicator to neutral. When lined up for take-off, check the gyro reading to correspond with the runway heading.

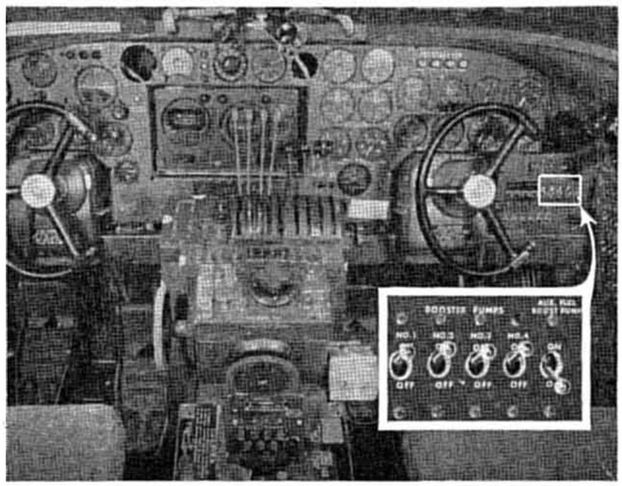
58—Pilot



CHECK TRIM TABS

Control tabs are adjusted for the best take-off positions; the elevator tabs are set; aileron tabs are set in neutral; rudder tabs are set for 1½°—2° right rudder, depending upon the performance. These are the settings for normal positions and loading.

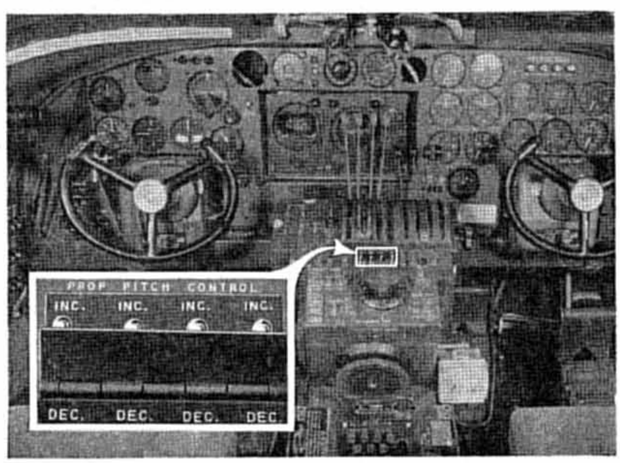
59—Pilot



FUEL BOOSTERS—ON

Check the fuel pressure with the fuel pump *off*. The normal reading should be approximately 17 p.s.i. On direction from the pilot the copilot will turn the booster pumps *on* for take-off. The booster pump switches are in the middle row, right, on the switch panel outboard of the copilot's control column.

60—Pilot



PROPELLERS TO INC.

Check propellers to *inc.* r.p.m. The pilot again moves the propeller governor gang switch on the pedestal to the *inc.* position to make certain the propellers are in high *r.p.m.* This is the forward position and the switches should be held here until all four green lights above the copilot's control column come on.

61—Pilot

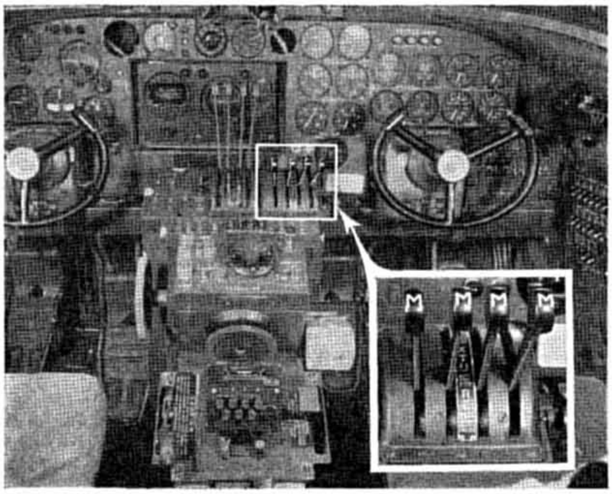
RECHECK SURFACE CONTROLS

Before take-off the surface controls are again checked for freedom of movement in a manner similar to that when you first enter the airplane. Move the controls in such a manner that full travel is tried in every direction. Be *positive* that they have full freedom of movement. These checks become automatic with experience because they are used so frequently in safety checking the airplane.

62—Pilot

MIXTURES TO AUTO RICH

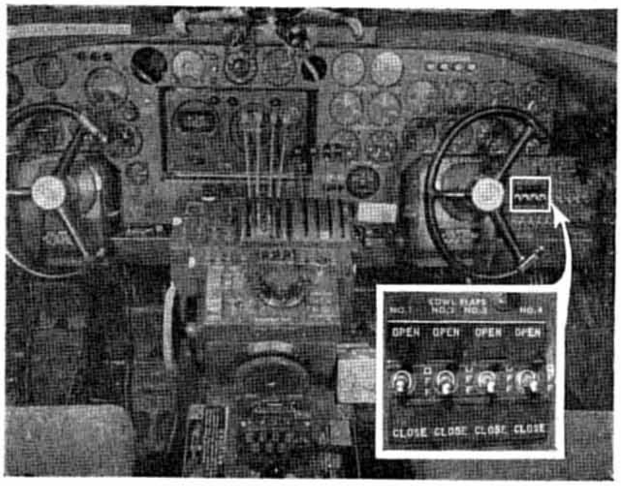
See that all mixture controls are in the *auto rich* position.



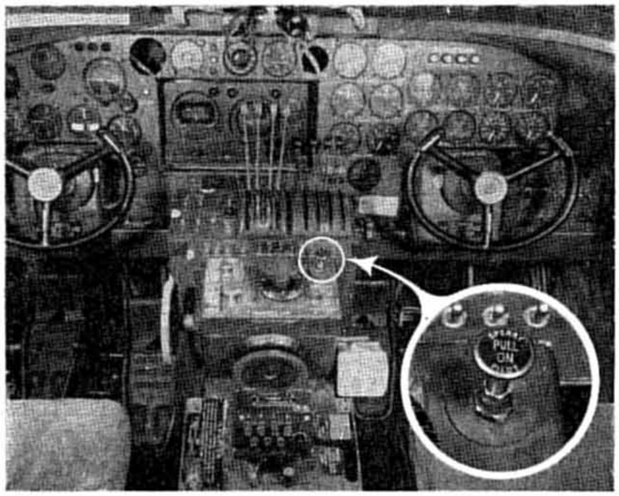
63—Pilot

CHECK COWL FLAPS

Cowl flaps are set to ⅓ open for take-off. Normally this gives ample cooling with a minimum amount of resistance for take-off. For normal temperature conditions, less than ⅓ open will not provide sufficient cooling. Remember that on an average the cowl flaps reduce the airplane's speed approximately eight-tenths of a mile per hour at cruising speed for each degree of cowl flap opening. Under some conditions of power usage loss in speed can be greater than that just given.



64—Pilot



CHECK AUTOMATIC PILOT—OFF CHECK CREW

Pilot will again see that the auto pilot is off, and that everyone is aboard and will make certain that the nose and nose wheel compartments are clear of all personnel. Now all is in readiness for the take-off run.

TAKE-OFF

TAKE-OFF

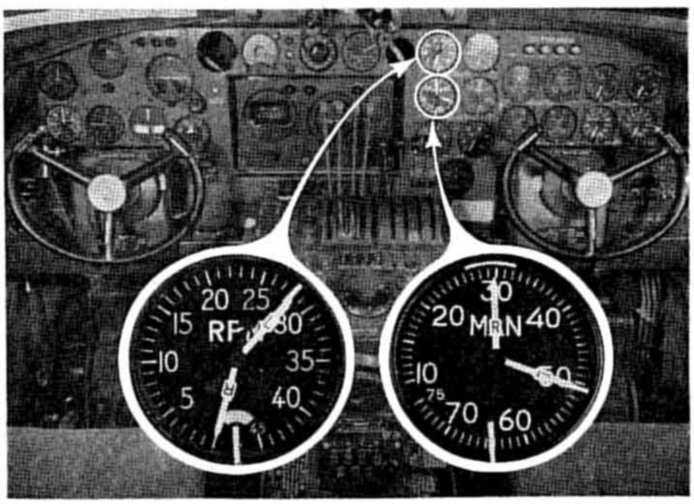
Take-off procedure is consistent with that of other large airplanes of the tricycle landing gear type. The ship will come off the ground easily at 95 knots for gross weights up to approximately 45,000 pounds to 113 knots for heavier loads.

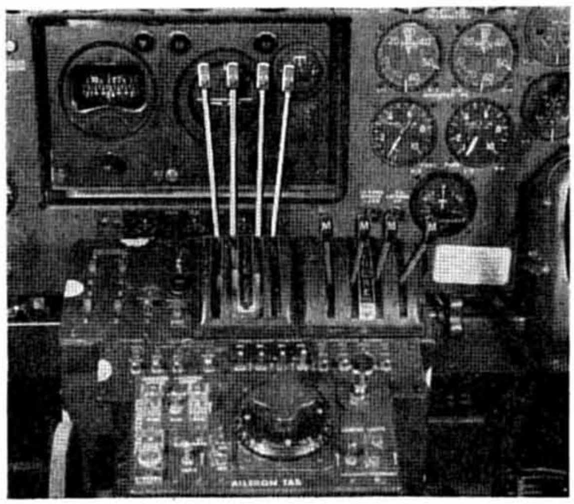
Standing starts offer a pilot the advantages of a last minute check before take-off when there is cause for this being desirable; however, attention *must* be given to the nose wheel alignment. Any change in direction of the nose wheel must be approached with a sweep broad enough for the nose wheel to easily follow through its 45° of free swivel action.

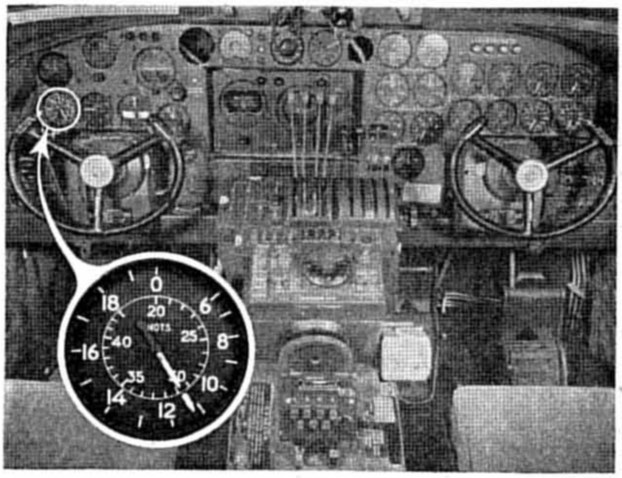
65—Pilot

OPEN THROTTLES—WATCH LIMITS

Open the throttles slowly and evenly to the desired take-off power. Have the copilot hold them in this position so they will not creep closed. Throttle frictions are usually set light for take-off and landing to permit free movement if necessary. It is much easier to maintain a straight course on take-off with power—*do not* use brakes. Manifold pressure should not exceed 51″ Hg and engines should not exceed 2800 r.p.m.







66—Pilot

GET AIR BORNE

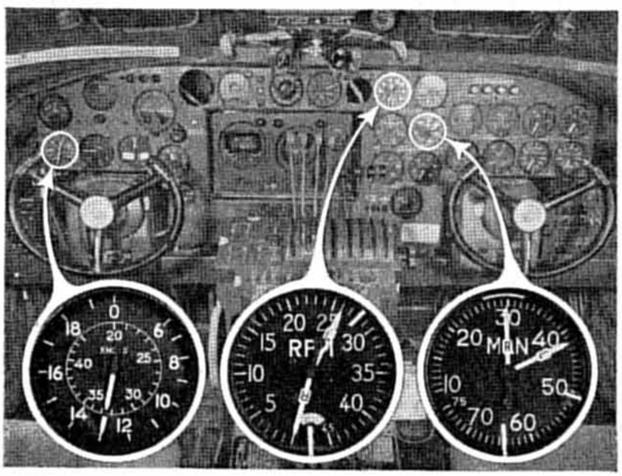
As the plane accelerates, the pilot should apply a gentle back pressure on the controls to assist in lifting the plane on the gear. The plane, with a moderate load, leaves the ground easily at 104 knots. This take-off speed increases up to 113 knots for a plane with a full load. Do not hold the airplane on the ground when it is ready to fly.

67—Pilot

RAISE GEAR AND BRAKE WHEELS

After leaving the ground the nose of the airplane should be held down and the take-off course maintained until the indicated airspeed reaches approximately 117 knots. At this speed full control is available in the event of engine failure, under average conditions. When definitely clear and air borne, inspect the nose wheel alignment through the window at the base of the pedestal. If a combination of banking and gyroscopic action has not changed the normal nose wheel alignment, raise the landing gear. Stop main wheel rotation with the brakes, before retraction is complete.

CLIMB



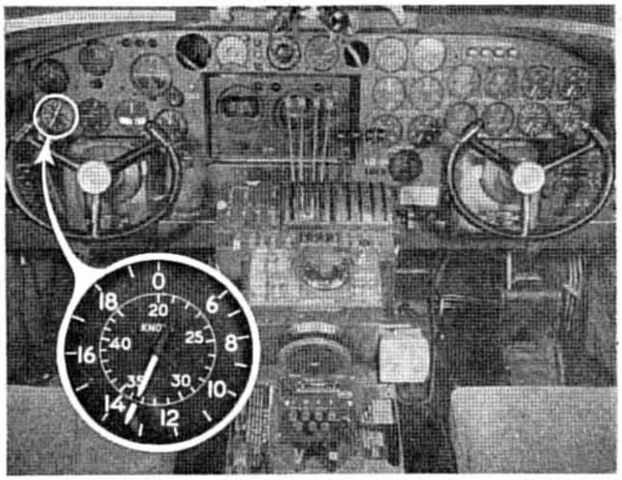
68—Pilot

ADJUST PROPELLERS AND MANIFOLD PRESSURE

Maintain an airspeed under 135 knots until wing flaps are raised. The most practical speed for the best average rate of climb is 130 knots. Adjust propeller revolutions to 2600 r.p.m. with governor switches and synchronize the propellers.

Manifold pressure should not exceed 42″ Hg as this is the maximum allowable continuous power rating for one hour.

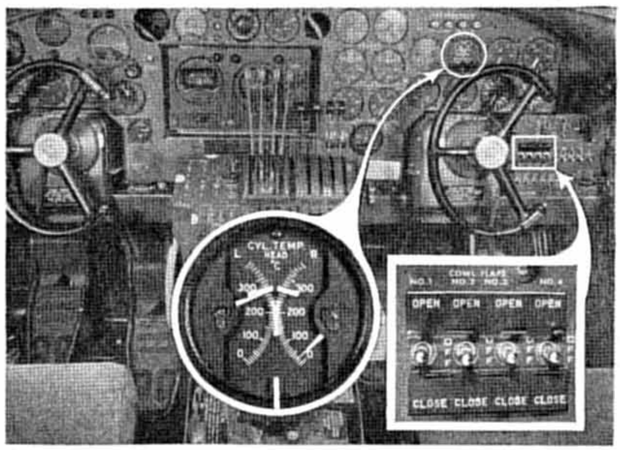
69—Pilot



ADJUST WING FLAPS

At approximately 800 ft. above terrain fully retract the wing flaps. Do not attempt to raise the landing gear and the flaps simultaneously because in the open center system the control valve nearest the engine pump cuts off all other units. Remember that an airspeed of 135 knots must not be exceeded with the wing flaps extended.

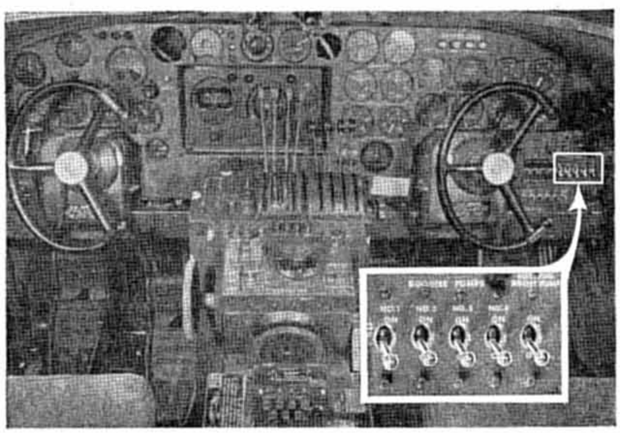
70—Pilot



ADJUST COWL FLAPS

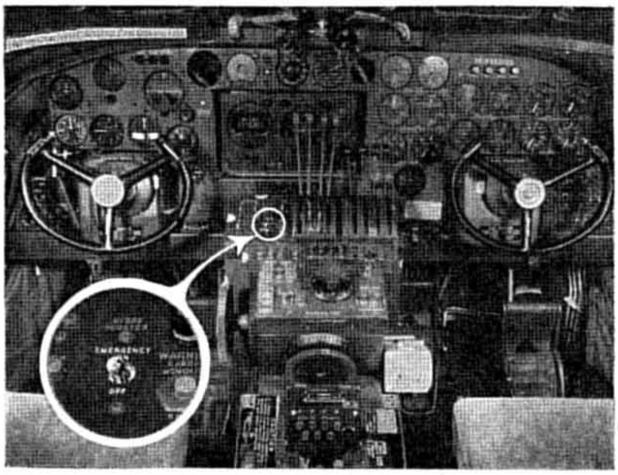
Cowl flaps are adjusted as necessary to control engine head temperatures not to exceed 260° C. in climb with mixture controls in *auto rich*. Lower head temperatures, however, are highly desirable.

71—Pilot



TURN BOOSTER PUMPS OFF

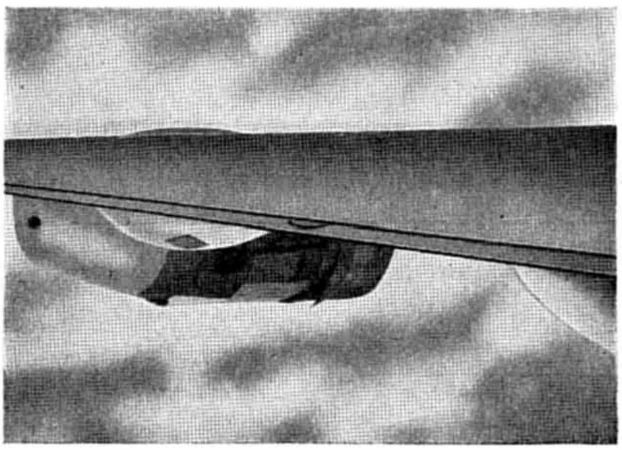
The fuel booster pumps are turned off as their auxiliary pressure is not again needed until the fuel pressure drops two pounds due to altitude or until landing.



72—Pilot

TURN HYDRAULIC SWITCH OFF

The auxiliary hydraulic electric motor is turned off when other than a purely local flight is being made. The hydraulic pump on No. 3 engine is capable of furnishing all the necessary power for flight operations.



73—Plane Captain

CHECK FOR DRAG AND LEAKS

During the climb the plane captain should observe from the waist turret blisters that landing gear has *fully* retracted. Wheels projecting beyond their well housings produce a drag which increases fuel consumption. Bomb bay doors are checked for fully closed. The under side of the wing, on each side, should be observed for possible fuel leaks. Nacelle cowling should be checked for indications of oil leakage and the exhaust should be observed for a possible excessive smoking condition.

74—

CRUISE

After reaching cruising altitude, climb another 500 feet, set power, and nose down slightly to return to cruising altitude. This is getting *on the step* and results in picking up speed before power is reduced to cruising requirements. If power were reduced too soon before the airplane has picked up full momentum for cruising it would mush along in a high attack, high drag altitude in trying to gain speed under reduced power and would probably be quite sluggish. Approach the cruising condition from the top in both speed and altitude, *never from below*.

When you have squared away on a mission, check the fuel supply frequently lest an unexpected leak or excessive consumption place you in a difficult position.

FLYING CHARACTERISTICS

Primary instruction in flying has made the pilot aware of load factors. Keep this in mind when banking or maneuvering so as to not exceed the safe limits. (See Special Instructions, page for flying limitations).

Steep banks up to 60° can be made safely. However, it should be borne in mind that in a normal bank of 60° the load factor is 2" and in this position all loads are twice as severe as in level flight. Turns steeper than normal increase this load factor.

Rough air operation is not critical. However, it is good practice to slow down when in extremely turbulent air, and extend the landing gear if flying on instruments. Disengage the Automatic Pilot when flying in rough air.

The longitudinal stability of the airplane is positive over a wide range of center of gravity locations. Under normal loadings the airplane will return to normal flight when released from a stall or other abnormal positions. The maximum forward location of the C.G. should not exceed 23° of the mean aerodynamic chord while maximum aft location of the C.G. should not exceed 35° M.A.C. Care should be exercised to operate controls smoothly when flying close to these limits, especially with the C.G. in extreme aft positions, as it is easily possible to develop the limit load factors of the tail assembly with sudden heavy elevator operation.

In the higher speed range, the elevators become "heavy." This is desirable inasmuch as it helps to prevent sudden extreme application of the elevators, which might prove damaging to the structure. When maneuvering the airplane, as in a dive, always keep the airplane trimmed by use of the trim tabs. If the pilot attempts to hold the full stick load, his sudden relaxing can apply a destructive force to the airplane.

The airplane has no inherent tendency to spin from a stall or slow, steeply banked turns and should not be forced to do so under any condition. The airplane was not designed for the loads imposed on the structure during a spin condition, and structural failure could result from spins.

The diving speed limits for various gross weights are:

41,000 lbs.	308 knots
56,000 lbs.	239 knots
65,000 lbs.	195 knots

Air loads build up rapidly on any large airplane in a dive, therefore, avoid abrupt movements of the controls.

Control trim should be maintained with the idea of keeping tail surface forces at a minimum. It is better to trim the airplane to slightly nose heavy rather than tail heavy. If it were trimmed tail heavy, in a dive the inherent tendency to pull up would make the application of up-elevator easier and more abrupt, creating higher load factors of "g's."

75—

BEFORE LANDING

Before entering the airport area, accomplish the Check List, page 39. Allow ample time to slow down to 135 knots. As speed is being reduced the pilot notifies the crew that the airplane is coming in for a landing.

76—Pilot

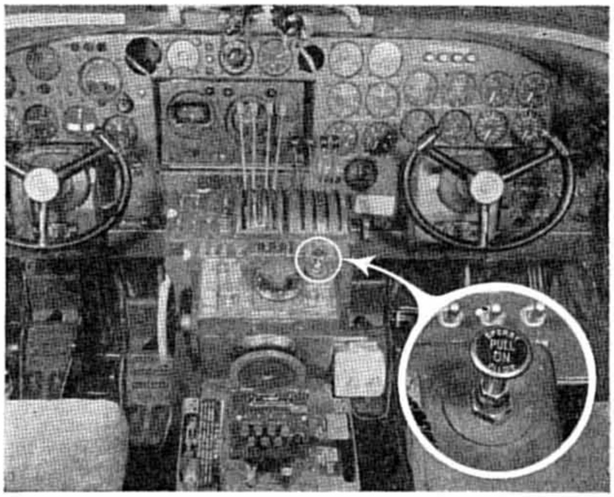
RADIO CALL, ALTIMETER SETTING

Remember to contact the control tower for clearance to land and for the field barometric pressure so that the altimeter can be set accordingly.

77—Pilot

CREW POSITION

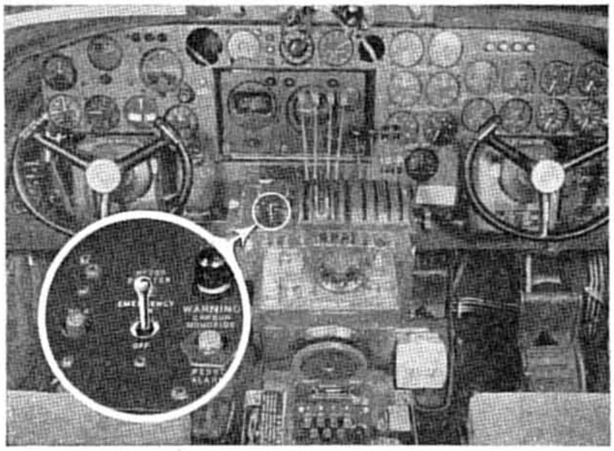
The nose section and nose wheel compartment should be cleared of all personnel. Personnel should be stationed in such a manner that a good C. G. is maintained.



78—Pilot

TURN AUTO PILOT OFF

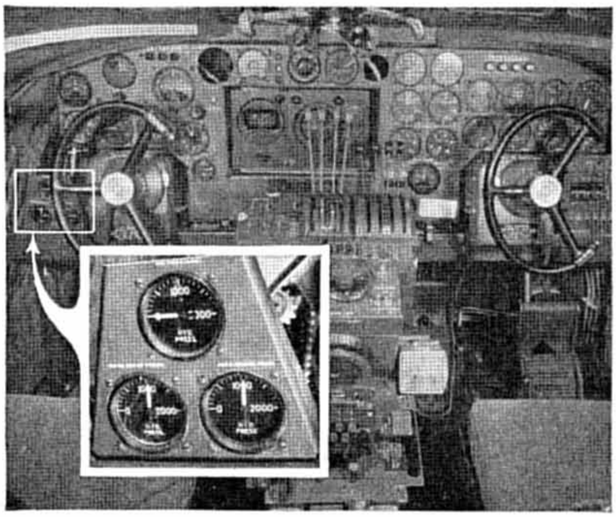
Make sure that the auto pilot is turned *off*. Landing would be hazardous if it were necessary to overpower the automatic control.



79—Pilot

TURN HYDRAULIC SWITCH ON

The auxiliary hydraulic switch is turned *on* to insure adequate brake pressure for landing, as the full supply of main hydraulic power will not be available when No. 3 engine is throttled.

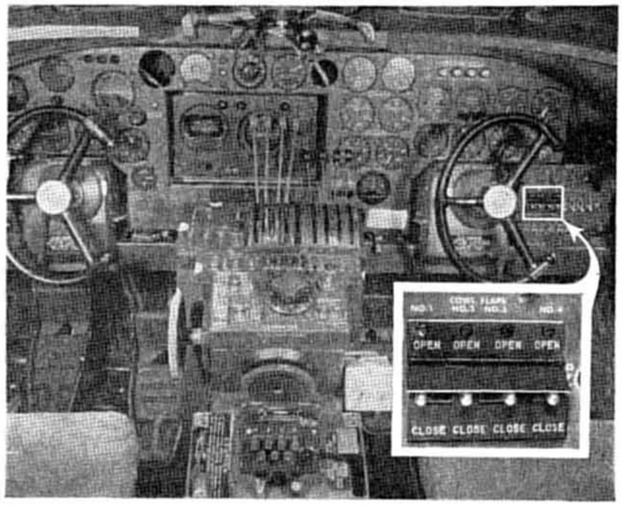


80—Pilot

CHECK ACCUMULATOR PRESSURE

Check the accumulator pressures as recorded on the brake gauges to be sure of adequate braking pressures. The gauges should read between 850 and 1125 p.s.i.

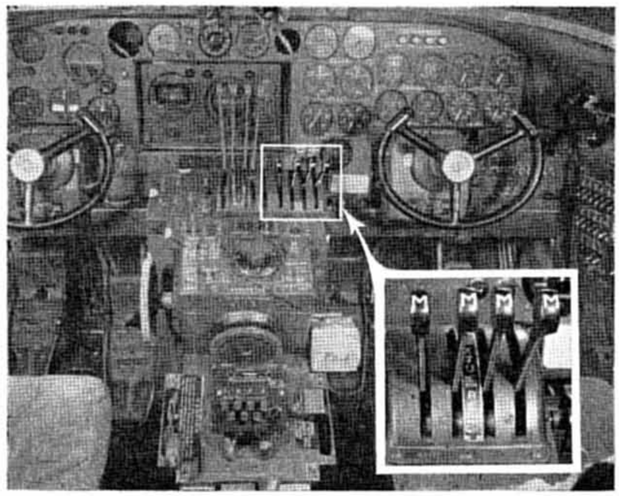
81—Pilot



CLOSE COWL FLAPS

Cowl flaps are closed on the approach to prevent rapid cooling in the glide and to cut down head resistance in the event landing is refused. Also, cowl flaps in the open position lower the lift of the wing surface directly behind them, which is a considerable area.

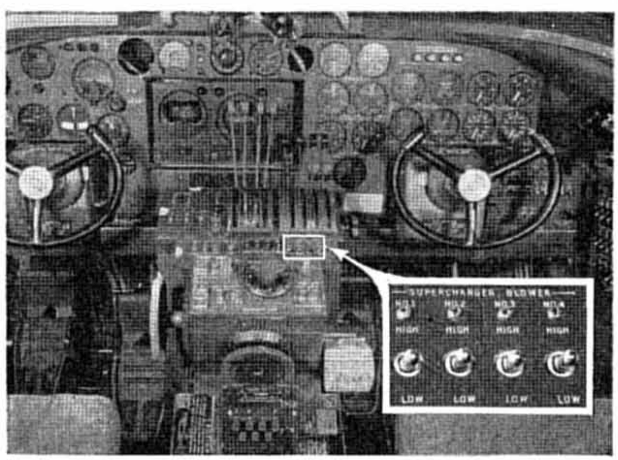
82—Pilot



MIXTURES—AUTO RICH

Mixture controls are placed in the *auto rich* position in the event full power might be needed. Full power is available only with the mixture controls in *auto rich*.

83—Pilot



BLOWERS TO LOW POSITION

Check and make certain the supercharger blowers are in low stage. Watch the oil pressure gauges closely as the switches on the pedestal are moved, one by one, to the low position.

84—Pilot

TURN ON BOOSTER PUMPS

All fuel booster pumps are turned *on* to insure a positive flow of fuel to the engine pumps.

85—Pilot

TURN HEAT ANTI-ICER OFF

If the anti-icer system has been in use, move all four switches on the pedestal panel to the *aft* or *cold* position. This closes the duct system and dumps the intake air overboard at the nacelle instead of allowing it to act as a spoiler in exhausting at the ports on the wind upper surface.

The propeller anti-icer system should be checked for *off*.

86—Plane Captain

CHECK NOSE WHEEL ALIGNMENT

As the landing pattern is approached, the plane captain observes that the nose wheel alignment is directly fore and aft. This will reduce the shimmy stresses on the damper when the nose wheel contacts.

87—Pilot

CHECK KICK OUT PRESSURE

Move the landing gear lever forward to the *up* position to check the kick out pressure; which should be from 1050 to 1100 p.s.i. This leaves a supply of hydraulic fluid in the *up* line which provides a cushion for the landing gear when it drops to the *down* position.

88—Pilot

LANDING GEAR DOWN

Move the landing gear lever aft to the *down* position. As the gear is lowering, check this sequence of operation: hydraulic pressure on the main gauge builds up suddenly, then drops; the green warning light in front of mixture control turns *on;* landing gear control handle returns to neutral; the return of the handle to neutral does not mean that latches are engaged. A surge as the gear bottoms could cause a premature kick out.

89—Plane Captain

INSPECT ALL LANDING GEAR LATCHES VISUALLY

The plane captain must check all three gear latches to be absolutely certain they are engaged. The nose gear latch may be inspected from the nose wheel compartment. Each of the main landing gear latches can be seen through the turret blisters on each side. Latches are painted a bright yellow for immediate identification. The main landing gear latches cannot be seen with the wing flaps extended. At night latches can be checked with a flashlight.

90—Plane Captain

RADAR HOUSING RETRACTED

Make a visual check to be certain that the radar housing is retracted.

91—Pilot

LOWER WING FLAPS ½ DOWN FIRST

After the landing gear lever has kicked back to neutral and the gear has been checked, with speed still reduced to 135 knots, enter the landing lane, extend the wing flaps 20° by moving the flap lever aft. When the indicator reads 20° return the control lever to neutral manually. This stops the flaps in the 20° down position. The flap lever only returns automatically from extreme *up* and *down* positions.

Half down flap is recommended for the beginning of the approach as lift and drag are both increased and the airplane attitude affords a greater angle of vision during landing. With flaps partially or completely extended the airplane is fully maneuverable but not so responsive.

92—Pilot

CARBURETOR AIR FILTER

Use of the carburetor air filter will be determined by prevailing conditions.

FINAL APPROACH

93—Pilot

FLAPS FULL DOWN

At any time during the glide the flap lever is placed in the *down* position and wing flaps fully extended. The lever will return automatically to neutral and the indicator will show 40° extended flap.

94—Pilot

PROPELLERS TO INC. R.P.M.

Move the propeller governor gang switch to the *inc.* position. This moves the propellers toward low pitch, high r.p.m. position. Set propellers at 2600 r.p.m. which will give ample take-off power in the event a landing is refused.

95—Plane Captain

CALL OUT AIR SPEED

Speed to be maintained in the glide varies, depending upon load, flap setting, and use of power. Under 55,000 loading glide should be maintained at 113 knots with flaps one-half extended, slowing to 104 knots with full flaps on leveling off for landing. The airplane is fully maneuverable with flaps extended. Maintain sufficient r.p.m. to continue at a rate of descent of 400-600 ft. per minute. When flying a heavy airplane remember that the inertia of a heavy body in motion resists effort to change the direction of that motion. Therefore, if a steep glide is being made with consequent high rate of descent it takes some time and a considerable force to flare out this rate of descent and change the direction to one parallel to the ground. It cannot be reasonably expected with a rate of descent in excess of 500 ft. per minute to start to level off 5 to 10 ft. above the ground and succeed in doing anything but "flying in." With no power the desirable indicated gliding speed is 113 knots. This speed also permits 10° banks near the ground and allows sufficient maneuverability with flaps extended for landing in bad visibility.

In case it is necessary to make a landing without use of the wing flaps due to no hydraulic pressure, no fluid, damaged tubing, or broken cables, an indicated airspeed of 130 knots may be required, in making the approach and a generous runway is essential. This is assuming a gross load of approximately 58,000 lbs.

96—

LANDING

As the plane begins to settle, compensate for drift and hold it off the ground as long as possible. The exception to this is an emergency when it is necessary to use brakes immediately on touching the ground, which is the only excuse for a three-wheel landing.

Normally, the main landing gear wheels should touch the ground first. A three-wheel landing should be avoided. Land tail down with the main gear touching first and as speed diminishes, allow the plane to settle gently on the nose gear, slowly and without shock.

Brakes should not be applied until the nose wheel is on the ground and the weight of the plane is taken by the oleo strut. The airplane will tend to rock forward onto the nose as it loses speed and it should be prevented from doing so as long as possible with the elevators. If a sudden application of the brakes is made with the nose wheel off the ground, the tail will snap up and excessive load factors will be built up in the nose wheel gear and in the tail, due to the length of the airplane. *Never land with brakes locked.*

Airplanes equipped with a retractable tail skid may be landed with the tail low, as are airplanes without tricycle landing gear. The retractable mechanism, while not recommended for full tail landing loads, will stand the load imposed by rocking back after landing, and by "dragging" the skid. In case of brake failure this feature may be used to advantage, particularly if the crew is stationed well aft in the tail to keep the skid on the ground during the full run, but do not exceed allowable C.G. limits for landing. In case of emergency or of faulty brakes, a nose high landing with tail skid dragging will enable the pilot to land on any normal airport without using brakes.

In case of emergency where the shortest possible landing run is imperative, the use of brakes immediately on landing is necessary. In this case, a three-wheel landing is made and the thrust of the nose gear must be taken up by pushing the elevator controls forward before applying brakes. Do not lock wheels as tires will tear though the fabric in an astonishingly short time. The airplane has no tendency to ground loop in a crosswind but any drift should be taken out before making ground contact.

97—

AFTER LANDING

After landing and the airplane is under ground control, *open cowl flaps immediately.* Raise wing flaps when convenient, preferably before taxiing to avoid possibility of rocks or mud being thrown into the tracks.

Keep mixtures in *auto rich*, turn booster pump *off* and taxi slowly. Steer with the outboard engines and use brakes only when necessary. Enter parking area carefully—the wing span is 110 ft. There is no excuse for carelessness.

98—

SECURING

On parking, align the nose wheel to coincide with the center line of the airplane.

Stop the engines with mixture controls in *idle cut-off*. Advance throttles before the engines stop rotating. Leave the cowl flaps open until engines cool. Set landing gear lever in *down* position after No. 3 engine has stopped. Do not set parking brakes until brake drums have cooled. With wheel chocks in place, setting parking brakes is unnecessary.

After the engines have stopped, instrument power (A.C.) may be turned off, as well as all other individual circuit switches. Turn generators off. Battery and master (bar) switches are turned off last to keep arcing in the battery solenoids at a minimum. Align the controls in neutral position and slowly engage the locking lever.

ALWAYS

Follow all items on check list.
Check fuel before take-off and regularly during flight.
Use battery cart when available.
Check generator switches *off* when starting.
Keep mixture in *idle cut off* until engine starts firing.
Check wing anti-icer *off* before take-off or landing.
Turn generator of first warm engine *on* to crank other three engines when necessary to start on ship's batteries.
Use outboard engines for steering when taxiing.
Turn off auxiliary hydraulic electric pump after take-off.
Check gear latches engaged before landing.
Check Auto Pilot *off* before take-off or landing.
Close cowl flaps before landing.

NEVER

NEVER—execute prohibited maneuvers.
NEVER—exceed airspeed restrictions.
NEVER—start engines before pulling propellers through.
NEVER—start with low batteries.
NEVER—start with superchargers in high blower.
NEVER—use starter for direct starting. Inertia flywheel must be energized before meshing.
NEVER—attempt to use intermediate positions on mixture control.
NEVER—turn on ground too sharply. It will damage landing gear and tires.
NEVER—take off with propeller in low r.p.m. high pitch.
NEVER—transfer fuel with radio *on*.
NEVER—apply brakes with nose wheel off ground.
NEVER—land with brakes locked.

PILOT'S CHECK LIST

BEFORE STARTING ENGINES

1. Pitot Cover—OFF
2. Form F, Weight and Balance
3. Engineer's Report
4. Master Bar and Ignition—OFF
5. Generators—OFF
6. Main Fuel Valves—TANK TO ENGINE
7. Bomb Bay Fuel Valve—OFF
8. Check Controls
9. Parking Brakes—SET
10. Wheel Chocks—Removed
11. Hydraulic Switch—OFF
12. Mixtures—IDLE CUT-OFF
13. Auto Pilot—OFF
14. Gyros Uncaged
15. Anti-Icer's, Wing Heat, and Prop.—OFF
16. Master Bar Switch—ON
17. Main Battery Switches One at a Time ON; Check Voltage, Polarity; turn OFF
18. Battery Cart ON, Check Voltage, Polarity
19. Hydraulic Switch—ON
20. Radar Housing—Retracted
21. Cowl Flaps—FULL OPEN
22. Props in INC. (High r.p.m.)
23. Superchargers to Low Blower
24. Carburetor Air Filter—As Required

STARTING ENGINES

1. Stand Fire Guard and call CLEAR
2. Ignition Switches—ON
3. A.C. Power—ON
4. Fuel Booster ON for Engine to be started, Check Fuel Pressure
5. Throttle Set; Accel. (20 Sec. Max.) Prime
6. Mesh Starter (30 Second Max.)
7. Mixture to Auto Rich when Engine Fires
8. Check Oil Pressure (30 Second Max.)
9. Booster—OFF; Check Engine Pump
10. Generators (of First Warm Engine)—ON if **necessary** to start on plane's batteries

BEFORE TAXIING

1. Check all Instruments
2. Remove Battery Cart
3. Check Brake Pressures
4. Check Vacuum Pressure
5. Generators—ON

ENGINE RUN-UP

1. Throttles to 1500 r.p.m.
2. Exercise Propellers and Wing Flaps
3. Exercise Blowers One at a Time
   1500 r.p.m.—Low to High
   2300 r.p.m.—High to Low
   Leave in Low Stage
4. Check Magnetos (Maximum r.p.m. drop of 75 at 2300)
5. Check Generators at 2300 r.p.m.

BEFORE TAKE-OFF

1. Doors and Hatches—CLOSED
2. Wing Flaps 20°
3. Gyros Uncaged and Set
4. Check Trim Tabs
5. Boosters—ON
6. Propellers (High r.p.m.)
7. Check Controls
8. Mixtures—Auto Rich
9. Cowl Flaps—⅓ Open

TAKE-OFF

1. Open Throttles; Limits 51″ Hg 2800 r.p.m.
2. Nose Wheel in Alignment
3. Raise Gear; Brake Wheels

CLIMB

1. Propellers—2600 r.p.m.; Manifold Pressure—42″ Hg
2. Wing Flaps—Fully Retracted
3. Cowl Flaps—Max. Temp. 260° C.
4. Fuel Boosters—OFF When Not Required
5. Auxiliary Hydraulic Switch—OFF

BEFORE LANDING

1. Radio Call, Altimeter Setting
2. Crew Positions
3. Auto Pilot—OFF
4. Auxiliary Hydraulic Switch—ON
5. Brake Pressure—1050 p.s.i.
6. Cowl Flaps—CLOSED
7. Mixtures—AUTO RICH
8. Blowers—Low Position
9. Boosters—ON
10. Anti-Icer, Wing Heat and Prop—OFF
11. Nose Wheel in Alignment
12. Landing Gear—UP
    a. Check Kickout Pressure at 1050 to 1200 p.s.i.
13. Landing Gear—DOWN
    a. Visual Locks
    b. Light
14. Radar Housing—Retracted
15. Wing Flap Setting (Air speed not to exceed 135 knots)
16. Carburetor Air Filter—**AS REQUIRED**

FINAL APPROACH

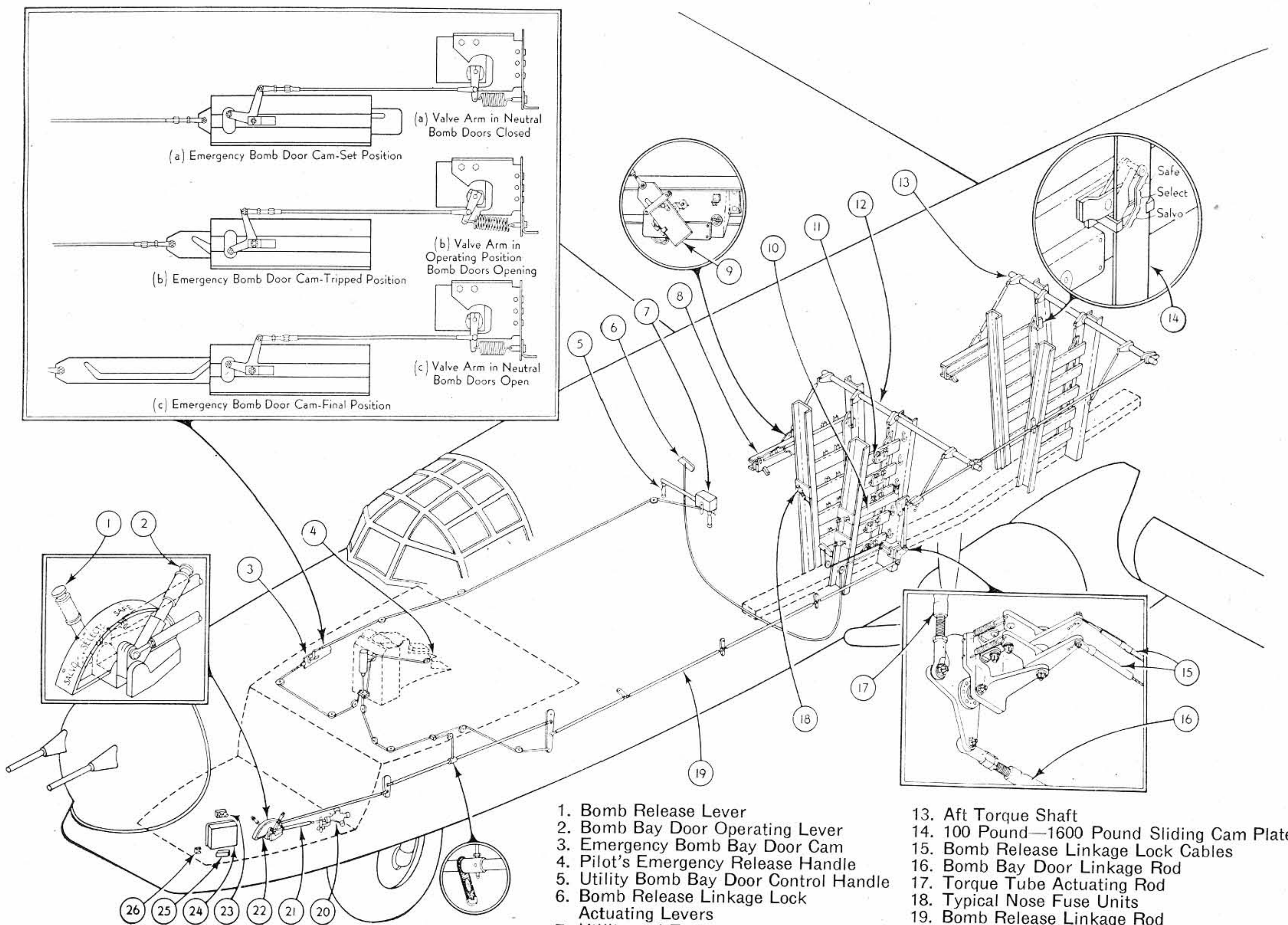
1. Wing Flaps Full Down
2. Propellers to 2600 r.p.m.
3. Call out air speed

AFTER LANDING

1. Open Cowl Flaps
2. Raise Wing Flaps
3. Boosters—OFF

SECURING AIRPLANE

1. Align Nose Wheel
2. Mixtures—Idle Cut Off
3. Throttles—Advanced
4. Landing Gear Lever—Down
5. Place Wheel Chocks; Parking Brakes—OFF
6. Electrical Load Units—OFF
7. Generators—OFF
8. Battery and Master Emergency Switches—OFF
9. Neutralize Controls and Lock



1. Bomb Release Lever
2. Bomb Bay Door Operating Lever
3. Emergency Bomb Bay Door Cam
4. Pilot's Emergency Release Handle
5. Utility Bomb Bay Door Control Handle
6. Bomb Release Linkage Lock Actuating Levers
7. Utility and Emergency Bomb Bay Door Control Valve
8. 2000 Pound Bomb Rack
9. 2000 Pound Bomb Sliding Cam Plate
10. B-10 Shackle
11. AN-A2A Release Unit
12. Forward Torque Shaft
13. Aft Torque Shaft
14. 100 Pound—1600 Pound Sliding Cam Plate
15. Bomb Release Linkage Lock Cables
16. Bomb Bay Door Linkage Rod
17. Torque Tube Actuating Rod
18. Typical Nose Fuse Units
19. Bomb Release Linkage Rod
20. Bomb Bay Door Control Valve
21. Bomb Bay Door Control Valve Rod
22. Bomb Quadrant
23. Bombardier's Instrument Panel
24. Bombardier's Control Panel
25. Intervalometer
26. Firing Key

Figure 3—Offensive Armament

CHAPTER II
ARMAMENT

THE PB4Y-2 airplane's primary mission is searching, reconnaissance, and tracking in sea areas where it may be exposed to fighter attack. A secondary mission includes antisubmarine patrol, mine laying, photography, and horizontal bombing.

The armament carried can be divided into two classifications: offensive and defensive.

OFFENSIVE ARMAMENT

The offensive armament system includes bombs which may range in weight from 100 lbs. to 2000 lbs. The control units are connected to the bomb rack installations by a series of rods in the mechanical release system by electrical wiring in the electrical release system. Bombs cannot be released

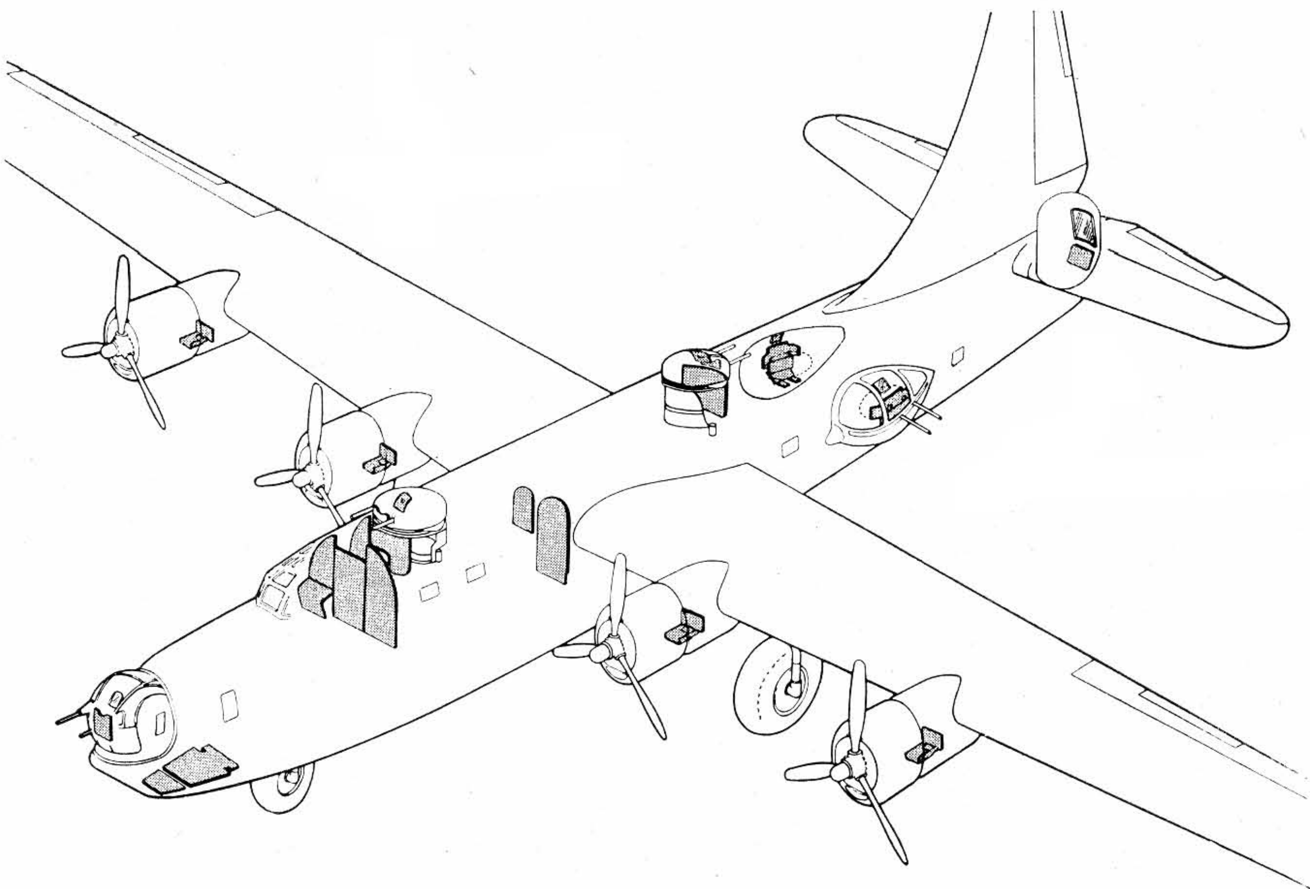


Figure 4—Location of Defensive Armor

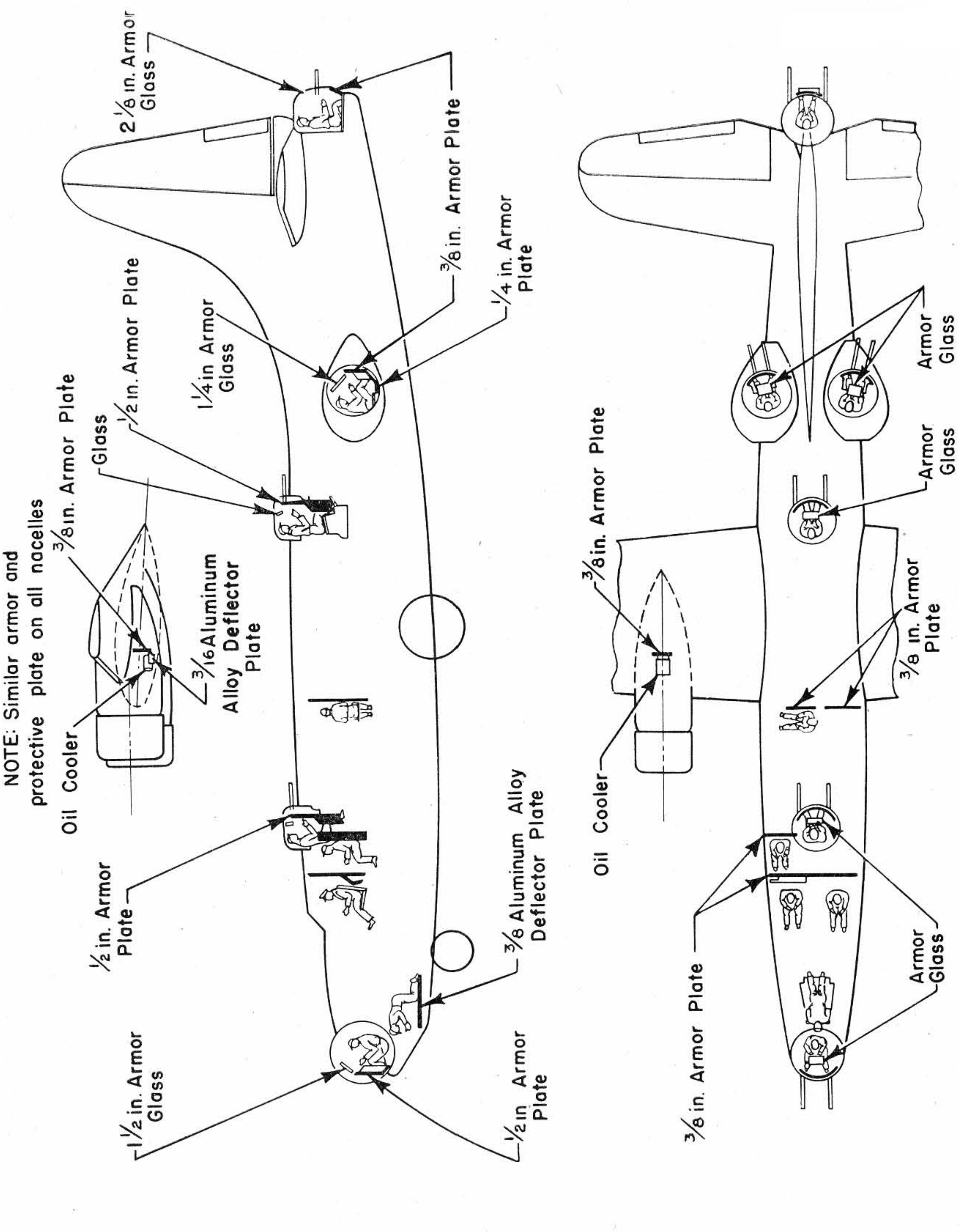


Figure 5—Defensive Armament—Angles of Armor Protection

electrically from the bombardier's position without first operating the mechanical system. The bombardier can effect release, however, in salvo position, through the mechanical system only. The pilot's emergency release control is mechanical only.

All of the bombing control units, with the exception of the pilot's emergency release handle, are located in the nose section of the PB4Y-2 airplane. The pilot's emergency release handle is located on the aft face of the control pedestal. It is identified by the words *bomb release* stenciled on the handle.

Note: Two distinct steps are necessary to salvo bombs: first, a sharp pull of the bomb release handle is necessary to open bomb bay doors, and a second pull of the handle is necessary to drop the bombs.

The bomb rack installations are located in the bomb bay of the airplane. The bomb bay extends from station 4.0 to station 6.0.

The bomb rack equipment is designed to support the following types of bombs: practice, fragmentation, incendiary, general purpose, depth, armor piercing, demolition, and mines.

Bomb bay door *indicator lights* flash on when bomb bay doors are fully opened. These lights are located on the bombardier's switch panel and on the pilot's instrument panel. They are controlled by two switches located in the lower rear section of the bomb bays. Circuit design prevents the dropping of bombs from the bomb bay section, in which either of these switches are located, in the event the doors are not *fully opened*. The right hand bomb bay door indicator light turns on when the right rear bomb bay door is opened for photographic purposes.

Armor Protection

In addition to the armor protection provided in the gun turrets, sections of armor plate are installed in the airplane for protection of crew members and of vital equipment. All of the armor plate sections are 3/8" thick homogeneous steel, bolted in position.

Location

Refer to Figures 4 and 5. At station 3.0, the pilots' compartment is separated from the radio-navigation compartment by four sections of armor plate. Two of these sections are located directly behind the copilot, another behind the pilot. The fourth is hinged to provide a door between the pilots' compartment and the radio-navigation compartment.

At station 4.1 are two vertical sections located in the plane of the bulkhead. One is directly over the compartment hatchway; the other is on the left and to the rear of the radio operator's position.

In each nacelle is a vertical section of armor plate, located at the rear of the oil cooler, and a curved section located beneath the oil cooler.

DEFENSIVE ARMAMENT

Nose Turret

The Erco 250 SH-3 (Spherical-Hydraulic) turret, illustrated in Figure 6, is located in the nose of the PB4Y-2 airplane.

The turret is constructed in the shape of a sphere with the upper portion made of Plexiglas which completely covers the gunner and all mechanical parts.

The instruments necessary for the operation of the turret consists of electrical switches, triggers, and a control handle—all easily accessible to the gunner.

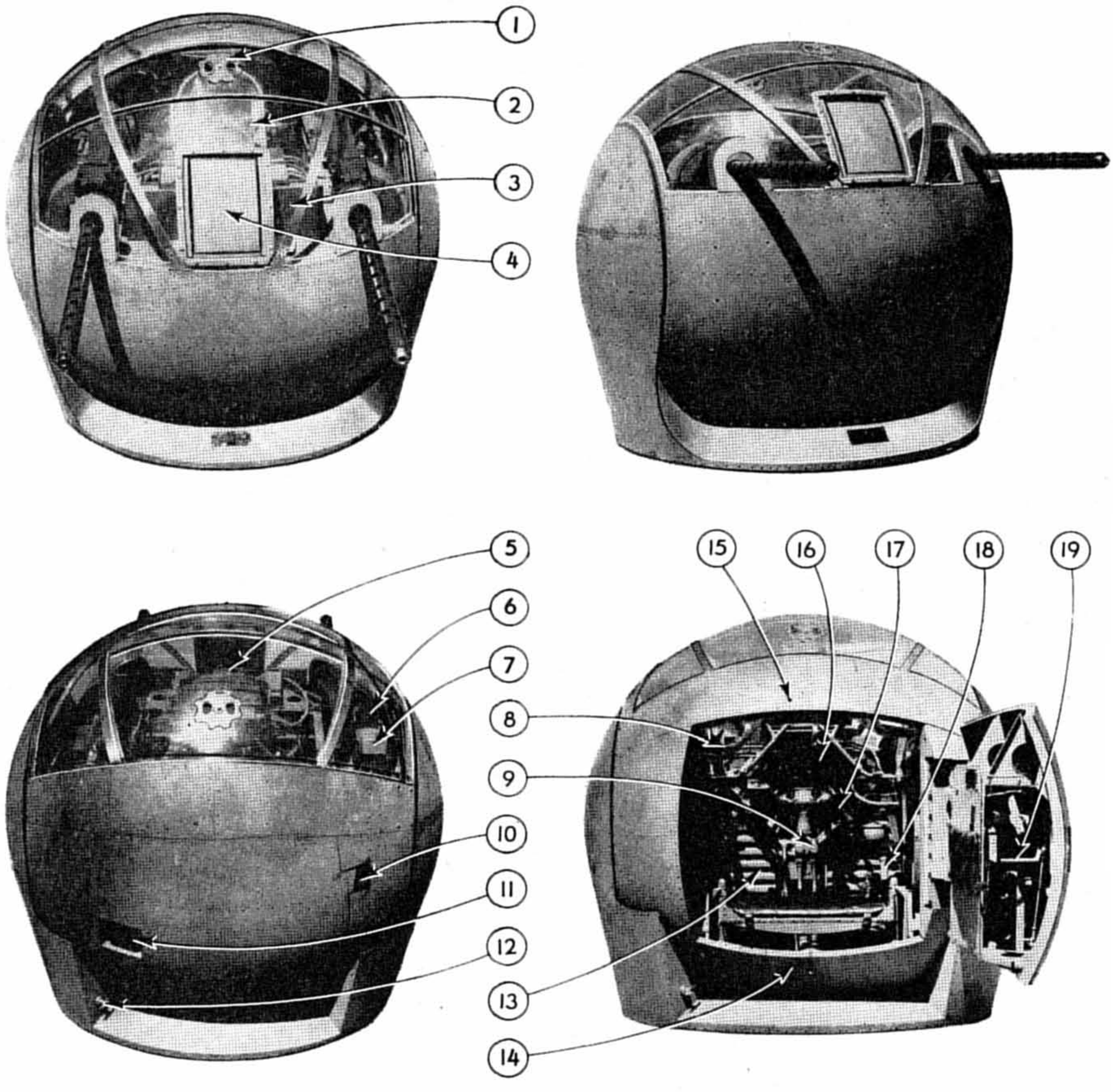
Martin Top Turrets

The Martin top turret is illustrated in Figure 7. Two top turrets are provided in the PB4Y-2 airplane. The center line of the forward turret is located at station 3.0; the center line of the aft turret is located between stations 5.3 and 5.4.

The upper portion of the turret (that portion which projects above the fuselage) is encased in a Plexiglas dome. This dome allows the gunner an unobstructed view. The turrets are so designed as to rotate continuously in azimuth (360°), and to elevate the two .50 caliber M-2 machine guns from $-6\frac{1}{2}°$ to $+85°$.

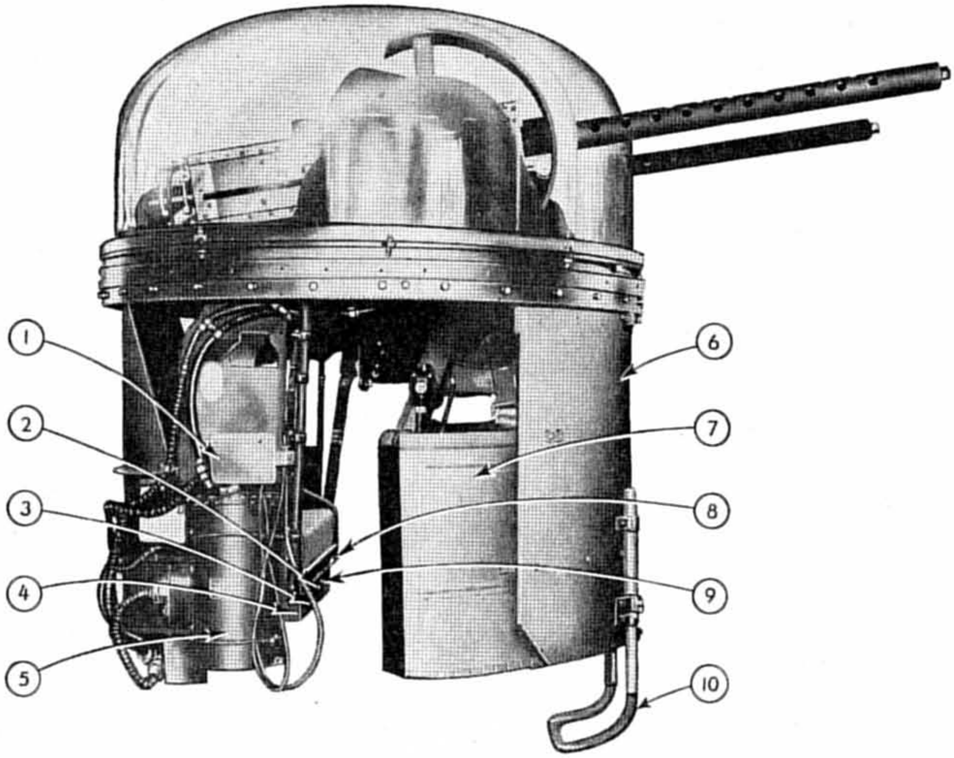
Both turrets are driven by electrical gear. The turret drive, actuated by 24 volt electrical units, mechanically elevates, trains, and fires the .50 caliber guns.

Profile gunfire interrupters are installed in each turret for the prime purpose of interrupting the fire



1. Ventilator
2. Armor Glass
3. Armor Plate
4. Sighting Window (Metal Guard Inserted)
5. Gun Camera Mounting Pad
6. Ejected Link Receiver Chute
7. Ejected Link Receiver Chute
8. Gunner's Shoulder Strap
9. Control Valve
10. Door Hinge
11. Door Handle
12. Elevation Declutch Handle
13. Front Ammunition Can
14. Emergency Tilting Handle Receptacle
15. Emergency Tilting Handle Receptacle
16. Switch Panel
17. Control Handle
18. Hydraulic Pump Handle
19. Door Latch Handle

Figure 6—Erco Nose Turret



1. Junction Box
2. Azimuth Reset
3. Auxiliary Reset
4. Master Switch
5. Amplydine
6. Armor Plate
7. Ammunition Container
8. Gunner's Seat Release
9. Elevation Reset
10. Gunner's Foot Rest

Figure 7—Martin Top Turret

of the guns when they come into line with the tail structure of the airplane.

> **Warning:** When operating the top turret *mechanically*, the fire interrupter is *inoperative. Firing is possible in* any gun position. Severe damage to aircraft and personnel may result by disregarding this possibility.

Waist Turrets

The Erco waist turret (250 TH teardrop-hydraulic) is illustrated in Figure 8.

The Erco waist turrets are located on both sides of the PB4Y-2 between station 6.2 and 7.3.

The instruments necessary for their operation consist of electrical switches, triggers, and a control handle. All the instruments are easily accessible to the gunner.

Power is brought into the turret, through electrical cables, to an electric motor. This motor actuates a hydraulic pump. The pump supplies the hydraulic power which operates the turret. The desired direction of movement of the turret is obtained by operating the control handles on the Clarke control valve. Rotation of the handle grips about the column swings the guns in azimuth. Pulling the hand grips elevates the guns and pushing them depresses the guns.

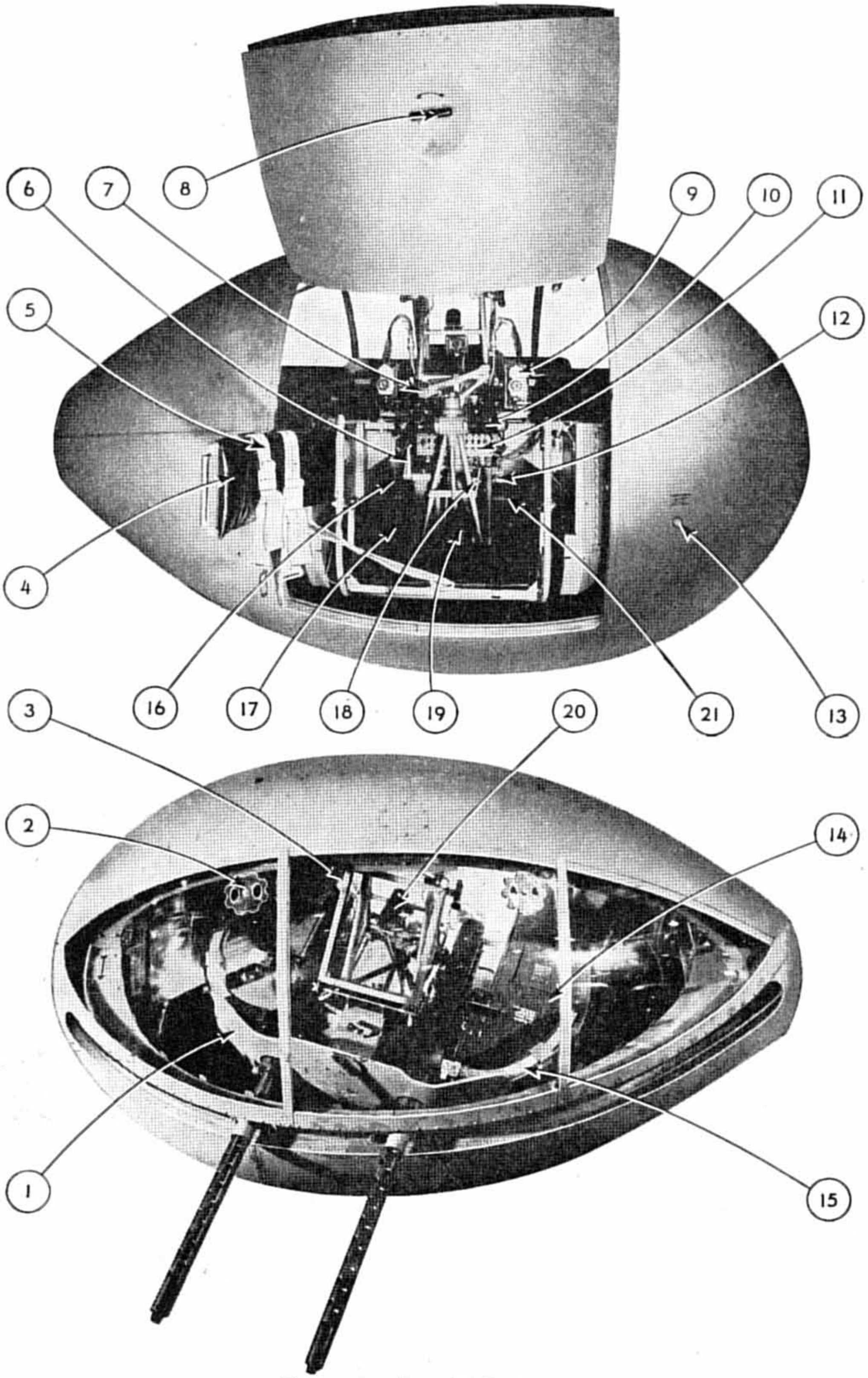


Figure 8—Erco Waist Turret

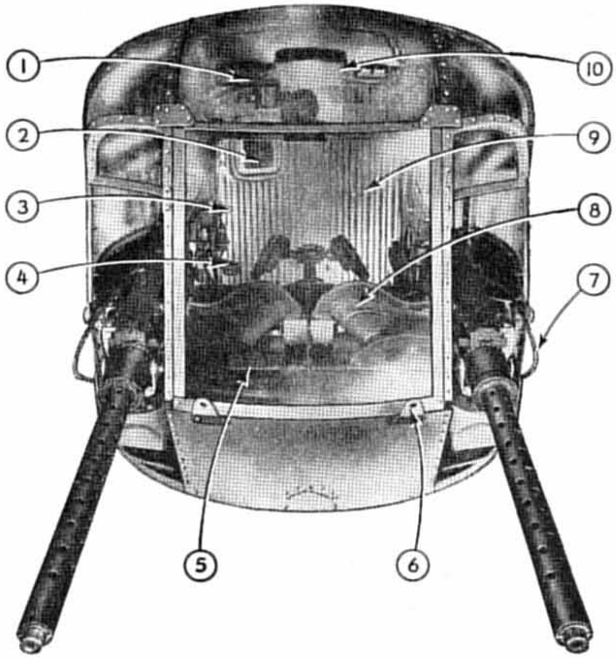
Tail Turret

The MPC 250-CH-6 (Cylindrical-Hydraulic) turret is located in the tail of the PB4Y-2 airplane.

The turret is cylindrical. It has a Plexiglas dome over the upper, rear quarter. The dome provides the gunner with an unobstructed vision to the rear as illustrated in Figure 9.

The instruments necessary for both the mechanical and manual operation of the turret are enclosed within the turret. They are all easily accessible to the gunner. The instruments consist of electrical switches, triggers, and a control handle. This handle enables the gunner to manipulate the turret at will within the operating range.

The tail turret has a separate hydraulic system. This system is mounted on a panel on the right side of the airplane, just forward of the turret. Hydraulic power actuates the turret both in elevation and in azimuth. The Clarke hydraulic valve, which is the control valve, controls the movements of the turret. The turret is rotated by turning the hand grips about their vertical axis; moving the control grips fore and aft raises and lowers the guns.



1. Hand Grip
2. Entrance Door Window
3. Azimuth Manual Crank Shaft
4. Azimuth Manual Control Hand Crank
5. Tie Rod
6. Hoisting Lug
7. Foot Firing Cable
8. Shell Chute
9. Entrance Door
10. Hand Rest

Figure 9—Motor Products Tail Turret (front view)

PYROTECHNIC EQUIPMENT

Pyrotechnic equipment consists of a signal pistol, drift signals, and parachute flares.

Signal Pistol

A signal pistol is stowed adjacent to the navigator's position, at the upper side of the radio-navigation compartment, between station 3.6 and 4.0. Provision is made for the stowage of 12 rounds of signal ammunition.

At the upper left side of the radio-navigation compartment is located a recoil absorbing mount. In this mount the pistol must be inserted and turned, to lock it into position for firing.

Warning: Do not attempt to fire the signal pistol unmounted, as a 200 lb. recoil is produced on firing.

Drift Signals

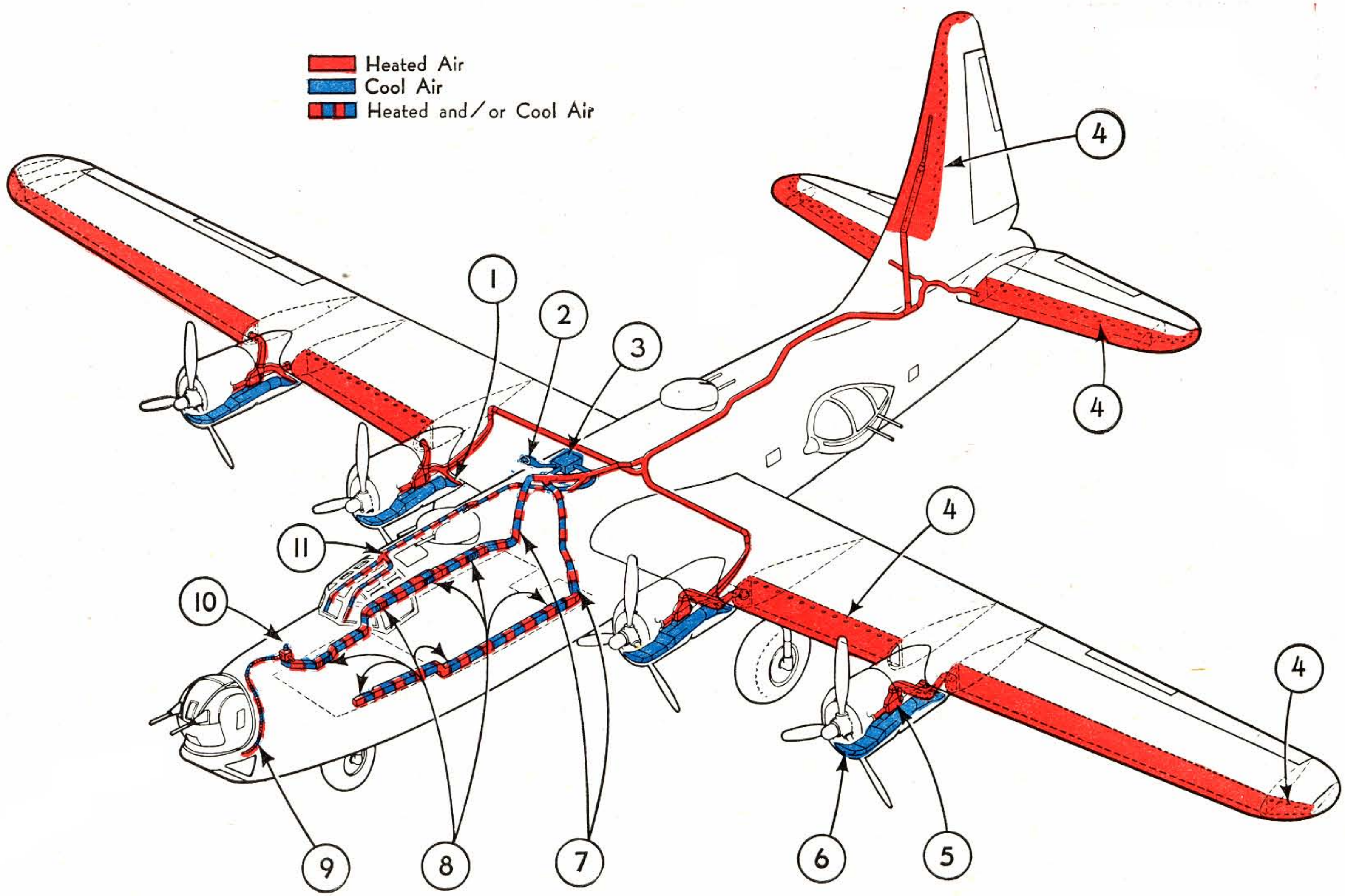
Stowage is provided for 12 drift signal bombs, six at either side of the rear compartment, between stations 7.5 and 7.6.

Parachute Flares

On either side of the rear compartment, forward of the side turrets, space is provided for stowage of armor-protected parachute flares.

LEGEND FOR FIGURE 8

1. Upper Armor Plate
2. Ventilator
3. Armor Glass
4. Gunner's Back Rest
5. Gunner's Shoulder Straps
6. Azimuth Manual Crank
7. Control Valve Cable and Pulleys
8. Door Handle
9. Firing Solenoid
10. Control Handle
11. Switch Panel
12. Foot Firing Lock
13. Emergency Elevation Release
14. Ejected Link Container
15. Ejected Link Chute
16. Intermediate Armor Plate
17. Diagonal Armor Plate
18. Azimuth Declutch Handle
19. Shell Feed Chute
20. Gun Sight
21. Foot Firing Pedal



1. Heated Air Discharge Duct
2. Air Scoop
3. Plenum Chamber
4. Vent Holes
5. Heat Exchanger
6. Air Scoop
7. Cabin Heating and Ventilating Duct
8. Adjustable Registers
9. Defrosting Tube
10. Control Valve
11. Defrosting Duct

Figure 10—Heat Anti-icing, Cabin Heating, Ventilating and Windshield Defrosting Systems

CHAPTER III
HEAT ANTI-ICING, CABIN HEATING, VENTILATING, AND WINDSHIELD DEFROSTING

THE complete duct system for heat anti-icing, cabin heating, ventilating, and windshield defrosting is illustrated in Figure 10. These functions are controlled by switches on the pilot's pedestal which allow the pilot to direct the flow of cool or heated air through a network of insulated metal ducts. The switches are illustrated in Figure 11.

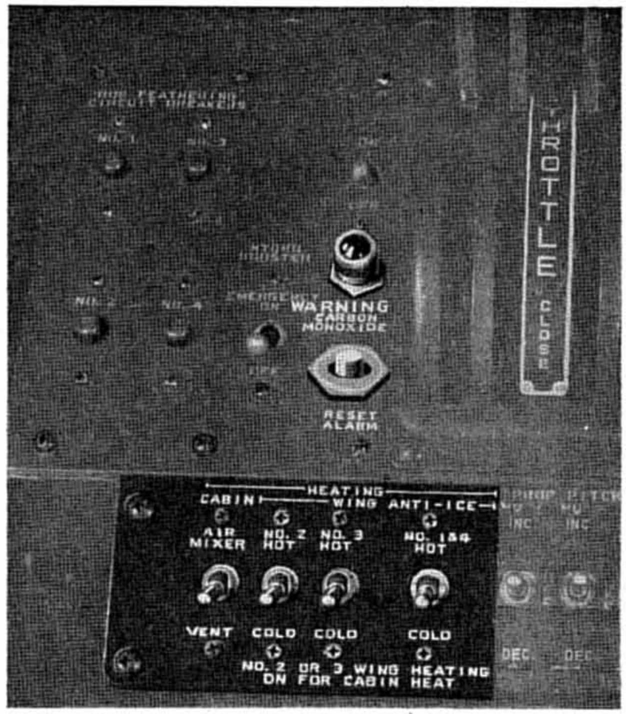


Figure 11—Heating Control Panel, CO Warning Light and Reset Relay

Heat Anti-Icing

Refer to Figure 10. Prevention of ice formation on the leading edges of the wing and empennage is accomplished by means of heated air directed from the heat exchangers in the four nacelles.

Wing Outer Panels and Wing Tips

Heated air from the heat exchangers in the outboard nacelles (nacelles No. 1 and No. 4) is used *only* for prevention of ice formation on the wing outer panel leading edges and wing tip leading edges. Valves in the ducts leading from these heat exchangers are controlled by reversible electric motors. Heat exchangers in both outboard nacelles are operated by a single switch marked *No. 1 & 4.* This switch, located on the pilot's pedestal, is illustrated in Figure 11. If this switch is in the *hot* position, heated air is directed into the outer panel leading edges; if it is in the *cold* position, the heated air is exhausted through outlets in the rear of the nacelles.

Caution: In the event of failure of an outboard engine when operating under icing conditions, place the switch for engines No. 1 and No. 4 in the *cold* position. This is necessary for the following reason: Engine failure causes the heat exchanger in that nacelle to be inoperative; consequently, ice may form on the adjacent wing outer panel. The resultant lowering of the airfoil efficiency of that wing area, in contrast to the normal airfoil efficiency of the opposite wing outer panel, would cause a hazardous yawing of the airplane.

Empennage and Wing Leading Edge Between Nacelles

Anti-icing of the wing between the engine nacelles and of the empennage is accomplished by means of the heated air directed from the heat exchangers in the inboard nacelles (nacelles No. 2 and No. 3). Two control switches, marked No. 2 and No. 3, are illustrated in Figure 11.

Thermostatic Control

Thermostatic control is provided for the entire anti-icing system by means of capillary tubes—one in each nacelle. If air temperature exceeds 400° F. in a hot air duct, the motor which controls the gate valve for that duct automatically rotates the gate valve into such a position that enough of the heated air is discharged through the outlet adjacent to the oil cooler air duct outlet, to prevent the air temperature in the hot air duct from rising above 400°. Thus, possible damage to the airplane structure is prevented.

Cabin Heating and Windshield Defrosting

Refer to Figure 10. Cabin heating and defrosting air is ducted from the two inboard nacelle heat exchangers, and is obtained when the two switches marked No. 2 and No. 3 on the pilot's pedestal are placed in the *hot* position. An adjacent switch, with two positions marked *air mix* and *vent*, must be placed in the air mix position to allow for complete automatic operation of the cabin heating and defrosting system. Two ducts, one along either side of the radio-navigation compartment and flight compartment, are equipped with adjustable registers for controlling the flow of heated air into the cabin. Control of cabin temperature is maintained by an adjustable thermostatic control, located to the left of the pilot's position.

A damper is located in the duct Y where heated air is distributed to the cabin heat and defrosting air ducts. A control, marked *Heat Control*, is located in the radio-navigation compartment, above and to the left of the entrance hatch. This control, which is fitted with a spring loaded catch, enables the damper to be placed in three positions: *neutral*, *cabin heat only*, or *defrosting heat only*.

The duct at the right extends into the nose compartment. This duct is equipped with flexible tubes through which heated air may be directed to defrost the bombardier's windshield, or adjacent transparent surface.

A duct along the top right side of the cabin divides at the flight compartment to provide heated air for defrosting the pilot's and copilot's windshields. The double panes of the windshields allow the heated air to flow between them and to distribute evenly.

Air forced into the plenum chamber scoop mixes with the heated air in the ducts of the cabin heating and defrosting systems to maintain safe temperatures.

Ventilating

Refer to Figure 10. When ventilation of the cabin is desired, place all heating switches in the *cold* position. This causes the heated air from the heat exchangers in all nacelles to exhaust overboard, the empennage duct valve to close, and the cool outside air from the plenum chamber to flow into the cabin through the registers located in the ducts on either side of the cabin.

Carbon Monoxide Detector

A CO detector is installed between stations 5.2 and 5.3 in the rear compartment. The CO detector determines the presence of carbon monoxide gas in the airplane. When carbon monoxide gas is detected, a circuit to the light on the pilot's pedestal is closed, causing the warning light to flash on. If this occurs, the pilot should immediately ventilate the cabin by placing all the heating system switches in *cold* position. A push button switch on the pedestal controls resetting of the warning system.

Caution: Be *sure* that the CO detector circuit breaker switch at station 4.0 is *on* when using the heating system. Be sure that the CO detector intake in the cabin is unobstructed and drawing air.

Be sure that the CO detector warning light is functioning. Push to test.

Warning: Carbon monoxide is a poisonous gas which may cause death when present in the air to the extent of only four parts in 10,000 (0.04 of 1 per cent) by volume. The gas is colorless and odorless, and, therefore, gives practically no warning of its presence.

CHAPTER IV
ELECTRICAL SYSTEM

POWER SUPPLY

Batteries

Main battery power is supplied by two 24V storage batteries. These are located under the flight deck forward of station 4.0, one on the right side and one on the left side. They are in parallel when connected to the ship's power distribution system. This connection is made by first turning the emergency master switch bar on the ignition panel overhead to *on*, and second, by turning the two individual battery switches, located on the copilot's power panel to *on*, one at a time. The remote control battery relays are thus energized connecting the ship's batteries to the power distribution system. If everything is quiet, clicks will be heard when the battery relay switches are energized. After the ship's batteries have been connected to the distribution system, it is wise to check their voltage and polarity at the generator switch panel. This is done by turning the voltmeter selector switch to the position marked *bus*. The voltmeter will then indicate the voltage of the ship's batteries as they are individually connected to the distribution system. If the needle swings to the left of zero, reverse polarity is indicated and the batteries have been installed incorrectly. It is wise also to make this test for both voltage and polarity of the external battery cart after the ship's batteries have been disconnected.

Generators

When engines are operating, power is generated by four engine driven generators, each of which has the following continuous rating: 4550/8000 r.p.m., 9 kilowatts, 30V, 300 amperes. This is without injury to the generator as long as cooling air not exceeding 30°C. is delivered to the inlet of the generator air blast tube. The generator has an overload rating of 150% or 450A for *two minutes* at 5200 to 8000 r.p.m. at sea level. Generator voltage may be adjusted at the voltage regulator under the flight deck, on the bulkhead at station 4.0, right or left. Generators are turned *on* or *off* by the four switches on the generator control panel. The panel is mounted aft of the pilot on the left wall of the flight compartment.

Battery Cart

For ground operation an external battery cart connection is provided on the right side of the nose wheel compartment. When available, *always* use the battery cart for starting the engines. This is most important since at this time no auxiliary power unit is provided. The excessive loads incident to initial start will greatly shorten the life of the main batteries.

Note: Battery switches must be left *off* when using battery cart.

When no battery cart is available and the ship's batteries are in a strong condition, it is recommended to start only No. 3 engine on ship's batteries; allow it to warm up and turn its generator *on* to supply the energy required to start the other three engines. When batteries are weak, engines can be started manually.

Inverters

The alternating current inverters mounted under the flight deck, right side, operate on the ship's 24V direct current system and deliver alternating current at 400 cycles per second at pressures of both 26V and 115V. Each inverter has a capacity of 750 volt amperes. Although two inverters are provided, only one is used in service, while the other is kept as a connected spare. Inverter output is used to operate the alternating current instruments (manifold pressure, fuel flow meter, oil pressure, and fuel pressure). It also supplies power to the gyro flux gate compass and to radio equipment. Power to operate the motor drive of an inverter is taken from a bus in the power panel on the forward side of the bulkhead at station 4.0. This is routed through two circuit breakers, located in the middle row of the pilot's power panel marked inverter power No. 1 and No. 2. Power to operate the inverter control relay is taken from a bus in the pilot's power panel and goes to the circuit breaker marked *relay*, in the middle row, on the pilot's power panel. The operating control switch for the inverter is located on the pedestal to the left of the rudder trim tab knob and is marked A.C. *power*.

DISTRIBUTION SYSTEM

Heavy duty power circuits which distribute electrical energy throughout the airplane are routed by multiple paths which are separate and independent from one another. This insures more positive distribution in the event of damage by gunfire. There are three main longitudinal paths along the axis of the fuselage: right and left, generally along the longerons, and generally along the center line. Aft of the bomb bays the center cable is along the top of the tunnel. Forward of the bomb bays it is in the nose wheel compartment on the underside of the flight deck. Two main lateral routes along the wing are located one on the front spar and one on the rear spar. The primary power circuits deliver energy to various bus bars, power panels, and fuse boxes, located throughout the airplane.

Power panels contain circuit breakers which can be reset manually in order to restore power to the operating circuits they serve. Ordinarily, circuit breakers are always in the *on* position and are therefore protected from being accidentally thrown to *off* by fixed metal caps which house them. When an overload occurs the circuit breaker automatically operates to the open circuit position which throws the switch handle out of the housing to the *down* position. Fuse boxes contain small cartridge fuses which can be replaced when they blow on overload.

There are only four heavy duty fuses in the power circuits. These are located at the generators and are therefore not replaceable in flight. These heavy duty fuses are called current limiters and function much like fuses, but stand high initial currents. No current limiters are provided at the batteries.

CIRCUIT IDENTIFICATION

Circuits of the electrical operating systems originate at their respective fuses in the fuse boxes. All circuits are coded independently for identification. In the codes, the number preceding the letter designates the wire size and the letter designates the system to which the wire belongs. The number following the letter identifies the wire as a particular circuit. Example of wire code—18P141; 18 is the wire size, P is for power circuit, and 141 is the wire number. The various letter designations are given in the following table:

Name of Circuit	Code letter of circuit used on wiring diagrams in aircraft data case at left of pilot.
Armament	A
Bomb Release	B
Heat Anti-icer	D
Cabin Heater	D
Pitot Heater	D
Windshield Wiper	D
Inverter	E
Inverter A.C. Instruments	E
Inverter D.C. Instruments	E
Gyro Flux Gate Compass	F
Landing Gear Safety Lock	G
Heated Flying Suits	H
Ignition	J
Propeller Governor and Fast Feather Controls	K
Engine Controls	K
Lights, Interior and Exterior	L
Camera	M
Ground	N
Power	P
Fuel System Control	O
Landing Gear Indicator and Alarm	W

CHAPTER V
FUEL SYSTEM

THE PB4Y-2 airplane fuel system is illustrated schematically in Figure 12. The nacelle fuel system illustrated in Figure 12 is for airplanes beginning with Bureau No. 59474. The nacelle fuel system for previous airplanes, up to Bureau No. 59473 inclusive, is illustrated in Figure 13. The remainder of the fuel system remains unaffected by the change.

Fuel System Storage Capacity

The main fuel supply is contained in twelve fuel cells which are installed in the wing. An auxiliary supply of fuel is contained in four fuel cells installed in the bomb bay. The auxiliary supply can be transferred to the wing tanks.

The wing tanks have a total fuel capacity of approximately 2544 U. S. gallons. The bomb bay auxiliary fuel cells have a total fuel capacity of approximately 1564 U. S. gallons. Hence, the total fuel storage capacity of the entire system is approximately 4108 U. S. gallons. Fuel capacity of individual fuel cells is indicated in Figure 14.

MAIN FUEL SUPPLY SYSTEM

Fuel Tanks

Refer to Figure 12. The twelve fuel cells installed in the wing are connected into four independent groups of three cells each by interconnector manifolds. Each group of three cells comprises a *tank*. Tank No. 1, which consists of fuel cells (17), (21), and (24), supplies fuel for operation of engine No. 1; tank No. 2 which consists of fuel cells (15), (19), and (22), supplies fuel for operation of engine No. 2; tank No. 3, which consists of fuel cells (3), (6), and (10), supplies fuel for operation of engine No. 3; tank No. 4, which consists of fuel cells (1), (4), and (8), supplies fuel for operation of engine No. 4.

Each of the four wing fuel *tanks* has a single filler neck, as illustrated on Figure 12. Each fuel cell manifold is fitted with a drain plug to allow drainage of condensed water at every preflight inspection.

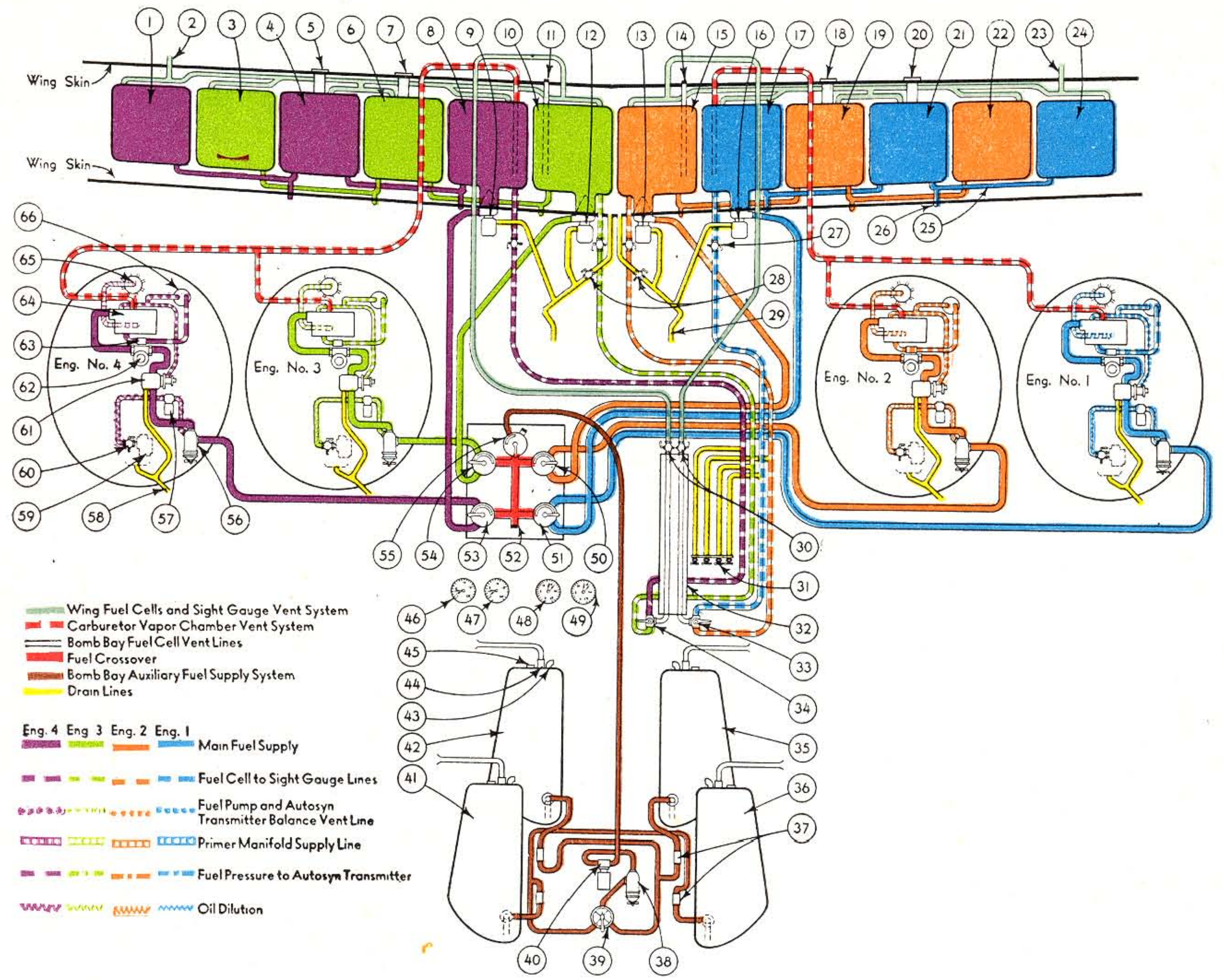
Fuel Cell Wing Compartment

The wing fuel cells are each contained in an individual compartment or *bay*, and are held in place by their fit in the compartment. When the fuel cell does not occupy the full fore and aft length of the compartment, plywood spacers can be installed at either end of the cell. Canvas curtains snap into place on the wing truss on each side of each fuel cell to prevent abrasion from damaging the cell.

Two wing compartment fuel drain lines (28), Figure 12, are provided to discharge overboard any fuel which leaks from fuel cells into wing compartment. The two drain lines connect to the lower surface of the wing forward of booster pumps (12) and (13), one drain on each side of the center line. The wing compartment drains are fitted with shutoff valves (26) which are normally safety wired *open*. The fuel booster pump gland drains are connected to the wing compartment drains. The drain lines discharge through the bottom of the bulkhead at station 5.0 on each side of the catwalk.

Fuel Flow—Wing Tanks to Carburetors

Each engine is supplied by an independent fuel system. Fuel from tank No. 4 flows through fuel booster pump (9) and selector valve (53), Figure 12, to engine No. 4. The fuel selector valve must be turned manually to the correct position for wing tank-to-engine fuel flow. In the nacelle, fuel passes through strainer (55), engine-driven fuel pump (61), and fuel flow transmitter (62) to carburetor (64). Fuel flows from tanks No. 1, 2, and 3 to engines No. 1, 2, and 3 respectively, in exactly the same



1. Wing Fuel Cell No. 6, Right
2. Vent System Air Intake
3. Wing Fuel Cell No. 5, Right
4. Wing Fuel Cell No. 4, Right
5. Fuel Filler Cap, System No. 4
6. Wing Fuel Cell No. 3, Right
7. Fuel Filler Cap, System No. 3
8. Wing Fuel Cell No. 2, Right
9. Fuel Booster Pump, System No. 4
10. Wing Fuel Cell No. 1, Right
11. Fuel Cell Outlet Plug
12. Fuel Booster Pump, System No. 3
13. Fuel Booster Pump, System No. 2
14. Fuel Cell Outlet Plug
15. Wing Fuel Cell No. 1, Left
16. Fuel Booster Pump, System No. 1
17. Wing Fuel Cell No. 2, Left
18. Fuel Filler Cap, System No. 2
19. Wing Fuel Cell No. 3, Left
20. Fuel Filler Cap, System No. 1
21. Wing Fuel Cell No. 4, Left
22. Wing Fuel Cell No. 5, Left
23. Vent System Air Intake
24. Wing Fuel Cell No. 6, Left
25. Fuel Cell Interconnector Manifold
26. Fuel Cell Manifold Drain
27. Fuel Sight Gauge Shut-off Valves
28. Wing Compartment Drain Valves
29. Wing Compartment and Booster Pump Drain
30. Sight Gauge Vent Line Shut-off Valves
31. Sight Gauge System Drain Manifold
32. Fuel Level Sight Gauge—Wing Fuel Tanks
33. Fuel Sight Gauge Selector Valve—Tanks No. 1 and No. 2
34. Fuel Sight Gauge Selector Valve—Tanks No. 3 and No. 4
35. Aft, Left Hand Bomb Bay Fuel Cell
36. Forward, Left Hand Bomb Bay Fuel Cell
37. Automatic Disconnect Couplings
38. Bomb Bay Fuel System Strainer
39. Bomb Bay Fuel System Selector Valve

Continued on page 57

Figure 12—Fuel System

The nacelle fuel system illustrated in figure 12 is factory installed on PB4Y-2 airplanes beginning with Bureau No. 59474. The nacelle fuel system for previous airplanes is illustrated in figure 13.

manner. The fuel flows from tank to carburetor through ¾" I.D. self-sealing, aromatic-resistant fuel hose.

Note: The fuel booster pumps should be turned *on* during take-off and climb, then turned *off* when cruising. They should be turned *on* again before landing, or for high altitude or forced operation conditions. The fuel booster pumps do not interfere with the free flow of fuel when turned off.

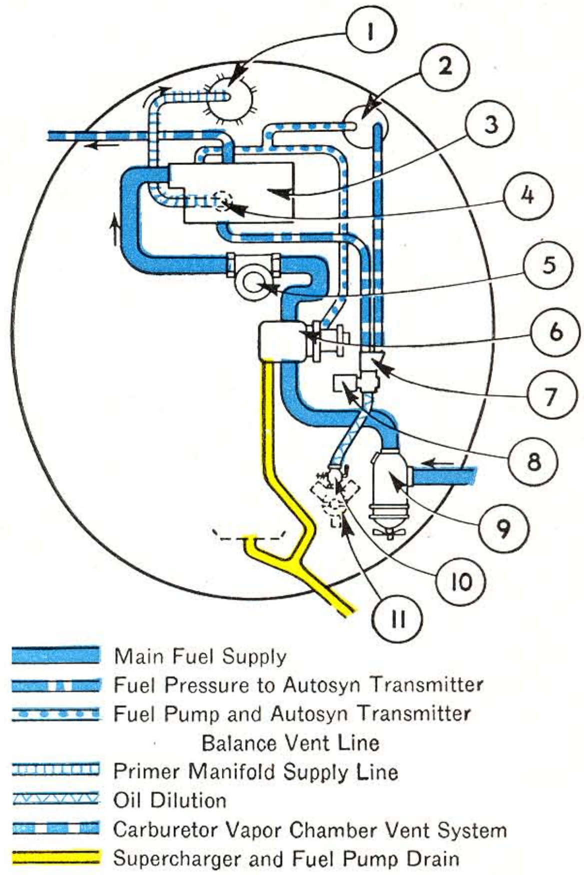
Fuel Level Sight Gauge System

The fuel level gauge (49) Figure 12, is mounted on the forward face of the bulkhead at station 4.1, as illustrated in Figure 15.

Wing tanks No. 1 and No. 2 are connected through aluminum alloy tubes to selector valve (7), Figure 15. Wing tanks No. 3 and No. 4 are connected to selector valve (6). Valves (2) and (3) connect through aluminum alloy tubes to the fuel cell vent system manifolds; valves (2) and (3) are normally safety wired open.

When the handle of selector valve (7), Figure 12, is turned so that it points vertically downward, fuel is admitted from tank No. 2 into gauge tube (4) until it finds a common level with the fuel in tank No. 2. The quantity of fuel is then determined by comparing the fuel level in the plastic tube with the calibration on the gauge mounting plate. When the handle of valve (7) is turned so that it points inboard, tank No. 2 is disconnected from gauge tube (4) and tank No. 1 is connected to the gauge tube.

Gauge tube (5), Figure 15, connects to tank No. 3 or tank No. 4, according to the handle position of



1. Engine Primer Manifold
2. Autosyn Fuel Pressure Transmitter
3. Carburetor
4. Primer Solenoid Valve
5. Autosyn Fuel Flow Transmitter
6. Engine-Driven Fuel Pump
7. Restricted Fitting
8. Oil Dilution Solenoid
9. Fuel Strainer
10. Oil Dilution Shutoff Valve
11. Y Oil Drain Valve

Figure 13—Fuel System in Nacelle for PB4Y-2 Airplanes up to Bureau No. 59473 inclusive

LEGEND FOR FIGURE 12—Continued

40. Bomb Bay Fuel System Pump
41. Forward, Right Hand Bomb Bay Fuel Cell
42. Aft, Right Hand Bomb Bay Fuel Cell
43. Fuel Level Gauge
44. Automatic Disconnect Couplings
45. Filler Cap
46. Fuel Flow Gauge—Eng. No. 3 and No. 4
47. Fuel Flow Gauge—Eng. No. 1 and No. 2
48. Fuel Pressure Gauge—Eng. No. 3 and No. 4
49. Fuel Pressure Gauge—Eng. No. 1 and No. 2
50. Fuel Selector Valve, Eng. No. 2
51. Fuel Selector Valve, Eng. No. 1
52. Fuel System Drain Plug
53. Fuel Selector Valve, Eng. No. 4
54. Fuel Selector Valve, Eng. No. 3
55. Bomb Bay Fuel Supply System Shut-off Valve
56. Fuel Strainer
57. Oil Dilution Solenoid Valve
58. Fuel Pump and Supercharger Drain
59. Oil Drain Valve
60. Oil Dilute Shut-off Valve
61. Engine-Driven Fuel Pump
62. Autosyn Fuel Flow Transmitter
63. Restricted Fitting
64. Carburetor
65. Engine Primer Manifold
66. Autosyn Fuel Pressure Transmitter

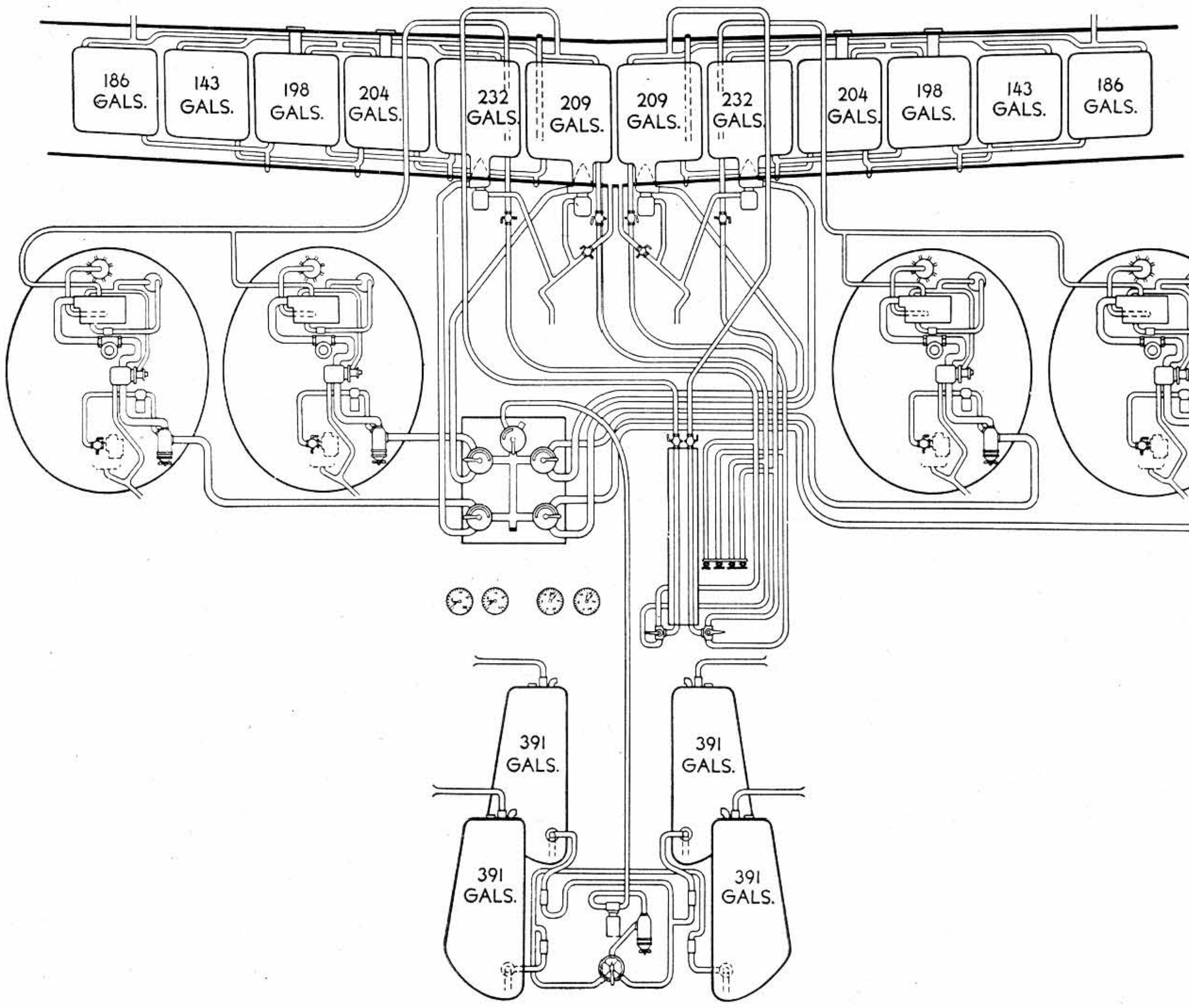


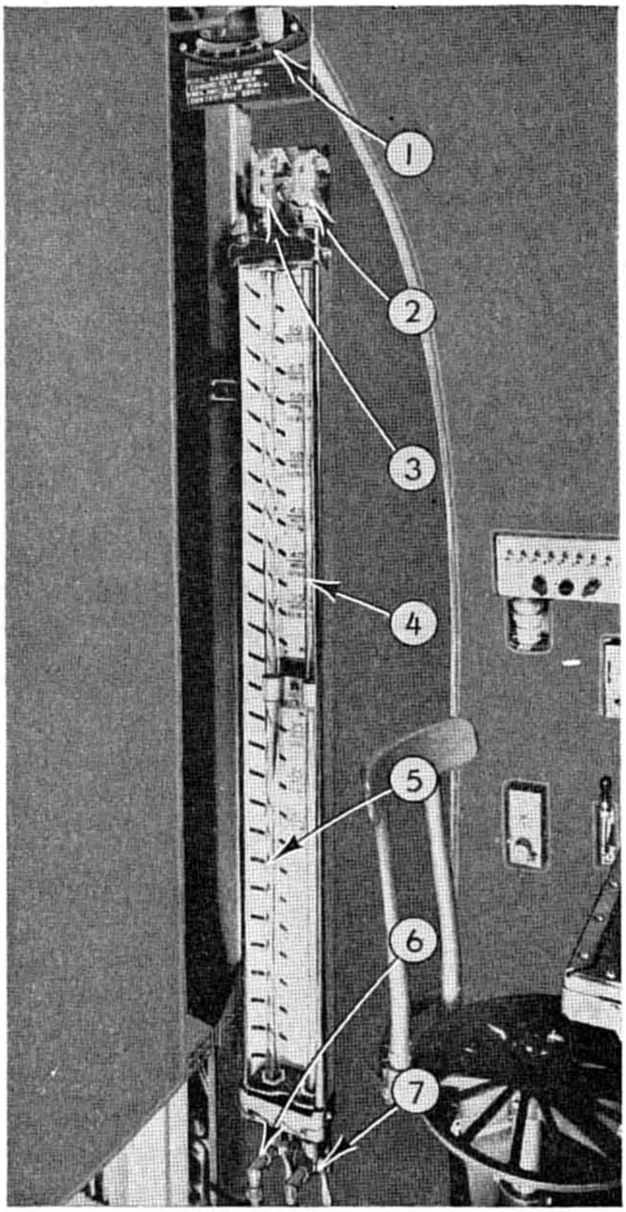
Figure 14—Fuel Storage Capacity

selector valve (6). When the valve handle points vertically downward, tank No. 3 is connected to the gauge tube. When the valve handle points inboard, tank No. 4 is connected to the gauge tube.

Note: The fuel level sight gauge reading is correct *only* when the inclinometer bubble is centered on zero. The inclinometer is mounted directly above the fuel level sight gauge, as illustrated in Figure 15.

The fuel sight gauge drain manifold (30), Figure 12, is illustrated photographically in Figure 16. Each of the four drain cocks is connected to one of the lines from wing tanks to sight gauge. At each preflight inspection the drain cocks should be opened to drain off condensed water.

Valves (27), Figure 12, are normally safety wired in open position. In the event of rupture in the fuel level sight gauge or the sight gauge supply lines, the valves must be closed to prevent loss of fuel.



1. Inclinometer
2. Vent System Valve—Tanks No. 1 and No. 2
3. Vent System Valve—Tanks No. 3 and No. 4
4. Gauge Tube—Tanks No. 1 and No. 2
5. Gauge Tube—Tanks No. 3 and No. 4
6. Selector Valve—Tanks No. 3 and No. 4
7. Selector Valve—Tanks No. 1 and No. 2

Figure 15—Fuel Level Sight Gauge

Wing Fuel Cells and Sight Gauge Vent System

There are two independent fuel cell and sight gauge ventilating systems, one for systems No. 1 and No. 2 and one for systems No. 3 and No. 4.

The six wing fuel cells on each side of the center line are interconnected by means of the ventilating system manifolds. The vent manifolds connect to the upper end of the fuel level sight gauge through valves (29), Figure 12.

Pressure in the vent system is always slightly in excess of atmospheric pressure so as to prevent the possibility of a partial vacuum in the cells. A partial vacuum would retard flow of fuel to the engines.

The vent (2), Figure 12, is illustrated in greater detail in Figure 17. The vent is designed in such a way as to maintain sufficient head pressure in the fuel cells, and to prevent loss of fuel through the vent systems when the airplane banks. Two vents are mounted on the upper surface of the wing, one on each side of the center line; each vent connects to an independent ventilating system.

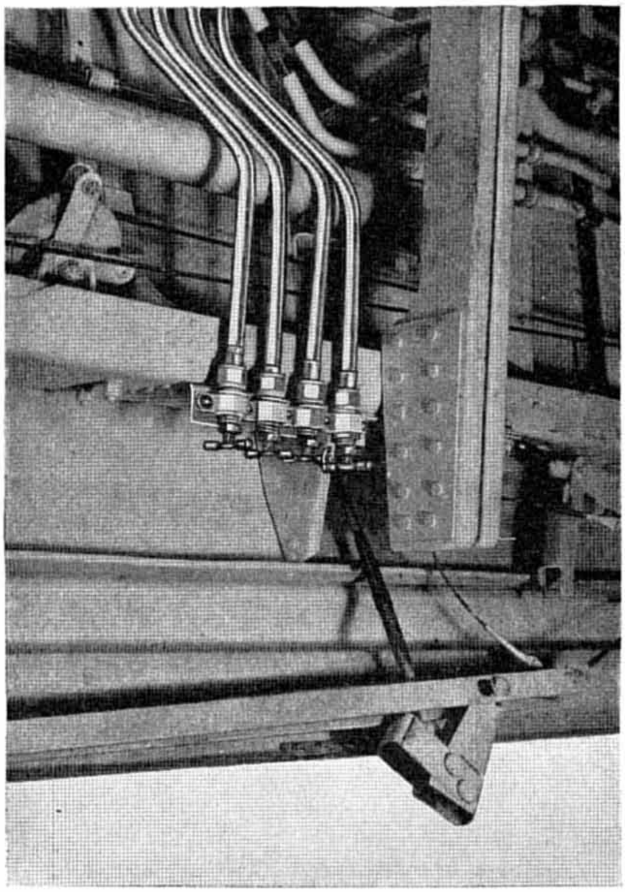
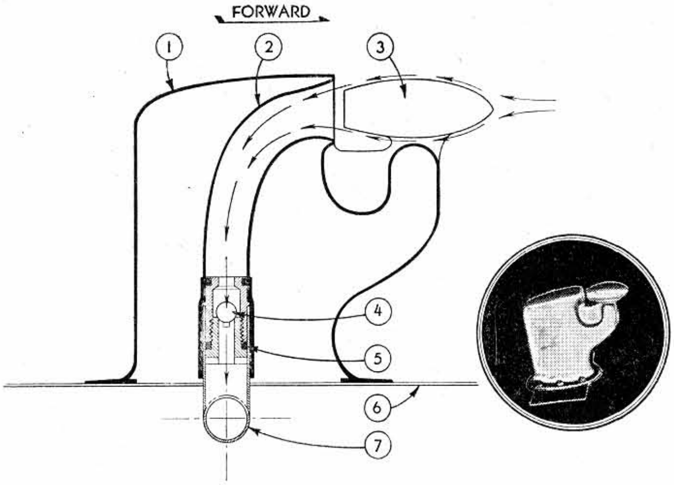


Figure 16—Fuel Level Sight Gauge Drain Manifold



1. Streamlined Housing
2. Vent Tube
3. Streamlined Bulb
4. Check Valve
5. Synthetic Packing Ring
6. Upper Wing Skin
7. Vent Manifold

Figure 17—Fuel Cell and Sight Gauge Vent

Each vent is mounted at a position free of turbulence, and with the vent opening facing into the air stream so as to maintain proper head pressure in the fuel cells. The vent tube (2), Figure 17, is encased in a streamlined housing (1). A streamlined bulb (3) is mounted on the housing directly in front of the vent opening; the bulb functions as an anti-icing device to prevent ice from closing the vent. Ball check valve (4), Figure 17, allows air to flow freely into the vent system manifold (7), but prevents fuel from flowing out of the vent manifold when the airplane maneuvers.

Carburetor Vapor Chamber Vent System

The vapor chambers of the carburetors on engines No. 1 and No. 2 are connected to fuel cell (17), Figure 12; the vapor chambers of the carburetors on engines No. 3 and No. 4 are connected to fuel cell (8).

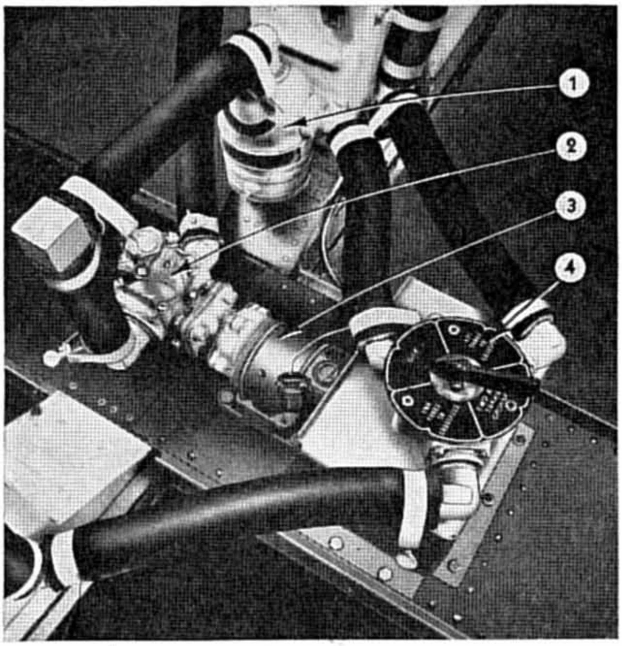
Vapor pressure in the carburetor vapor chamber depresses the fuel level in the chamber. This causes a float controlled needle valve to open, so that vapor and a small quantity of fuel passes into the vent line. Release of vapor pressure causes the needle valve to close. The needle valve alternately closes and opens in this manner when the engine is operating. The fuel lost from the carburetor vapor chamber is thus returned directly to the fuel cells

Fuel Flow and Fuel Pressure Indicating Systems

The Autosyn fuel flow transmitter (62), Figure 12, and the Autosyn fuel pressure transmitter (66) are connected electrically to Autosyn indicators on the copilot's instrument panel.

The Autosyn fuel flow transmitter (62), Figure 12, consists of measurement mechanism and Autosyn unit. Flow of fuel activates a vane mechanism, rotation of which, through a magnetic coupling, turns the rotor of the transmitter Autosyn. The Autosyn indicator on the instrument panel duplicates the motion and indicates fuel flow on a dial graduated in pounds per hour. There are two fuel flow indicating instruments, each a dual instrument with two indicating needles. Gauge (46), Figure 12, indicates fuel flow to engines No. 1 and No. 2; gauge (45) indicates fuel flow to engines No. 3 and No. 4.

The Autosyn fuel pressure transmitter (66), Figure 12, consists of a mechanical pressure gauge and an Autosyn. The pressure gauge is connected to the carburetor pressure chamber. Fuel pressure, introduced into a sealed chamber, deflects a sensitive diaphragm, attached by a linkage to a rocking shaft. The rocking shaft moves a sector and pinion which turns the rotor of the Autosyn. Wires from electrical receptacle are connected to the Autosyn indicator on the copilot's instrument panel, where motion of the transmitter Autosyn is duplicated and indicated on a dial graduated in pounds per square inch. There are two fuel pressure indicating instruments, each a dual instrument with two indicating needles. Gauge (48), Figure 12, indicates fuel pressure at engines No. 1 and No. 2; gauge (47) indicates fuel pressure at engines No. 3 and No. 4.



1. Fuel Strainer
2. Fuel Pump
3. Electric Motor
4. Fuel Selector Valve

Figure 18—Bomb Bay Fuel System Units

Restricted fitting (63), Figure 12, is installed in the pressure line to the Autosyn fuel pressure transmitter (66), to prevent fuel pressure surges from damaging the transmitter diaphragm.

Oil Dilution System

An oil dilution system is provided for starting cold engines. The oil dilute solenoid valve (56), Figure 12, is normally *closed*. When the oil dilute switch for a specific engine is closed, the fuel booster pump for that engine turns *on*, and the oil dilute solenoid valve *opens*, so that fuel flows from strainer (55) through the oil drain valve (59) into the engine oil system. Normally, shutoff cock (60) is safety wired in open position; however, under certain high temperature operating conditions, cock (60) must be safety wired in closed position to prevent inadvertent dilution of the engine oil.

BOMB BAY AUXILIARY FUEL SUPPLY SYSTEM

The bomb bay auxiliary fuel supply system consists of four fuel cells, fuel strainer, electrically driven pump, and selector valve. Strainer, pump, and selector valve are mounted on the catwalk at station 5.0, as illustrated in Figure 18.

The fuel cell filler caps and fuel level gauges are on top of each cell. Connected to the top of each cell is a vent line which leads outboard of the fuselage.

The fuel cells can be jettisoned if necessary. The fuel cell outlet couplings (36) and (38), Figure 12, and the vent line couplings (43) disconnect automatically when the cells are released.

FUEL TRANSFER — Bomb Bay Tanks to Wing Tanks

Fuel must be transferred from bomb bay fuel cells to wing tanks during flight to replenish burned fuel.

It is very important that the fuel level in each of the four wing tanks be checked periodically by using the fuel level sight gauge. It is inadvisable to allow the wing tank fuel level to fall too low before transferring fuel from bomb bay cells to wing tanks. The following procedure is recommended:

1. When the fuel level in each wing tank has dropped approximately 350 gallons from full,

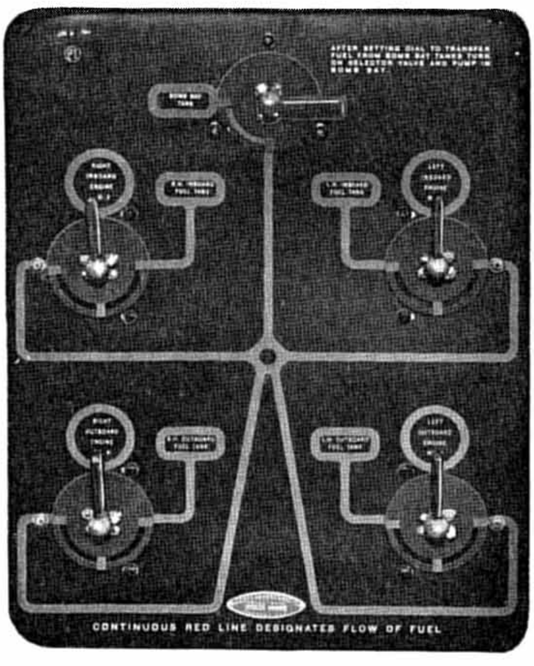


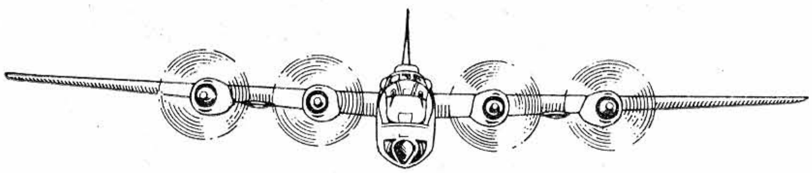
Figure 19—Main Selector Valves in Off Position

transfer approximately 250 gallons into each wing tank from the bomb bay fuel cells; the wing tanks should then be approximately 100 gallons from full. When the 250 gallons have been consumed, repeat the transfer operation.

2. Allow a few minutes for the fuel to flow through the manifolds and distribute itself properly in each tank before taking a final sight gauge reading on each tank; otherwise, the sight gauge reading might be inaccurate.

The red lines on the fuel selector valve panel should preclude the possibility of error in setting the selector valves. *Before* turning the bomb bay fuel pump on, be *certain* to properly set the selector valves on the selector valve panel, and also the bomb bay selector valve (4), Figure 18. To transfer fuel from both forward tanks only, set bomb bay selector valve (4), at FWD TANKS to CROSSFEED; to transfer fuel from aft tanks only, set the bomb bay selector valve at AFT TANKS to CROSSFEED; to transfer fuel from *all* bomb bay tanks at once, set the bomb bay selector valve at FWD AND AFT TANKS TO CROSSFEED.

Caution: When setting the selector valves on the selector valve panel for fuel transfer during flight, do *not* inadvertently turn any of the four wing-tank-to-engine-valves to the *off* position, illustrated in figure 19, or fuel flow from tank to engine will be shut off immediately.



CHAPTER VI

HYDRAULIC SYSTEM

HYDRAULIC SYSTEM POWER SUPPLY

Fluid under pressure, for operation of the PB4Y-2 hydraulic system, illustrated schematically in figure 20, is supplied through an *Open Center System* and an *Accumulator System*.

Open Center System

The open center system supplies fluid under pressure for normal operation of:

1. Bomb bay doors
2. Wing flaps
3. Landing gear
4. Accumulator system

The main feature of the open center system is that all three selector (or control) valves are connected to a common fluid supply and reservoir return line called the *open center line*. When the three selector valves are in neutral position, pressure ports are open to return ports, so that fluid circulates constantly from the reservoir through the engine-driven hydraulic pump and the open center line which connects the open center selector valves, then back to the reservoir.

Accumulator System

The accumulator system provides a supply of hydraulic fluid under constant, high pressure for operation of:

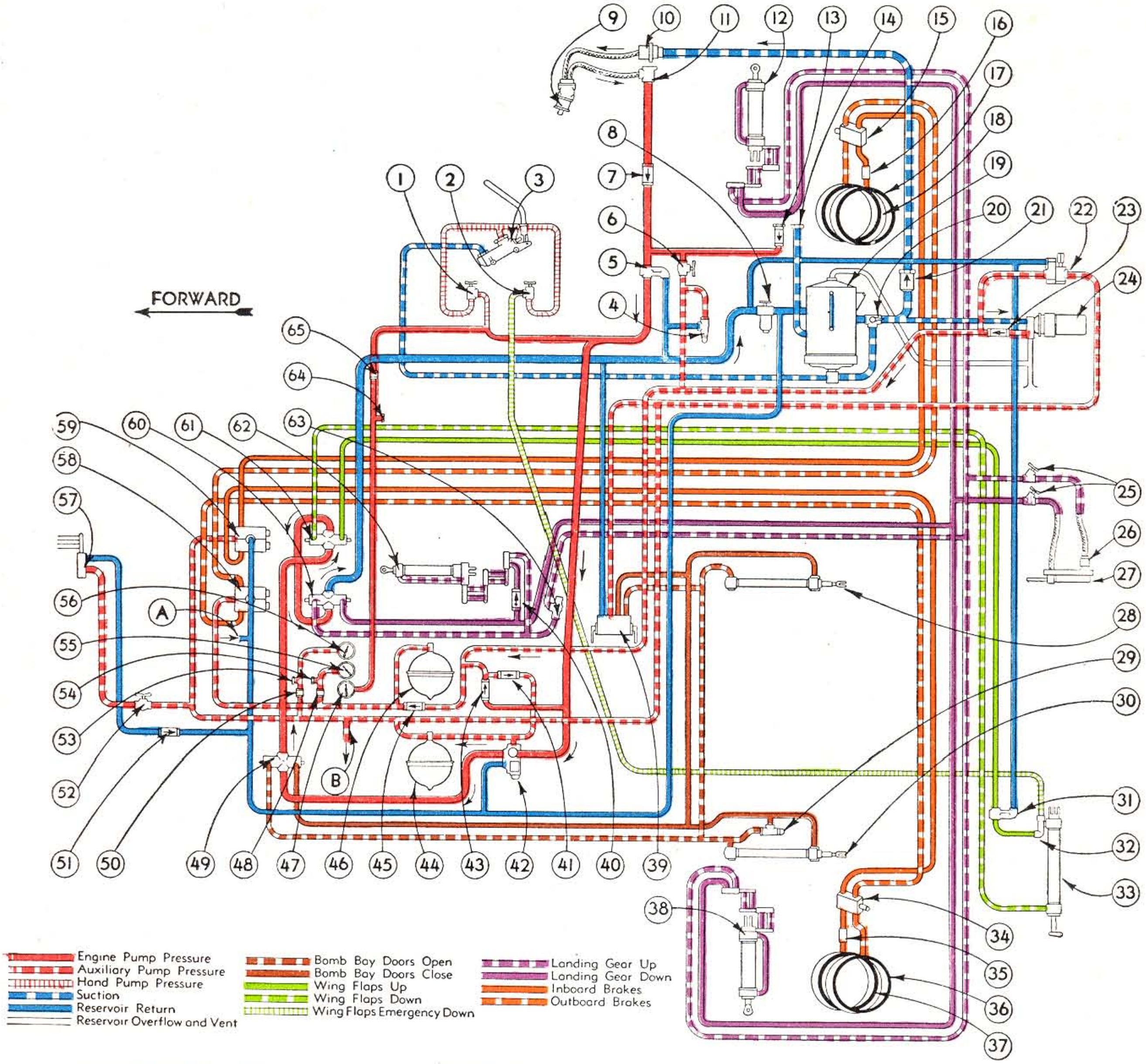
1. Brakes (Both accumulators)
2. Auxiliary or emergency operation of bomb bay doors (Lower accumulator only)
3. M.P.C. Nose Turret (Lower accumulator only)

Accumulators (44) and (46), Figure 20, can be charged with hydraulic fluid under pressure, in the following ways:

1. During normal flight (auxiliary electric pump (24) *off*), unloading valve (42) acts as an accumulator pressure regulator, diverting fluid from the open center line to both accumulators when pressure in lower accumulator (44) drops to 850 ± 50 p.s.i., and returning the full flow to the open center line when accumulator pressure rises to 1000 ± 50 p.s.i.
2. If the open center line back pressure, which builds up when the bomb bay doors, the wing flaps, or the landing gear are operated through an open center selector valve, exceeds the pressure in either or both accumulators, accumulator pressure will rise with open center line pressure, independent of unloading valve (42). If open center line pressure exceeds the fluid pressure in lower accumulator (44), fluid flows from the open center line through check valves (43) and (41) into the lower accumulator until lower accumulator pressure equals open center line pressure; likewise, fluid flows from open center line through check valves (43) and (45) into upper accumulator (46), when open center line pressure exceeds upper accumulator pressure.
3. When auxiliary electric pump (24), Figure 20, is turned *on*, and emergency crossover valve (6) remains closed, the auxiliary electric pump supplements the engine-driven pump (9) by taking over the charging of the accumulators, maintaining accumulator pressure between the limits 970 ± 50 and 1140^{+30}_{-10} p.s.i., while the engine-driven pump supplies fluid to the open center selecter valves only. This is made possible by the relative pressure adjustments of unloading valve (42) and pressure switch (22).

Engine-Driven Hydraulic Pump

A seven-piston pump (9), Figure 20, mounted on the accessory drive section of No. 3 engine, pro-



A. Sperry Auto-Pilot Reservoir Return
B. Sperry Auto-Pilot Pressure Supply
1. Emergency Pump Valve
2. Emergency Flap Valve
3. Emergency Hand Pump
4. Auxiliary Pump Relief Valve
5. Engine Pump Relief Valve
6. Emergency Crossover Valve
7. Engine Pump Check Valve
8. Filter
9. Engine-Driven Pump
10. Seal Coupling
11. Seal Coupling
12. Main Landing Gear Actuating Cylinder—Right Side
13. Test Connection Check Valve
14. Suction Test Connection
15. Brake Bleeder Valve—Right Side
16. Brake Disconnect Coupling—Right Side
17. Inboard Brake Expander Tube—Right Side
18. Outboard Brake Expander Tube—Right Side
19. Fluid Reservoir
20. Emergency Reservoir Valve
21. Suction Check Valve
22. Pressure Switch
23. Auxiliary Pump Check Valve
24. Auxiliary Electric Pump
25. Tail Bumper Shutoff Valves
26. Tail Bumper Restrictor
27. Tail Bumper Cylinder
28. Bomb Bay Door Actuating Cylinder—Right Side
29. Bomb Bay Door Relief Valve
30. Bomb Bay Door Actuating Cylinder—Left Side
31. Wing Flap Relief Valve
32. Shuttle Valve
33. Wing Flap Actuating Cylinder
34. Brake Bleeder Valve—Left Side
35. Brake Disconnect Coupling—Left Side
36. Outboard Brake Expander Tube—Left Side
37. Inboard Brake Expander Tube—Left Side
38. Main Landing Gear Actuating Cylinder—Left Side
39. Bomb Bay Door Utility and Emergency Control Valve
40. Nose Landing Gear Restrictor Valve
41. Lower Accumulator Check Valve
42. Unloading Valve
43. Auxiliary Pressure System Check Valve
44. Lower Accumulator
45. Upper Accumulator Check Valve (Spring Removed)
46. Upper Accumulator
47. Hydraulic System Pressure Gauge
48. Pressure Gauge Surge Restrictor
49. Bomb Bay Door Selector Valve
50. Pressure Gauge Surge Restrictor
51. Nose Turret Check Valve
52. Nose Turret Shutoff Valve
53. Gauge Test Fitting
54. Gauge Test Fitting
55. Outboard Brakes Pressure Gauge
56. Inboard Brakes Pressure Gauge
57. Nose Turret Swivel
58. Outboard Brakes Control Valve
59. Inboard Brakes Control Valve
60. Landing Gear Selector Valve
61. Wing Flap Selector Valve
62. Nose Landing Gear Actuating Cylinder
63. Main Landing Gear Restrictor Valve
64. Gauge Test Fitting
65. Pressure Gauge Surge Restrictor

Figure 20—PB4Y-2 Hydraulic System

vides the hydraulic system main power supply. During normal operation the engine-driven pump circulates fluid through the open center system, and charges the accumulators through unloading valve (42).

Auxiliary Electric Pump

The auxiliary electric pump (24), Figure 20, has a normal load of 95 to 98 amperes. It is turned *on* or *off* by two switches in series. One switch, located at station 4.1, is manually operated; the other is an automatic pressure regulating switch (20), Figure 20.

The auxiliary electric pump has two functions:

1. Accumulator charging function—The auxiliary electric pump should be turned *on* before take-off and before landing, and *off* during flight. When the pump is turned *on*, while the emergency crossover valve (6) remains closed, the auxiliary electric pump supplements the engine-driven pump by taking over the charging of the accumulators, maintaining accumulator pressure between the limits 970 ± 50 and 1140^{+30}_{-10} p.s.i., while the engine-driven pump supplies fluid to the open center selector valves only. This is made possible by the relative pressure adjustments of unloading valve (42) and pressure switch (22).
2. Emergency function—In the event of failure of engine-driven pump (9), Figure 20, or of engine No. 3, on which the pump is mounted, the auxiliary electric pump can be connected to the open center pressure line by *opening* emergency crossover valve (6). When thus connected, the auxiliary electric pump replaces the engine-driven pump, and supplies fluid for operation of the entire hydraulic system; under these conditions pressure switch (22) remains in the *on* position, and unloading valve (42) controls the charging of the accumulators.

Emergency Hand Pump

Hand pump (3), Figure 20, provides an emergency method of suppling hydraulic fluid for operation of the hydraulic system in the event of failure of both the engine-driven pump and the auxiliary electric pump.

Note: Do not operate the hand pump too fast. It has single action suction, and double acting discharge. That is, on both forward and back strokes fluid is discharged, but fluid is drawn into the pump only on the rearward stroke. If the rearward stroke is too fast, there is insufficient time for the pump to fill with liquid. For best results use an even, steady back stroke and a quick forward stroke.

Fluid for hand pump operation is drawn through the hand pump suction outlet at the bottom of reservoir (19), Figure 20. Two valves, (1) and (2), control the direction of fluid flow from the hand pump; normally valve (1) is wired in open position, while valve (2) is wired in closed position. Fluid flow from the hand pump is controlled in the following manner:

1. With valve (1) open and valve (2) closed, fluid flows from the hand pump through valve (1) to the open center line for operation of the entire hydraulic system.
2. With valve (1) closed and valve (2) open, fluid flows from the hand pump through valve (2) directly to wing flap actuating cyclinder (32) for emergency lowering of wing flaps.

Note: Wing flaps can be lowered either directly through valve (2), or through valve (1) and the open center system by using wing flap selector valve (61). Under emergency conditions pumping fluid through the open center system to the wing flap cylinder with the hand pump may be too slow, therefore the direct routing of fluid from the hand pump through valve (2) to the wing flap cylinder is provided.

EMERGENCY VALVES

Emergency Crossover Valve

Emergency Crossover Valve (6), Figure 20, located at station 4.2, right side, *must be closed* during normal operation of the hydraulic system. However, in the event of failure of engine-driven pump (9), or of engine No. 3 on which the pump is mounted, turn on the auxiliary electric pump and *open* the emergency crossover valve to allow fluid under pressure from the auxiliary electric pump to flow into the open center pressure line.

Emergency Flap Valve

Emergency flap valve (2), Figure 20, located on the right side of the fuselage, adjacent to the hand pump, connects the hand pump to a direct line to the shuttle valve, which is mounted on the inboard end of the wing flap cylinder, for emergency lowering of the wing flaps. Normally, the emergency flap valve is secured in the *closed* position by safety wire. The valve should be opened *only* for emergency lowering of wing flaps.

Emergency Pump Valve

Emergency pump valve (1) Figure 20, located on the right side of the fuselage, adjacent to the hand pump, connects the hand pump to the open center pressure line for emergency operation of the entire hydraulic system. Normally, the emergency pump valve is secured in the *open* position by safety wire. The emergency pump valve should be closed *only* when the emergency flap valve has been opened for emergency lowering of wing flaps.

Emergency Reservoir Valve

Emergency reservoir valve (20) Figure 20, located aft of the reservoir, directs the flow of fluid from the bottom and center reservoir suction outlets. The valve is a simple plug valve with three ports. For normal operation, the valve handle must be horizontal so that all three valve ports are open, and fluid can flow from both the center and the bottom reservoir outlets. When the valve handle is in the vertical or emergency position, only two of the valve ports are open, so that only the bottom reservoir suction outlet is open to the main suction line, while the center reservoir suction outlet is closed.

Warning: Do not move the handle of emergency reservoir valve (20) to vertical position for suction from the lower half of the reservoir unless the system has been checked for leaks. Normally, loss of fluid will be the only reason for shifting to lower half of reservoir. Therefore, the source of fluid loss must be checked or the reserve supply will be wasted through the same outlet.

OPERATING PRESSURES

There are three hydraulic pressure gauges, mounted on the pilot's instrument panel.

Hydraulic System Pressure Gauge

Hydraulic system pressure gauge (47), Figure 20, indicates fluid pressure in the open center pressure line. With the engine-driven pump in operation, accumulators charged, and none of the open center selector valves in operating position, the hydraulic pressure indicated on the gauge varies from 25 to 75 p.s.i. When accumulators are charging through the unloading valve, gauge (47) will indicate the same pressure as brake pressure gauges (55) and (56), i.e., up to 1000 ± 50 p.s.i. The bomb bay door, wing flap, and landing gear operating pressures are indicated on gauge (47). The highest pressure attained is the landing gear selector valve relief (or kickout) pressure, 1100^{+0}_{-50} p.s.i.

Inboard Brakes Pressure Gauge

Inboard brakes pressure gauge (56), Figure 20, indicates fluid pressure in lower accumulator (44). Accumulator pressure can vary from 850 ± 50 to 1000 ± 25 p.s.i. when the accumulator is charged by the engine-driven pump through the unloading valve, or by the auxiliary electric pump through the emergency crossover valve and the unloading valve. When the emergency crossover valve is closed and the auxiliary electric pump is turned on, accumulator pressure can vary from 970 ± 50 to 1140^{+30}_{-10} p.s.i.

Outboard Brakes Pressure Gauge

Outboard brakes pressure gauge (55), Figure 20, indicates fluid pressure in upper accumulator (46). Operating pressures are the same as for the lower accumulator (inboard brakes pressure gauge).

Pressure Settings

Engine pump relief valve	1250 p.s.i.
Auxiliary electric pump relief valve	1250 p.s.i.
Bomb bay doors *open* relief valve	700 p.s.i.
Wing flaps *down* relief valve	500 p.s.i.

Auxiliary electric pump pressure switch	970 ± 50 to 1140^{+30}_{-10} p.s.i.
Accumulator unloading valve	850 ± 50 to 1000 ± 50 p.s.i.

Selector valve relief (or kickout) pressures:

Landing gear:	Gear *up*	1100^{+0}_{-50} p.s.i.
	Gear *down*	850 ± 25 p.s.i.
Wing flaps:	Flap *up*	750 ± 25 p.s.i.
	Flap *down*	470 ± 5 p.s.i.
Bomb bay doors:	Doors *open*	600 ± 25 p.s.i.
	Doors *close*	1000 ± 25 p.s.i.

HYDRAULIC FLUID

Fluid Specification: AN-VVO-366b

Reservoir Fluid Capacity: 6.8 gallons from bottom of reservoir to center suction outlet, plus 3 gallons from center suction outlet to filler neck.

BOMB BAY DOORS HYDRAULIC CONTROL

The bomb bay doors can be actuated through three independent hydraulic controls:

1. Bomb bay door selector valve (49), Figure 20, in bombardier's compartment.
2. Utility control valve under flight deck, forward of station 4.0.
3. Emergency bomb release handle on aft side of pedestal.

Controls 2 and 3 are independent, but are incorporated in one valve called the bomb bay door emergency and utility control valve (39).

Normal Hydraulic Operation of Bomb Bay Doors

Bomb bay door selector valve (49) is operated by the bombardier through a control lever. When the control lever is placed in either *doors open* or *doors* close position, the selector valve piston remains in position and directs fluid from the open center line to the bomb bay door actuating cylinders. Fluid which returns from the actuating cylinders flows through the selector valve into the open center line, and returns to the reservoir. When the door actuating pistons reach the end of their strokes, fluid pressure in the line and the selector valve immediately builds up because the fluid is incompressible. The selector valve is designed and adjusted so that the selector valve piston *kicks out* (automatically returns to neutral) when bomb bay door operating pressure builds up to 600 ± 25 p.s.i. at the end of the *doors open* operation, and to 1000 ± 25 p.s.i. at the end of the *doors close* operation. When the selector valve piston returns to neutral, fluid flowing in the open center line passes through the valve and returns to the reservoir.

The two ends of cylinder (30), Figure 20, are interconnected through bomb bay doors relief valve (29). Relief valve (29) discharges fluid from the *doors open* line to the *doors close* line if fluid pressure in the *doors open* line exceeds 700 p.s.i.

Utility and Emergency Operation of Bomb Bay Doors—General

The bomb bay door utility and emergency valve (39) Figure 20, is located just forward of the bomb bay bulkhead at station 4.0.

The utility operation lever, located on the aft side of the bomb bay door utility and emergency valve, can be moved inboard to close the bomb bay doors, or outboard to open the doors.

The emergency operation lever, located on the *forward* side of the bomb bay door utility and emergency valve, is connected by cable to the emergency bomb release system. The emergency operation lever can be moved *only* in the outboard direction to *open* the bomb bay doors. A stop prevents the lever from moving inboard.

Utility Operation of Bomb Bay Doors

A control rod is connected to the *utility operating lever* on the aft side of the bomb bay door utility and emergency valve. Two handles on the control rod provide a convenient method for operating the valve either from inside or from outside the airplane. One handle is located inside the airplane adjacent to the valve. The other handle can be reached from outside through a hand hole provided with a locking cover. A spring returns the control rod and the valve operating lever to neutral when the handle is released. To open the bomb bay doors, the control rod must be moved outboard and held until the doors are fully open. To close the bomb bay doors, the control rod must be moved inboard and held until the doors are fully closed.

Emergency Bomb Release System

The bomb bay doors can be opened and the entire bomb load jettisoned *unarmed* by pulling the emergency bomb release handle located on the pilot's control pedestal.

For best results operate the emergency bomb release system as follows: Pull the emergency bomb release handle approximately four inches, then wait until the bomb bay doors are fully open. After the bomb bay doors are fully open, pull the handle all the way out to jettison the bombs.

Bomb Bay Door Position Indicators

When the bomb bay doors are fully open, the following lamps are illuminated:

1. Two lamps (right hand doors and left hand doors) on the bombardier's control panel.
2. Two lamps (right hand doors and left hand doors) on the pilot's instrument panel.

WING FLAP HYDRAULIC CONTROL

The flaps can be operated hydraulically in three ways:

1. Normal Operation—To lower and retract the wing flaps, fluid is forced through wing flap selector valve (61), Figure 20, to wing flap actuating cylinder (33) by the engine-driven pump, or by the auxiliary electric pump in case of failure of the engine pump.
2. Emergency Lowering—To lower the wing flaps, fluid is pumped by hand pump (3), Figure 20, directly to the wing flap actuating cylinder through flap emergency valve (2) and shuttle valve (32).
3. Supplementary Emergency Lowering Method —Fluid can be pumped through emergency pump valve (1), Figure 20, by the hand pump into the open center system and through wing flap selector valve (61) to raise or lower the flaps. This method is very slow if the accumulator pressure charge is low; therefore, it is not recommended as an emergency method for lowering the wing flaps unless damage to the system has rendered method 2 inoperative.

Normal Hydraulic Operation of Wing Flaps

Wing flap selector valve (61), Figure 20, is located forward of the pilot's control pedestal and is operated by a lever on the right side of the pedestal. When the control lever is placed in either the *flap up* position or the *flap down* position, the selector valve piston remains in position and directs fluid from the open center line to the top or the bottom of the actuating piston in the wing flap cylinder (33). Fluid which returns from the cylinder flows through selector valve (61) into the open center line, and returns to the reservoir.

When the actuating piston in the flap cylinder reaches the end of its stroke, fluid pressure in the line and the selector valve immediately builds up because there is no further fluid flow and the fluid is incompressible. The selector valve is designed and adjusted so that the selector valve piston *kicks out* and returns to neutral when wing flap operating pressure builds up to 470 ± 5 p.s.i. at the end of the *flap down* operation, and to 750 ± 25 p.s.i. at the end of the *flap up* operation. When the selector valve piston returns to neutral, fluid flowing in the open center line passes through the valve and returns to the reservoir.

When the wing flaps are in down position, air pressure due to excessive flying speed tends to force the wing flaps upward toward the retracted position. The force is transmitted through the wing flap cable system to the actuating piston, causing hydraulic pressure to build up in the *flap down* line. If fluid pressure in the *flap down* line exceeds 500 p.s.i. relief valve (31) will open, allowing fluid to discharge into the reservoir return line, and the flaps will *creep* up. The relief valve is a safety device only and should not be tested in flight, as the excessive pressure required for the operation might damage the wing flap mechanism. Wing flaps should not be lowered if air speed exceeds 155 m.p.h.

Emergency Lowering of Wing Flaps

In the event of failure of the open center system, the wing flaps can be lowered through operation of hand pump (3) Figure 20. Emergency lowering of wing flaps is effected as follows:

Refer to Figure 20.

1. Place wing flap selector valve (61) in the *flap down* position.
2. Close valve (1) and open valve (2).
3. Operate hand pump (3) to lower the wing flaps. Observe the flap position indicator. When the wing flaps are fully lowered, the hand pump *must lock*, indicating that the wing flaps are locked down hydraulically. If the wing flaps are not locked down hydraulically, air impact pressure will cause them to *creep* upward. If the hand pump does not lock when the wing flaps are fully lowered, do not continue to pump until the wing flap emergency lowering line has been investigated for leaks.
4. When wing flaps are fully extended, return the wing flap selector valve control handle to neutral position.

Wing Flap Position Indicator

The wing flap position indicator on the pilot's instrument panel indicates the angular position of the wing flaps from fully retracted position (0°) to fully lowered positon (40°).

LANDING GEAR AND TAIL BUMPER HYDRAULIC CONTROL

Each of the landing gear units is operated by a hydraulic actuating cylinder. The nose landing gear cylinder is extended fully when the nose gear is down. The main landing gear cylinders are compressed fully when the main gear is down. The tail bumper cylinder is compressed fully when the tail bumper is down in landing position.

The landing gear selector valve (60), Figure 20, is located forward of the pilot's control pedestal and is operated by a lever on the port side of the pedestal. When placed in either the *gear up* or *gear down* position, the selector valve remains in position and directs fluid from the hydraulic open center line to the main landing gear, nose landing gear, and tail bumper actuating cylinders. Fluid which returns from the actuating cylinders flows through the landing gear selector valve into the hydraulic open center line and returns to the fluid reservoir. When *all* the landing gear and tail bumper actuating pistons have reached the end of their strokes, fluid flow is stopped and fluid pressure in the lines immediately builds up because hydraulic fluid is incompressible. The landing gear selector valve is designed and adjusted to that when fluid pressure reaches 850 ± 25 p.s.i. at the completion of *gear down* operation, or when it reaches 1100^{+0}_{-50} p.s.i. at the completion of *gear up* operation, the selector valve piston automatically *kicks out* and returns to neutral. When the selector valve piston returnes to neutral, fluid flowing in the open center line passes through the valve and returns to the reservoir.

Sequence of Operation

The sequence of operation when *retracting* the landing gear is as follows: The nose gear retracts first, followed by the main gear, then by the tail bumper.

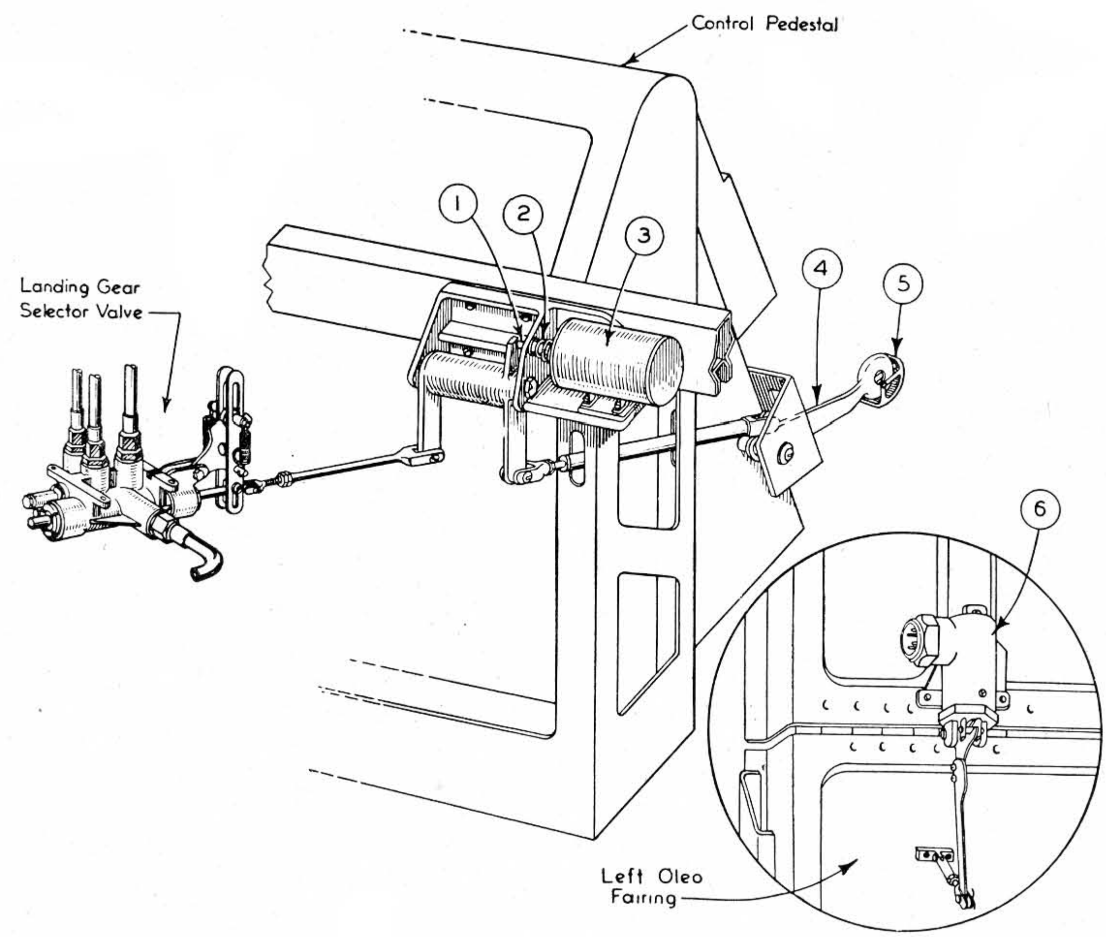
The sequence of operation when *lowering* the landing gear is as follows: The main landing gear and nose landing gear sometimes lower and lock simultaneously while sometimes the nose gear lowers first, followed by the main gear. This will depend on the adjustment of the main landing gear uplatches. The tail bumper lowers into landing position only after main and nose wheels are locked down.

The nose gear *retracts* first because main landing gear restrictor valve (63) Figure 20, is installed in the *gear up* hydraulic pressure aft of the point where the nose gear hydraulic line connects to the landing gear hydraulic lines. The primary function of the main landing gear restrictor is to insure approximately simultaneous retraction of the main landing wheels. Main landing gear restrictor valve (63) restricts the flow of hydraulic fluid during *gear up* operation until fluid pressure builds up to 800 p.s.i., a pressure sufficient to fully retract the nose gear before the restrictor valve opens fully. Approximately simultaneous retraction of the main landing wheels is thus assured because no part of the fluid flow is diverted to the nose gear actuating cylinder while the main landing wheels are retracting. During *gear down* operation the main landing gear restrictor valve opens to allow returning fluid to flow without restriction from the actuating cylinders back to the selector valve.

Tail Bumper

The tail bumper mechanism is designed so that the hydraulic pressure required to fully retract or lower the mechanism is in excesss of the pressure required to fully retract or lower the nose landing gear and the main landing gear. Therefore, the tail bumper is last in both lowering and retracting sequence. Since the nose and main landing gear actuating pistons have reached the end of their strokes before the tail bumper mechanism operates, the full flow of fluid is diverted to tail bumper cylinder (27), Figure 20. To prevent excessively violent lowering or retraction of the tail bumper mechanism, tail bumper restrictor (26), is installed. The restrictor is a modified banjo fitting, a 1/16" hole is drilled through one wall of the hollow banjo fitting swivel bolt.

In case of failure of the tail bumper hydraulic lines, tail bumper shutoff valves (25), Figure 20, must be closed to prevent loss of hydraulic fluid. Normally, the shutoff valves must be *open.*



1. Safety Latch
2. Spring
3. Solenoid
4. Selector Valve Operating Lever
5. Push Button
6. Safety Switch

Figure 21—Landing Gear Safety Lock System

Main Landing Gear Safety Lock System

The landing gear safety lock system is illustrated in Figure 21. Movement of landing gear selector valve operating lever (4) into the *gear up* position is restrained by a solenoid operated latch (1) which is controlled by two switches in series. One switch is a push button (5) on the selector valve operating lever; the other switch (6), located on the left main landing gear oleo fairing, closes *only* when the oleo strut extends.

When the electrical circuit is open, spring (2) holds the solenoid operated safety switch (1) in the engaged position to prevent forward movement of lever (4) to the *gear up* position. When the electrical circuit is closed by extension of the oleo strut and by pressing button (5), solenoid (3) retracts safety latch (1) so that lever (4) can be moved forward to the *gear up* position.

Since switch (6), Figure 21, closes *only* when the oleo strut extends, it is *impossible* to move lever (4) into the *gear up* position and thus *raise* the landing gear while the oleo struts are supporting the airplane. The oleo struts extend only when the airplane is placed on wing jacks, or when the airplane leaves the ground in flight. The selector valve operating lever can be moved aft to the *gear down* position without restraint. The solenoid operated safety latch (1), restrains lever (4) from the *gear up* position only.

If the electrical circuit fails in flight and solenoid latch (1), Figure 21, fails to release, release the latch with a screw driver or other suitable tool, working from the left side of the pilot's pedestal. The solenoid latch operates easily if the landing gear selector valve operating lever is in neutral position.

Main and Nose Landing Gear Downlatch Indicator

The main and nose landing gear downlatch indicator lamp is on the pilot's instrument panel. The green lamp is illuminated only when all three landing gear units are down and latched; hence, the lamp must be illuminated before the airplane lands.

HYDRAULIC POWER BRAKES

The hydraulic brake system consists of two complete and independent brake systems, so that failure of one system will not cause complete brake failure.

Each brake control valve consists of two independent brake control units; each brake control unit operates a single brake expander tube.

There are two independent brake assemblies at each of the main landing wheels. Each of the four brake assemblies on the airplane is connected to an independent brake control unit on one of the brake control valves.

The *inboard* brake assembly at *both* of the main landing wheels is controlled by brake control valve (59), Figure 20. Hydraulic fluid under pressure, for operation of inboard brakes, is supplied by upper accumulator (46). The upper accumulator maintains a constant fluid pressure on brake valve (59).

The *outboard* brake assembly at *both* of the main landing wheels is controlled by brake control valve (58), Figure 20. Hydraulic fluid under presssure, for operation of outboard brakes, is supplied by lower accumulator (44). The lower accumulator maintains a constant pressure on brake valve (58).

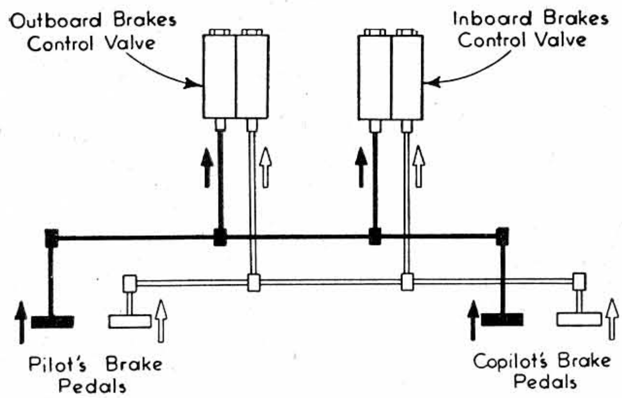


Figure 22—Schematic Diagram of Brake Pedal Linkage

The brake control valves are mechanically interconnected, as illustrated schematically in Figure 22. When either the pilot's or the copilot's right brake pedal is depressed, both the inboard and outboard brake assemblies at the right side main landing wheel are actuated. Likewise, when either the pilot's or the copilot's left brake pedal is depressed, both the inboard and outboard brake assemblies at the left side main landing wheel are actuated.

Brake operating pressure is directly proportional to the distance the brake pedals are depressed.

Two hydraulic pressure gauges are mounted on the pilot's instrument panel to indicate the hydraulic pressure available in the accumulators for operation of the inboard and outboard brake systems. Inboard brakes pressure gauge (56), Figure 20, indicates fluid pressure in the lower accumulator. Outboard brakes pressure gauge (55), indicates fluid pressure in the upper accumulator. Pressure gauge surge restrictors (48) and (50) prevent damage to the brake pressure gauges by damping pressure surges. Each surge restrictor is a simple union with an .028″ diameter hole.

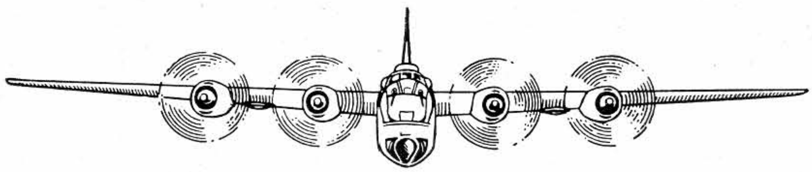
Parking Brake

To set the parking brake:

1. Depress both brake pedals all the way.
2. While holding the brake pedals depressed, raise the parking brake lever which is located on the lower, rear corner of the pilot's pedestal; raising the lever causes engagement of a locking cam which locks the brake valve operating levers in position.
3. Still holding the parking brake lever up, release the brake pedals. Then release the parking brake levers.

To release the parking brake:

1. Depress the brake pedals all the way, and push downward gently on the parking brake lever. Often the parking brake lever will fall as soon as force is applied to the brake pedals.



CHAPTER VII
POWER PLANT

THE Pratt & Whitney Twin Wasp R-1830-94 is a fourteen cylinder, radial, twin row, air-cooled engine illustrated in Figure 23. Features of the engine are as follows:

1. Increased mechanical strength to permit operation at the increased power ratings.
2. Revised valve timing to enable using higher r.p.m. and power.
3. Increased cooling area on the cylinder heads and barrels. The aluminum muff type of cylinder barrel finning replaces the former integral steel fins. The increased cooling area is especially valuable at high altitudes.
4. The blower and intermediate rear sections provide increased supercharging capacity and improved distribution. The supercharger is the single stage, two-speed type with an 11.3 in. impeller driven by two dual oil-operated cone clutches. Fuel is injected at the face of the impeller through a discharge nozzle and spinner mounted on the impeller shaft.
5. The R-1830-94 engine incorporates automatic two position spark advance. At very low engine speeds or at small throttle openings, the magnetos are timed to fire the appropriate spark plug at 25° in advance of the top center. At somewhat higher power, the control mechanism shifts the spark timing to 32° advance (cruising advance), providing improved fuel economy for cruising. At 400 to 500 b.h.p. the control mechanism shifts back to the normal 25° advance position which is used at all greater powers. Similar spark advance changes occur with decreasing powers, although the actual shift points will occur at slightly lower powers than with increasing powers.

Carburetor and Mixture Control

The R-1830-94 engine is equipped with the Bendix PD-12F7 injection carburetor. Four positions of the pilot's mixture control lever are provided: full rich, automatic rich, automatic lean, and idle cut-off. The carburetor is illustrated in Figure 24.

Full rich position of the mixture control is used only when the automatic mixture control unit has ceased to function or is believed to be faulty.

Automatic rich position is used *at all other times* except when cruising at low power output. At such times *Automatic lean* is used.

When the mixture control is placed in the *Idle cut-off* position, fuel flow to the engine ceases. This provides a positive means by which the engine can be stopped even though overheated at the time. Also, personnel injury is not so apt to occur if the propeller is accidentally turned with the switch in the *on* position.

The accelerating pump is mounted on the intermediate rear crankcase, and is connected with the supercharger entrance passage. The pump is operated by momentary changes in air pressure in this passage. Therefore, when the engine is not running, fuel is not pumped from the carburetor or accelerating pump by moving the throttle.

Supercharger Operation

To aid in the prevention of sludge accumulation and to check the operation of the two-speed blower mechanism, shift the blower ratio selector valve in accordance with the following procedure prior to each flight and before stopping the engine after long flights. *This is important.*

After the oil inlet temperature has reached at least 40° C. increase the engine speed to 1200 or 1400 r.p.m. with the propeller control in the take-off position, or sufficiently high speed to obtain more than the 40 p.s.i. minimum oil pressures required

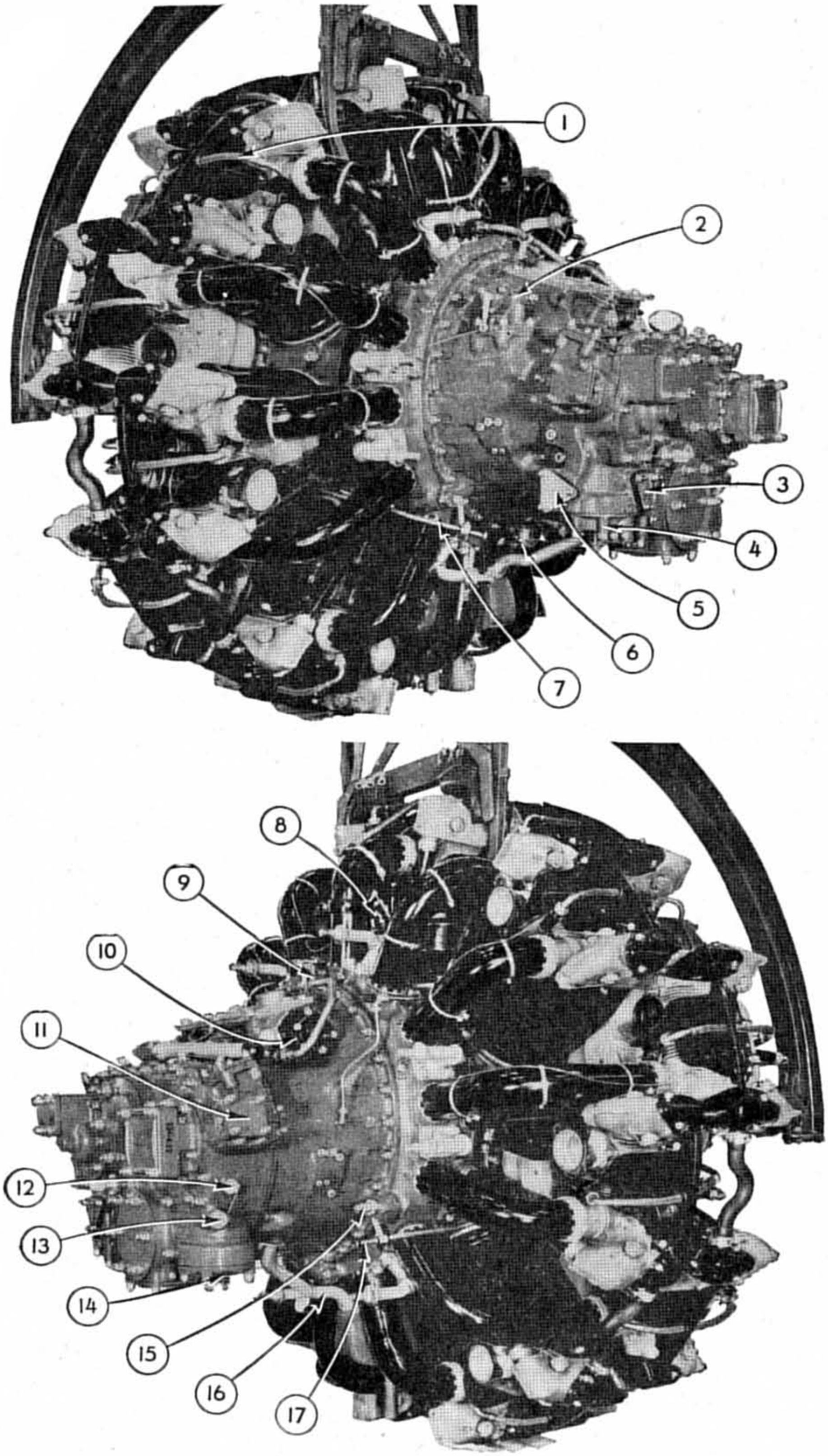
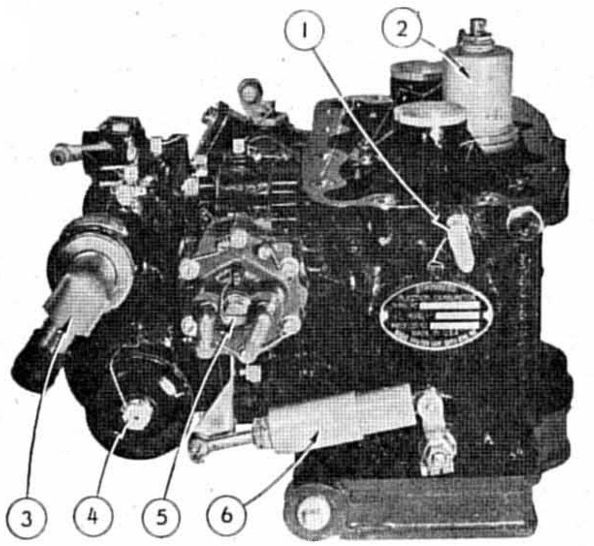


Figure 23—Right and Left Rear Views P & W R1830-94 Engine



1. Fuel Pump and Fuel Pressure Transmitter Balance Vent Connection
2. Automatic Mixture Control Unit
3. Fuel Supply from Fuel Pump
4. Finger Strainer
5. Automatic Spark Advance Control Unit
6. Throttle Balance

Figure 24—Right Side of Carburetor

for clutch operation and shift the blower ratio selector valve to the *high* position by moving the blower selector switch on the right hand side of the pilot's pedestal. A momentary drop in oil pressure should accompany the shift. Open the throttle to obtain about 2300 r.p.m., lock the throttle, and immediately shift back to *low* blower ratio. Blower shifts should be made without hesitation or dwelling between the control stops to avoid dragging or slipping the clutches. A drop in manifold pressure should accompany the shift from *high* to *low* blower and the manifold pressure gauge should be watched for this indication when the shift is made. The drop in pressure is a positive indication that the control system is functioning properly, and this check is important to prevent inadvertent take-off in *high* blower ratio. As soon as the check for change in manifold pressure has been made, reduce the engine speed to 1000 r.p.m. or less. If the shift did not appear to be satisfactory, operate the engine at 1000 r.p.m. or less for two minutes to permit heat generated during the shift to dissipate from the clutches, then repeat the shifting procedure. Prolonged fluctuation or loss of manifold pressure when shifting from low blower ratio to high blower ratio would indicate improper high clutch engagement, in which case the blower ratio selector control should be returned to the low position and the shift repeated as just described. Make sure that the blower ratio selector valve control is in the *low* position when ground tests have been completed.

During long range cruising flights, when using either low or high blower ratio, the blower clutches should be shifted every *two* or *three hours* to prevent excessive sludge accumulation. At least two shifts, each of about two minutes' duration, should be made. It should normally be unnecessary to change throttle or propeller control positions when making the clutch shifts.

Oil System

The R-1830-94 engine is of the dry sump type. For this reason each of the four engines is provided with an oil supply system as illustrated in Figure 25.

The oil is carried in a hopper type reservoir located in the aft center of each nacelle. Oil flows out of the sump on the bottom of the reservoir through a Y drain valve fitting and lines to the engine inlet.

Return oil passes through an oil temperature regulator and cooler to the top of the hopper inside the reservoir.

An oil temperature resistance bulb is installed in the Y drain valve. The resistance bulb is connected electrically to the oil temperature gauge on the copilot's instrument panel.

LEGEND FOR FIGURE 23

1. Spark Plug Leads
2. Blower Clutch Ratio Selector Valve
3. Oil Outlet
4. Rear Oil Pump
5. Oil Inlet
6. Supercharger Automatic Drain Valve
7. Left Hand Magneto Vent Intake
8. Engine Primer Manifold
9. Magneto Vent Suction Line
10. Accelerating Pump
11. Hydraulic Pump Mounting Pad (Pump Mounted on Engine No. 3 Only)
12. Oil Inlet Thermometer Connection (Not Used on PB4Y-2 Airplane)
13. Oil Strainer By-Pass Valve
14. Oil Strainer
15. Oil Pressure Transmitter Connection
16. Main Sump Vent Pipe
17. R.H. Magneto Vent Intake

Oil Dilution

Oil dilution is accomplished by operating an electrically controlled solenoid which allows fuel under engine driven or booster pump pressure to enter the oil system at the Y drain valve. Whenever a cold start is anticipated, oil should be diluted before shutting down, on the preceding run. This can be accomplished by operating the oil dilution switches located on the copilot's instrument panel.

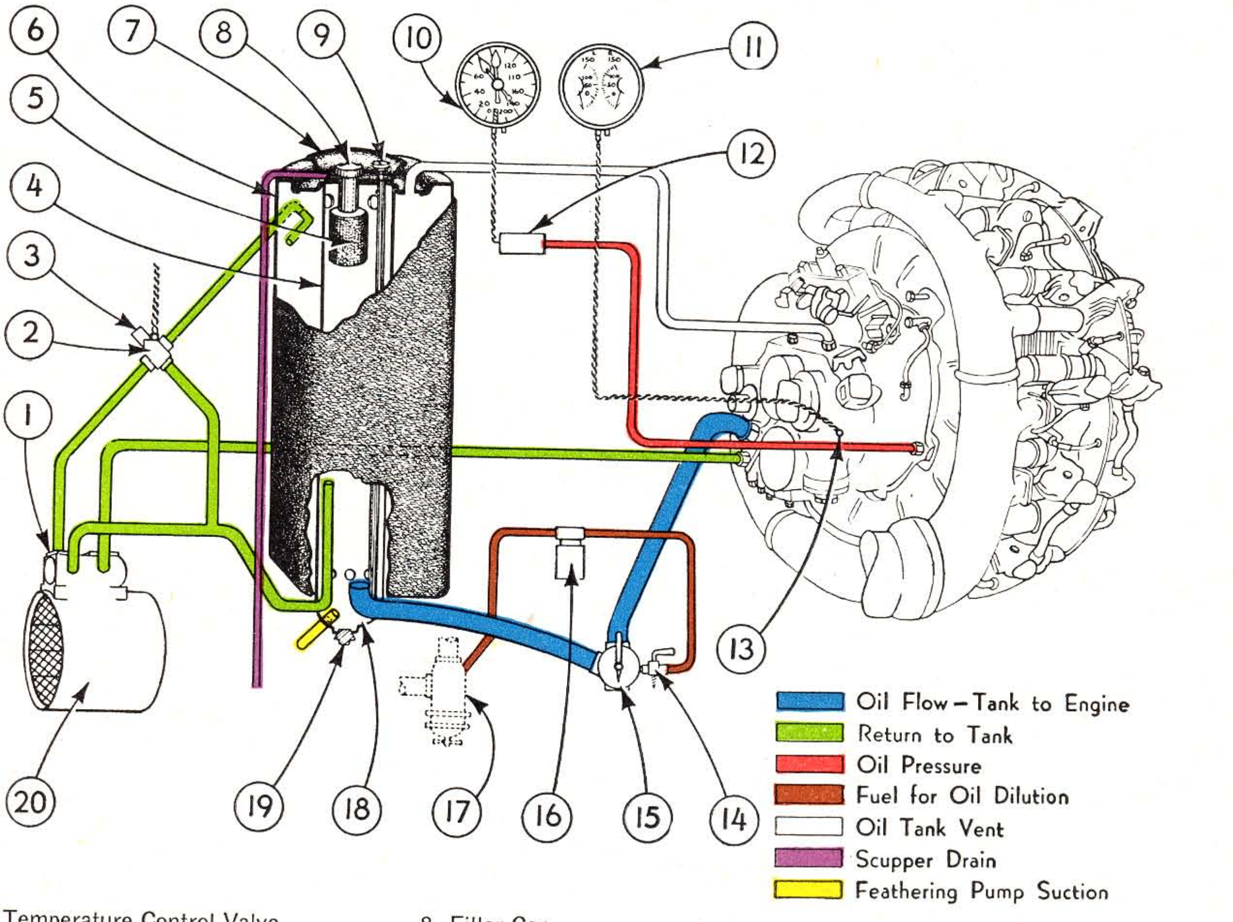
In the event the engine fuel pump is not operating and the fuel booster pump is not energized by its own circuit, a supply of fluid is assured by the oil dilute circuit energizing the fuel booster pump.

Dilute oil according to the following instructions:

1. Operate engine at 1000 to 1200 r.p.m.
2. Dilute each engine separately.
3. Maintain oil temperature below 50° C. (122° F.) and oil pressure above 15 p.s.i. (shut down engine to allow oil to cool to 40° C. (104° F.) and restart, if necessary, to maintain oil pressure).
4. Dilute engine oil as follows for ground temperatures shown:

   4° to −12° C. (40° to 10° F.)—Depress dilution switch for two minutes.

   −12° to −29° C. (10° to −20° F.)—Depress dilution switch for four minutes.



1. Oil Temperature Control Valve
2. Oil Diverter Valve
3. Oil Diverter Valve Control Solenoid
4. Accelerating Well
5. Oil Strainer
6. Self-Sealing Oil Cell
7. Scupper
8. Filler Cap
9. Sounding Rod
10. Oil Pressure Indicator
11. Oil Temperature Indicator
12. Autosyn Oil Pressure Transmitter
13. Oil Temperature Bulb
14. Oil Dilution Shutoff Valve
15. Oil Drain Valve
16. Oil Dilution Solenoid Valve
17. Fuel Strainer
18. Sump
19. Plug
20. Oil Cooler

Figure 25—PB4Y-2 Oil Supply System

−29° to −46° C. (−20° to −50° F.)—Depress dilution switch for six minutes.
Depress dilution switch 1 minute for each additional 5° C. (9° F.) when ground temperatures are below −46° C. (−50° F.).

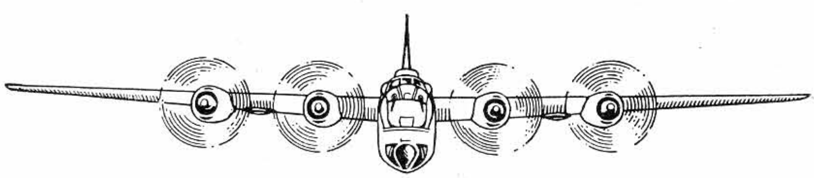
5. During the last two minutes of the dilution period depress propeller feathering switch until drop of 400 r.p.m. is observed. Pull out switch and allow r.p.m. to return to normal. Repeat this operation three times.

Note: Continue to hold oil dilution switch *on* until propellers cease rotating after mixture control has been placed in *idle cut-off*.

PILOT'S CHECK CHART

R-1830-94; Single Stage, Two-Speed Supercharger

Operating Condition	BHP	RPM	Altitude Feet	Critical Altitude	Manifold Pressure In. Hg	Blower Ratio	Mixture Control	Oil Pres. Limits P.S.I.	Oil Temp. Limits C	Max. Cyl. Head Temp. C	Cowl Flaps	Approx. Fuel Cons U.S. Gals. per Hr.
Take-off......	1350	2800	....	....	51	Low	Auto Rich	85-100	40-85	260	Part Open	180
Military Power (5 Min.)	1350 1100	2800	0-10, 500 10,500 up	4500 13,500	49 43.5	Low High	Auto Rich	85-100	40-85	260	As Req'd.	180 155
Rated Power..	1100 1000	2600	0-11,000 11,000 up	7700 14,400	40 39.5	Low High	Auto Rich	85-100	60-85	260	As Req'd.	135 130
Climb Desired. (75% power)	825 750	2350	....	....	....	Low High	Auto Rich	85-100	60-85	232	Part Open	82 76
Cruising Maximum	735 675	2250	....	....	....	Low High	Auto Lean	65-95	60-75	232	Closed	56 55
Cruising—Maximum B.M.E.P.	650 450	1900 1300	....	....	....	Low Low	Auto Lean	50 Min.	60-75	(204 or less desired)	Closed	48 32

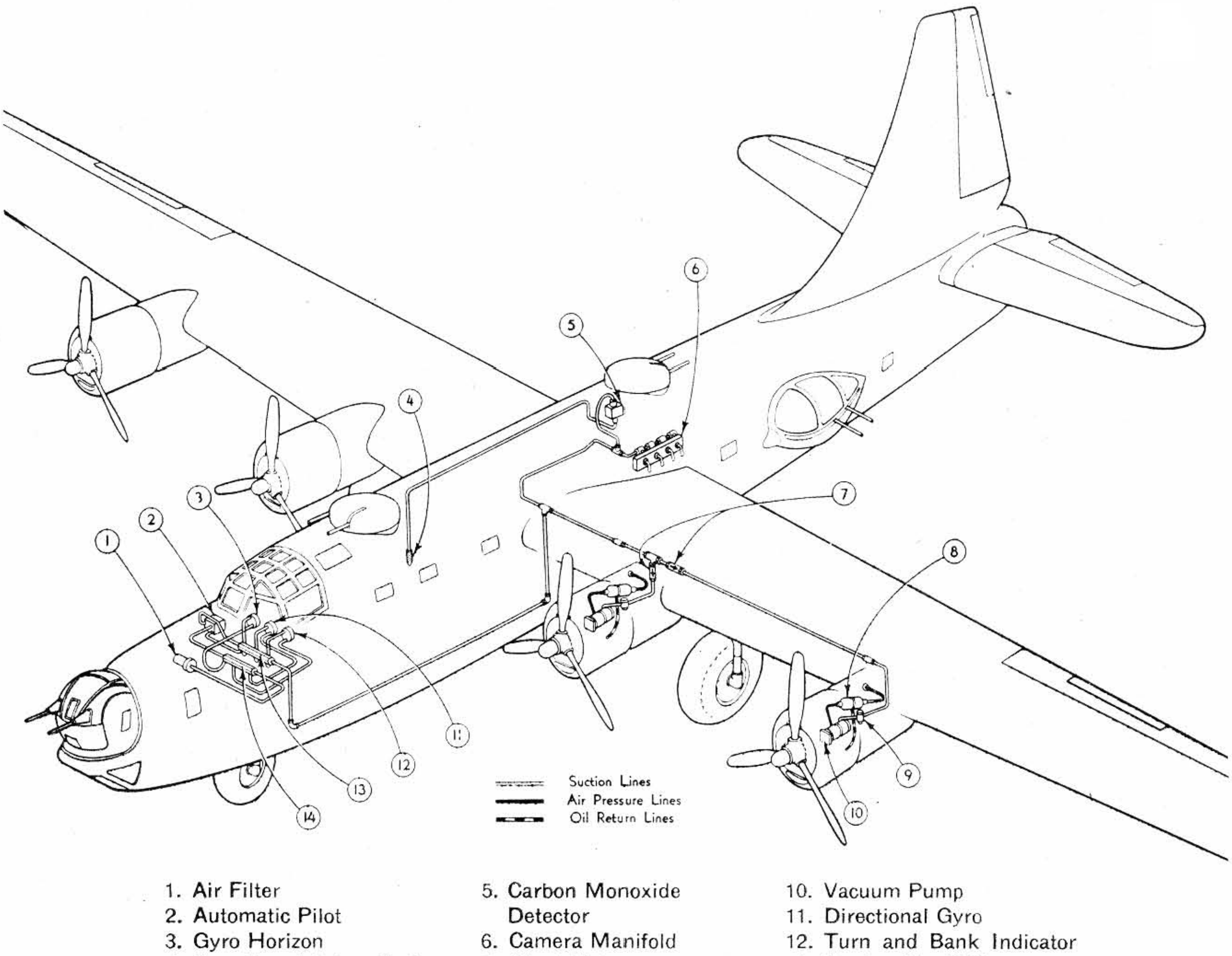


CHAPTER VIII
VACUUM SYSTEM

VACUUM is furnished by two pumps, one mounted on engine No. 1 and the other on engine No. 2. Both pumps are in operation at the same time as there is no selector valve. Because of check valves inserted in the lines, failure of one pump does not affect operation of the system. Vacuum pressure can be checked by observing the gauge in the automatic pilot; 4.0″—4.2″ mercury is satisfactory.

These pumps furnish vacuum to operate the gyro instruments, CO detector, and the camera manifold.

The complete vacuum system is illustrated in Figure 32.



1. Air Filter
2. Automatic Pilot
3. Gyro Horizon
4. Sampling Intake—Carbon Monoxide Detector
5. Carbon Monoxide Detector
6. Camera Manifold
7. Check Valves
8. Oil Separator
9. Suction Relief Valve
10. Vacuum Pump
11. Directional Gyro
12. Turn and Bank Indicator
13. Suction Manifold
14. Distributor Manifold

Figure 26—PB4Y-2 Vacuum System

APPENDIX

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GENERAL SPECIFICATIONS

Airplane General Dimensions and Clearances

Fuselage Maximum Height	10′ 6 29/64″
Fuselage Maximum Width	7′ 5 13/32″
Overall Span	110′
Overall Length (with Motor Products nose turret)	74′ 8 1/4″
Overall Length (with Erco nose turret at 13° angle)	74′ 7″
Overall Height	29′ 1 5/8″
Clearance, Fuselage to Ground	1′ 8″
Clearance, Inboard Propeller Tip to Ground	3′ 1″
Clearance, Outboard Propeller Tip to Ground	3′ 6″
True Diameter of Propeller	11′ 7″

Wings

Root Chord	14′
Mean Aerodynamic, Inches	123.7

Wing Flaps

Wing Flap Type	Fowler
Movement of Flaps (Maximum Down)	40°
Movement of Flaps (Up)	0°
Wing Flap Control	Hydraulic, with position indicator
Wing Flap Span	27′ 9 1/2″

Ailerons

Aileron Span	20′ 6 7/8″
Aileron Movement (Down)	17 1/2°
Aileron Movement (Up)	22 1/2°
Aileron Control Wheel Movement (Right)	135°
Aileron Control Wheel Movement (Left)	135°
Aileron Tab Movement (Up)	10°
Aileron Tab Movement (Down)	10°
Aileron Tab Control Movement	1/4 turn for 1° movement

Vertical Stabilizer

Vertical Stabilizer Height	18′ 1 1/2″
Wing Leading Edge to Rudder Hinge Line	39′ 7 35/64″

Rudder

Rudder Height	12′ 6″
Rudder Movement (Right)	18°
Rudder Movement (Left)	18°
Rudder Pedal Travel (Forward)	3 ½″
Rudder Pedal Travel (Aft)	3 ½″
Rudder Tab Movement (Right)	8°
Rudder Tab Movement (Left)	8°

Horizontal Stabilizer

Horizontal Stabilizer Span	34′ 6″
Wing Leading Edge to Elevator Hinge Line	40′ 9 ⅛″

Elevator

Elevator Span	14′ 6 ½″
Elevator Movement (Up)	30°
Elevator Movement (Down)	20°
Elevator Control Movement (Forward)	7 ⅛″
Elevator Control Movement (Aft)	10 ⅞″
Elevator Tab Movement (Up)	3°
Elevator Tab Movement (Down)	3°
Elevator Tab Control Movement	½ turn for 1° movement

Landing Gear

Tread	25′ 7 ½″
Wheel Base	23′ 0″
Main Landing Gear Tire Size	56″
Nose Landing Gear Tire Size	36″

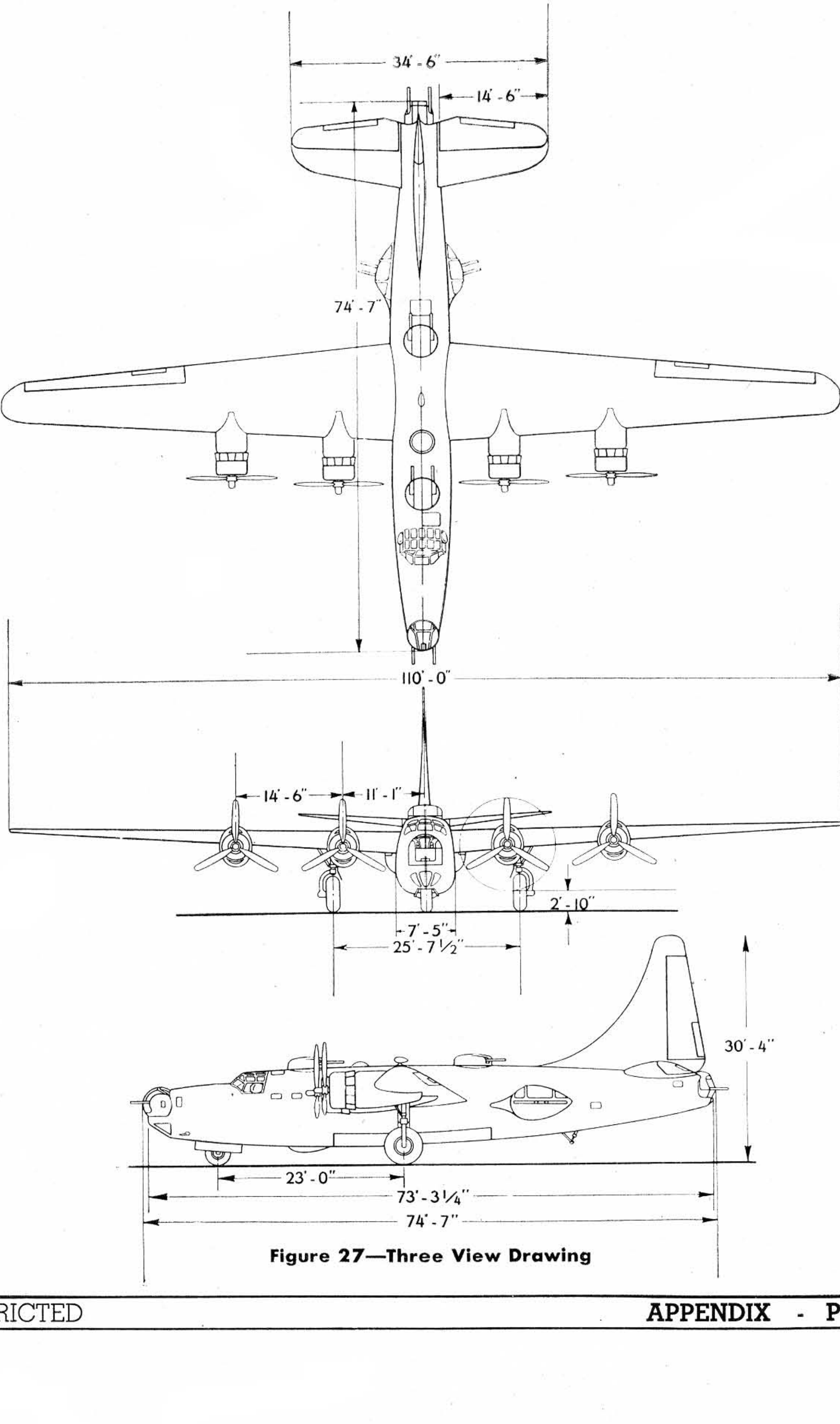


Figure 27—Three View Drawing

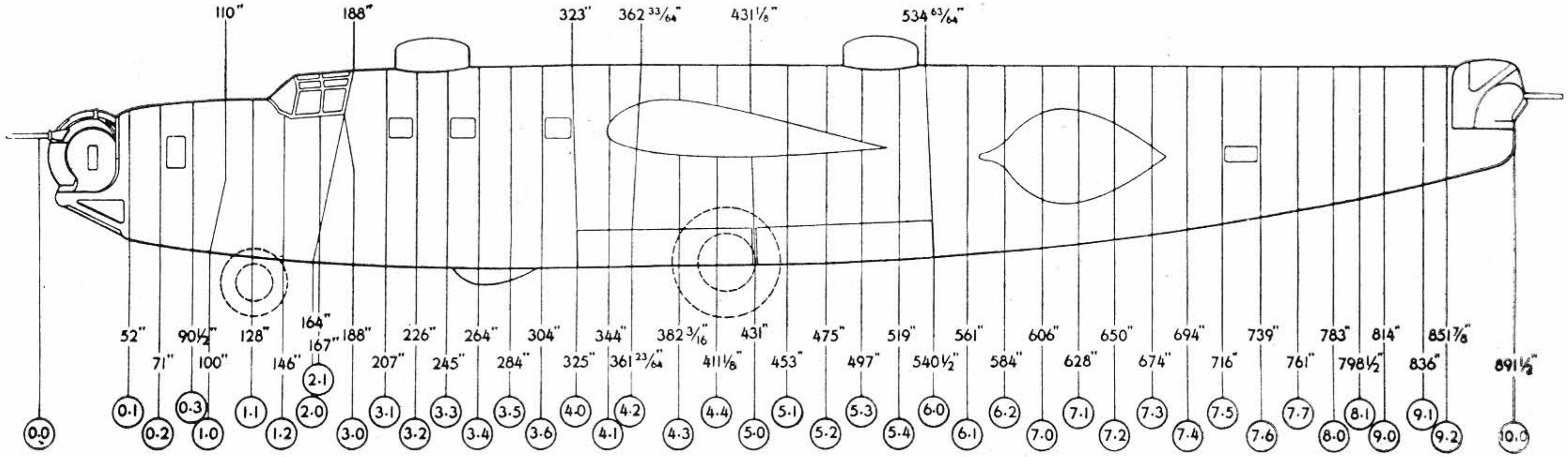


Figure 28—PB4Y-2 Fuselage Station Diagram

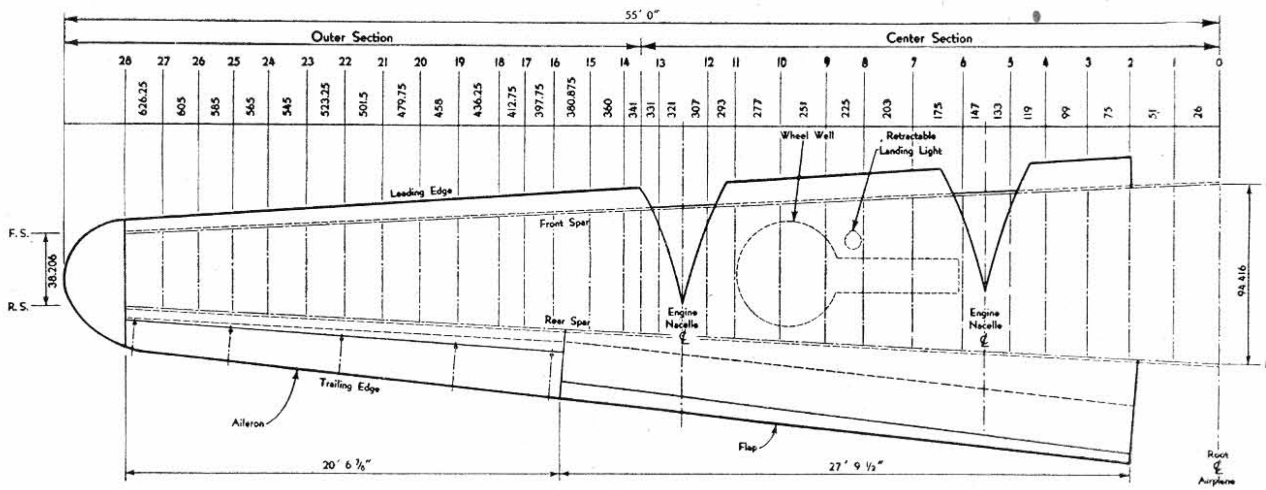
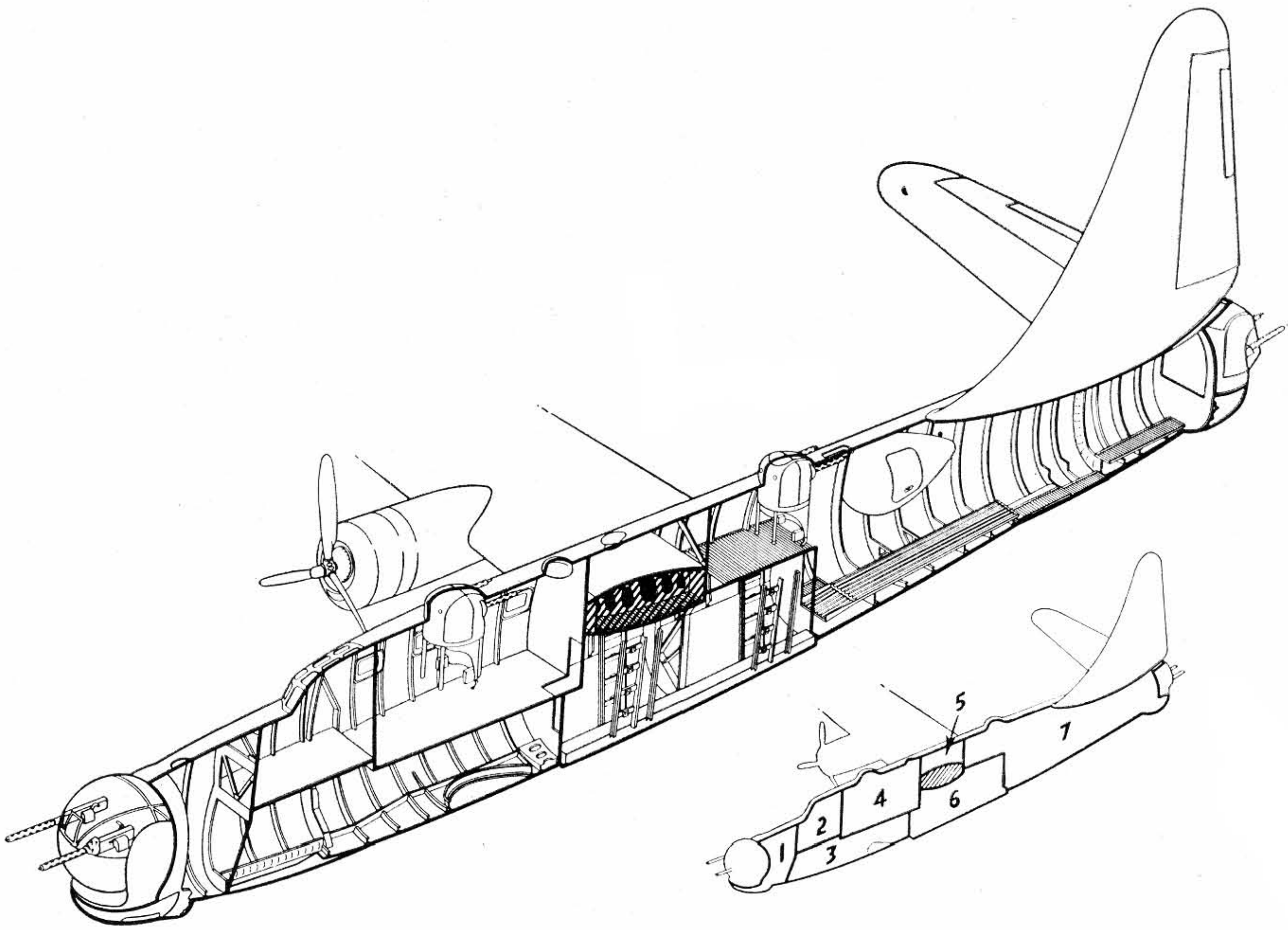


Figure 29—Wing Station Diagram



1. Nose Compartment
2. Flight Compartment
3. Nose Wheel Compartment
4. Radio and Navigator Compartment
5. Over Wing Compartment
6. Bomb Bays
7. Rear Compartment

Figure 30—PB4Y-2 Compartments

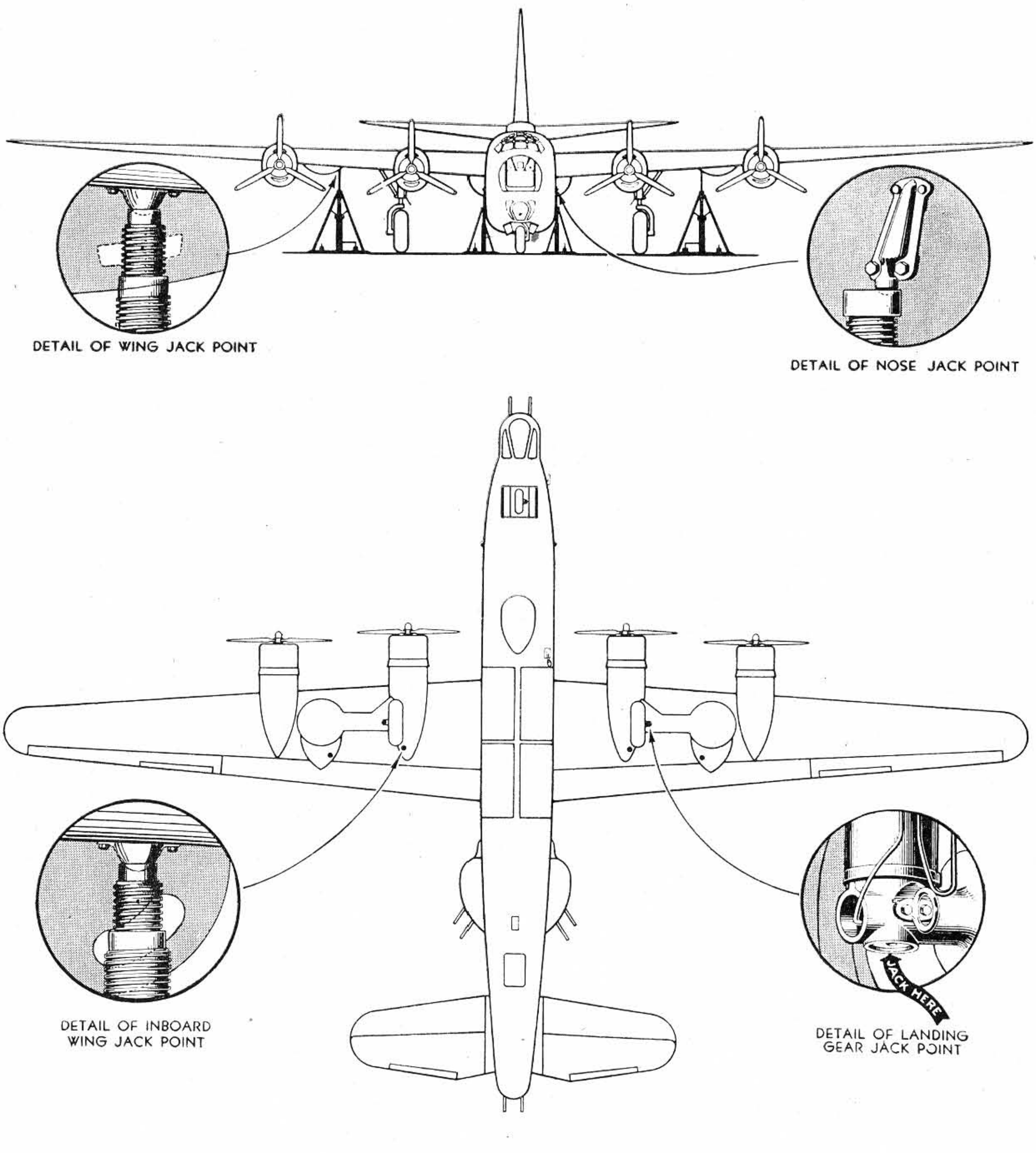


Figure 31—Jacking Points

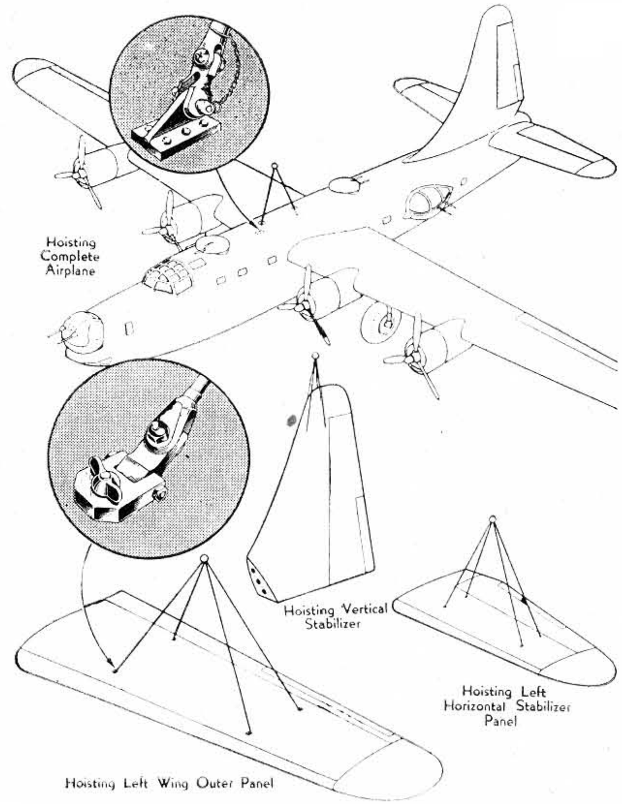


Figure 32—Hoisting Points

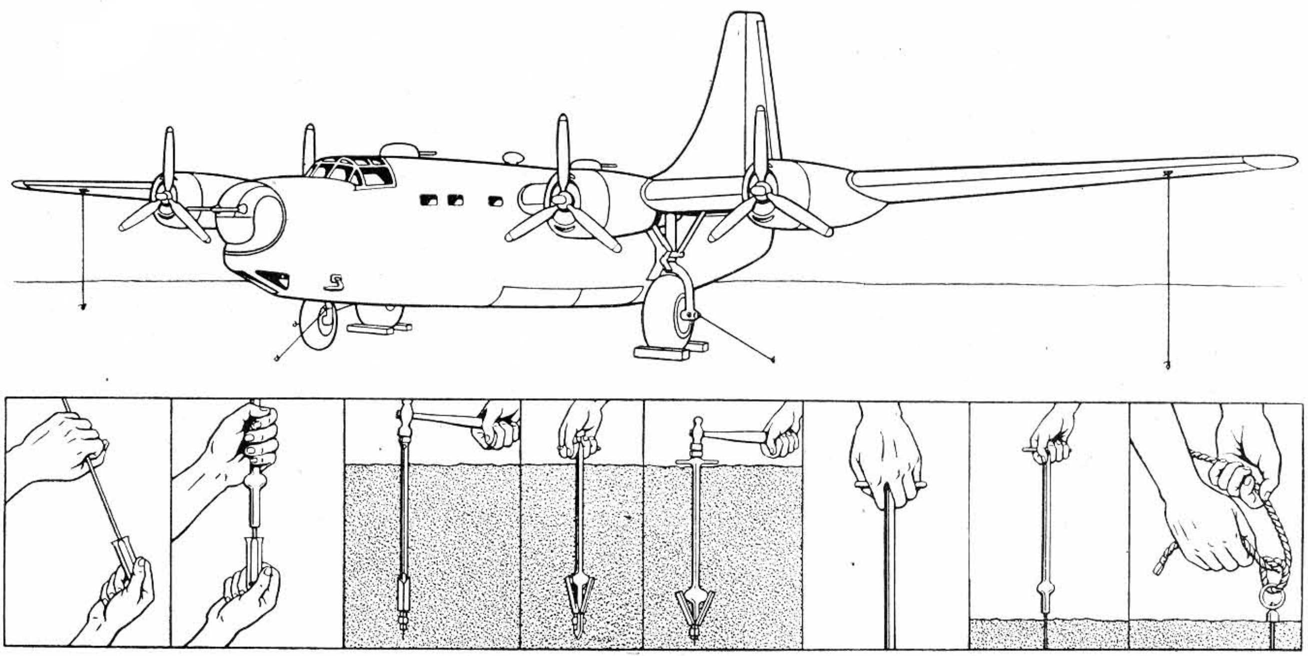


Figure 33—Mooring Diagram

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SUPPLEMENT

AIRPLANE PERFORMANCE CONTROL CHARTS

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COMPOSITE LEVEL-FLIGHT CRUISING CONTROL CHART

(Document No. 100-1-2)

The composite cruising control chart (Figure 38) is not difficult to use if it is properly understood. The chart is divided into four sections, namely Density Altitude, Air Speed Conversion, Power Settings, and Weight Correction. An analysis of each section, as given below, reveals the facts on which the chart is based and how each contributes to the make-up and use of the complete chart.

Density Altitude

Refer to Figure 34. Density altitude describes the mass per unit volume of air at a standard pressure and temperature. Certain conditions of air at sea level have been accepted by agreement as standard. The conditions involve temperature and pressure. The accepted standard is defined as a temperature of 15° C (59°F) at a barometric pressure of 29.92 inches of mercury (in. Hg) of 1013 millibars. Air is a gas, therefore its density varies with pressure and temperature. Since the physical properties of air vary with changes in altitude, standard air conditions must also be specified for each altitude above and below sea level conditions. Thus, it has been assumed that the temperature decreases 1° C. for every 504.6 feet increase in altitude above sea level up to a height of 35,332 feet, where the temperature is −55° C. (−67° F.). Above this altitude the air is assumed to retain a constant temperature of −55° C. Standard air conditions have therefore been defined and the physical relationships may be found in any Standard Atmosphere Table. Reference is made to N.A.C.A. Technical Report No. 218.

Usually actual air conditions differ from the calculated standard air conditions. In order that air density may be determined, a comparison must be made with conditions where the air density is already known. This is done by comparing the density of the air through which the flight is being made with the density of the air at a given pressure altitude when the temperature is standard.

The altimeter is set to a barometric pressure of 29.92 in. Hg on the dial of the instrument and the pressure altitude is then read. In this case the pressure altitude reading represents the pressure due to the weight of the air above the altitude level through which the flight is being made. Since the pressure altitude has been determined at standard temperature and since the density of the air under this condition is known, a starting point has been established. Temperature is the other factor which affects density, and may now be considered.

At standard temperature the pressure altitude and density altitude are the same and the air has a certain known density. When the temperature is higher than standard, the air expands and becomes less dense, therefore the density altitude is greater than the pressure altitude. Conversely, when the temperature is lower than standard, the air contracts and becomes more dense and the density altitude is lower than the pressure altitude. Examples from Figure 34 may help to clarify the use of the pressure altitude to density altitude conversion chart included on the left-hand side of the composite cruising control chart.

Example 1:

Given: a. Pressure Altitude = 4000 ft.

b. Air Temperature = 47° C (117° F.)

Read from chart: Density Altitude = 8500 ft.

To use the chart (interpolate for intermediate values) select the point on the temperature scale representing 47° C. Extend upward to intersect the *pressure* altitude 4000 foot line. Extend this intersection point (to the left) to the *density* altitude scale and read density altitude at 8500 feet.

Example 2:

Given a. Pressure altitude = 10,000 ft.

b. Air Temperature = −32° C. (−26° F.)

Read from chart: Density Altitude = 6,500 ft.

Note: Pressure altitude is the altimeter reading when the barometric scale on the instrument is set to 29.92 in. Hg (1013 millibars).

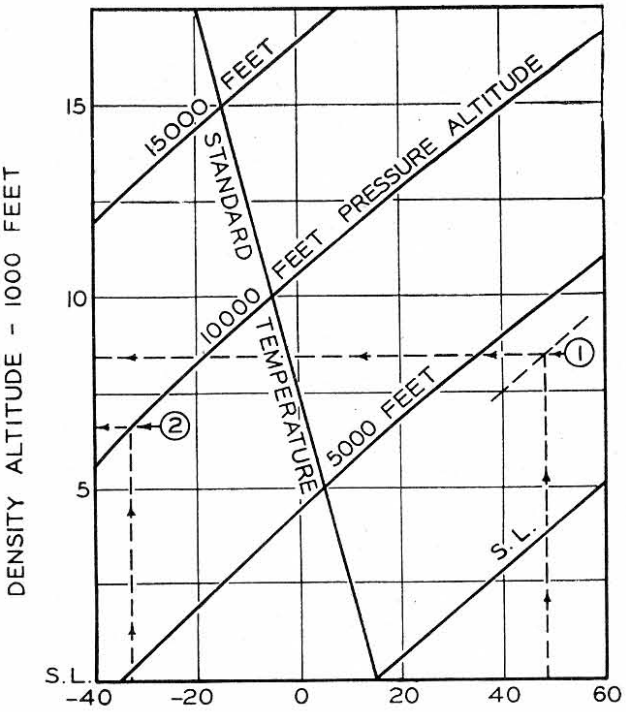


Figure 34—Density Altitude /Temperature

BY CORRECTING THE PRESSURE ALTITUDE FOR TEMPERATURE, THE DENSITY OF THE AIR THROUGH WHICH THE FLIGHT IS BEING MADE IS DETERMINED AND IS EXPRESSED IN TERMS OF DENSITY ALTITUDE.

The performance of the airplane (lift, drag, speed, power required and power available) depends upon the density of the air. All aerodynamic calculations and all aerodynamic charts of the cruising control type are usually based upon standard conditions and therefore *the pressure altitude must be converted to density altitude for the proper use of the cruising control and other aerodynamic charts.*

Air Speed Conversion

The next section of the chart to be considered is that portion dealing with the air speed conversion. This is the main body of the cruising control chart just to the right of the pressure altitude conversion chart. The vertical lines represent the true indicated (calibrated) air speed with the scale given at the top of the chart. The true air speed, or the speed in relation to the surface of the earth, with no wind, is represented by the light diagonally curved lines sloping from the top left-hand part of the chart to the lower right-hand part of the chart. At sea level the true air speed and true indicated air speed are the same.

This portion of the cruising control chart facilitates the conversion of true indicated air speed into true air speed as shown by the examples taken from Figure 35.

Example 1:

Given: a. True Indicated Air Speed = 157 knots
b. Density Altitude = 4000 ft.
Read from chart: True Air Speed = 167 knots

From the chart (Figure 35) interpolate for intermediate values and select the point representing 157 knots. Extend upward to intersect density altitude of 4000 feet. Read the true air speed, at the point of intersection, as 167 knots.

Example 2:

Given: a. True Indicated Air Speed = 176 knots
b. Density Altitude = 9000 ft.
Read from chart: True Air Speed = 202 knots

The pilot's air-speed indicator reading must be corrected for installation and instrument errors to obtain true indicated air speed as given on the cruising control chart.

The conversion of indicated air speeds to calibrated air speeds results in making proper allowances for the effect of the disturbed flow of air around the pitt-static tube, and for the mechanical errors of the pitot-static tube and the indicator. If there were no mechanical errors in the pitot-static tube and the indicator, and if the pitot-static tube could be projected far enough forward of the airplane to reach a point where it would meet undisturbed air under all flight conditions, the necessity for calibrating air-speed indicator installations would cease to exist. It would then be possible to apply density corrections directly to the indicated air speed as read from the face of the air-speed indicator.

Definitions

Indicated Air Speed is the reading or indication of the air-speed indicator.

True Indicated (Calibrated) Air Speed is the reading of the air-speed indicator corrected for instrument and installation errors.

Note: The term *True Indicated Air Speed* is used on all charts in this supplement.

True Air Speed is the actual speed of the airplane with respect to the air, or the true indicated air speed corrected for effect of air density and compressibility. True air speed is identical with ground speed under *no wind* conditions.

Ground Speed is the actual speed of the airplane with respect to the ground. This value includes the effect of the wind.

Power Settings

The power lines are the heavy lines sloping toward the left and superimposed on the air-speed conversion chart. These power lines give the power settings (r.p.m. and manifold pressure), the fuel consumption in pounds per hour and the speed-power relationship for the airplane.

The power settings given are recommended for obtaining the maximum efficiency from the engines with a minimum amount of wear, and the optimum r.p.m. considering propeller efficiency and specific fuel consumption in order that the resulting miles per gallon may be as high as possible. A relatively high r.p.m. and low manifold pressure setting would be easier on the engine; however, the engine would not develop the power of which it is capable and would have an excessive fuel consumption. On the other hand, a relatively low r.p.m. and high manifold pressure setting would build up higher pressures within the cylinders than the engine was designed to withstand and this would result in detonation and possibly blown cylinder heads, etc. It is evident that a compromise must be made between the r.p.m. and manifold pressure settings to obtain the best performance, therefore, the power settings on the cruising control chart were determined for this purpose.

Weight Correction

The fourth and last section composing the cruising control chart includes the weight correction lines underneath the air-speed conversion section. The power lines previously mentioned give the speed-power relationship only for the gross weight at which the chart is based. Consequently, corrections have to be made for variations in gross weight. The chart is based upon a gross weight of 40,000 pounds establishing the base line. The weight correction lines are applicable for any range of gross weights from 40,000 to 65,000 pounds.

The method for using the weight variation lines to correct for gross weight is illustrated in Figure 36.

Increasing the weight increases the lift required to maintain the airplane in level flight. This increases the required angle of attack which results in increased drag. More drag reduces the speed for the

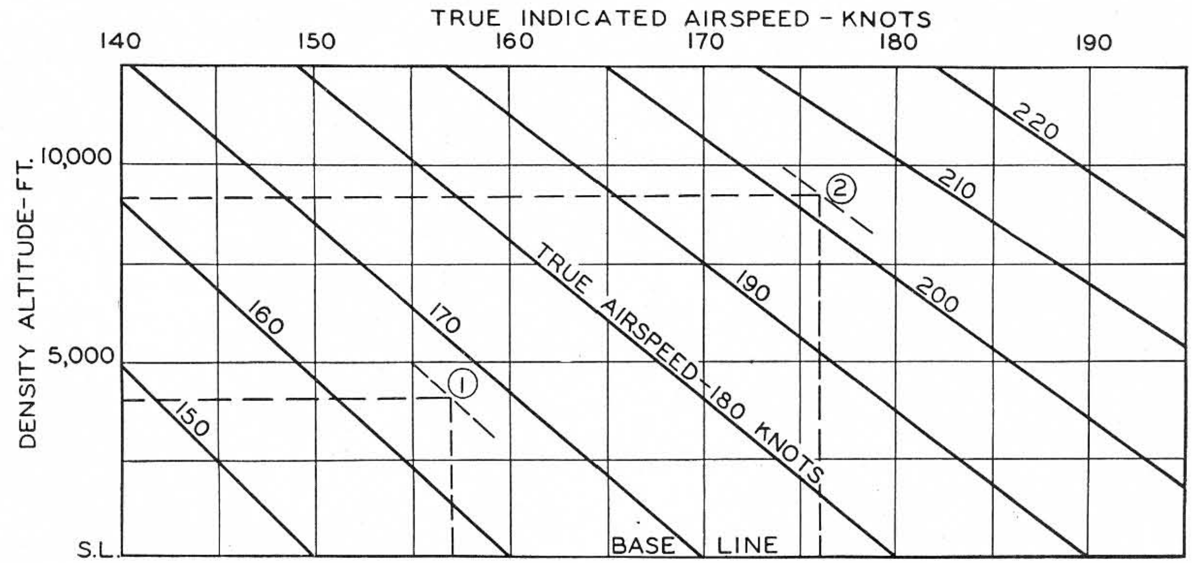


Figure 35—True Indicated Air Speed/Density Altitude

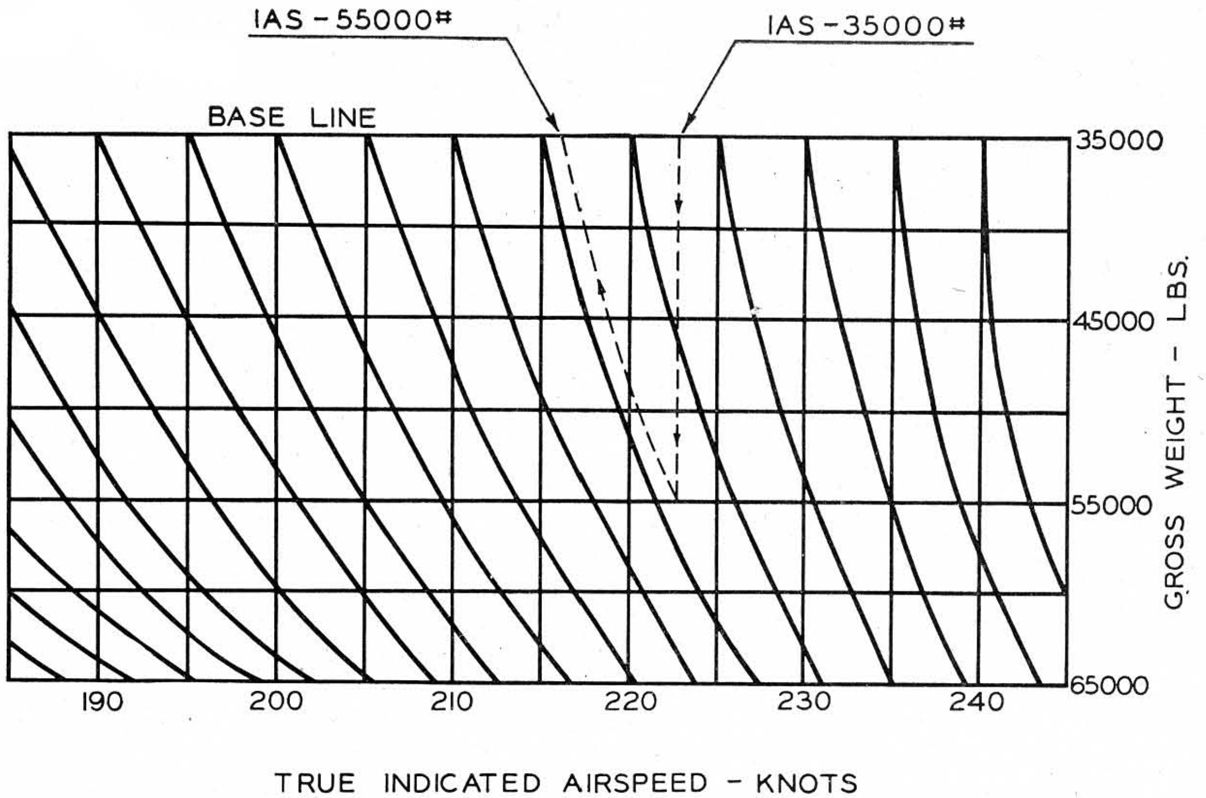


Figure 36—True Indicated Air Speed/Gross Weight

same amount of power or demands increased power to fly at the same speed. It is necessary, therefore, to adjust for gross weight to obtain the correct air speed or correct power.

The gross weight of an airplane in flight will decrease as the fuel is burned. This decrease in weight will increase the speed for a given power setting. If a constant air speed is desired, less power is required as the gross weight decreases. For steady cruising it should not be necessary to set power oftener than each hour; every three hours will probably be satisfactory.

Combining the four sections as shown below, one may see the basis on which the composite cruising control chart is established.

Chart for Density Altitude	Required power curves plotted on background of Air Speed Conversion Due to Altitude
	Chart for Weight Correction

INSTRUCTIONS FOR USING THE CRUISING CONTROL CHART

The cruising control chart will give the power required to fly at a desired air speed or the air speed for a selected power. Thus two methods may be employed in using the cruising control chart, depending upon which conditions of flight are chosen. Both methods are illustrated in the examples given below and as shown on Figure 37.

Case 1: To determine power required for any desired air speed at any gross weight and any altitude.

Solution: Enter chart at outside air temperature (A) and follow arrows to pressure altitude (B) determining density altitude. Follow arrows horizontally across to desired or selected air-speed (C). Project vertically down to base line at (D). Follow slope of weight variation lines to gross weight at (E). Project vertically up to density altitude at (F). True air speed and true indicated air speed are read at (C). The power required (r.p.m. and manifold pressure) and the fuel flow are found at (F).

Case 2: To determine air speed for any desired power at any gross weight and any altitude.

Solution: For this method the procedure is just the reverse of that given in case (1), except for steps (A) and (B), which are used for determining the density altitude. In this case the desired power is known at (F). Reverse the directions of the arrows, projecting vertically down to gross weight at (E) and following the slope of the weight variation lines to the base line at (D). Project vertically up to the density altitude at (C) and read true air speed or true indicated air speed.

Examples for Illustrating the Use of Model PB4Y-2 Cruising Control Chart

Refer to Figure 38. The proper use of the PB4Y-2 Cruising Control Chart entails three major considerations namely, blower position, mixture position, and throttle position. The first two are self-explanatory and are clearly shown by the shaded area on the chart for the use of high blower and the red line for limiting auto-lean operation. Full throttle operation is clearly shown by the diagonal broken blue lines, however, the throttle position requires some explanation if the proper manifold pressure and r.p.m. combinations are to be obtained.

On the chart (Figure 38) manifold pressures are represented by the curved dotted lines in the auto-lean area and are given at increments of 5000 feet in the auto-rich region. As no control of the manifold pressures can be maintained when operating at full throttle, the manifold pressures in the area above the full throttle line are given as an indication of the value of the gauge reading at standard conditions and at the particular altitude, r.p.m., and brake horsepower shown on the chart.

The horsepower output of an engine is influenced by a great many factors and variables. Only the three primary components of r.p.m., manifold pressure and altitude are of paramount importance to the pilot. For a given r.p.m. an engine will produce a certain amount of power at a particular manifold pressure at sea level. As the altitude is increased the same amount of power may be maintained by advancing the throttle a certain degree which results in a new but lower manifold pressure as shown on the cruising control chart. This procedure

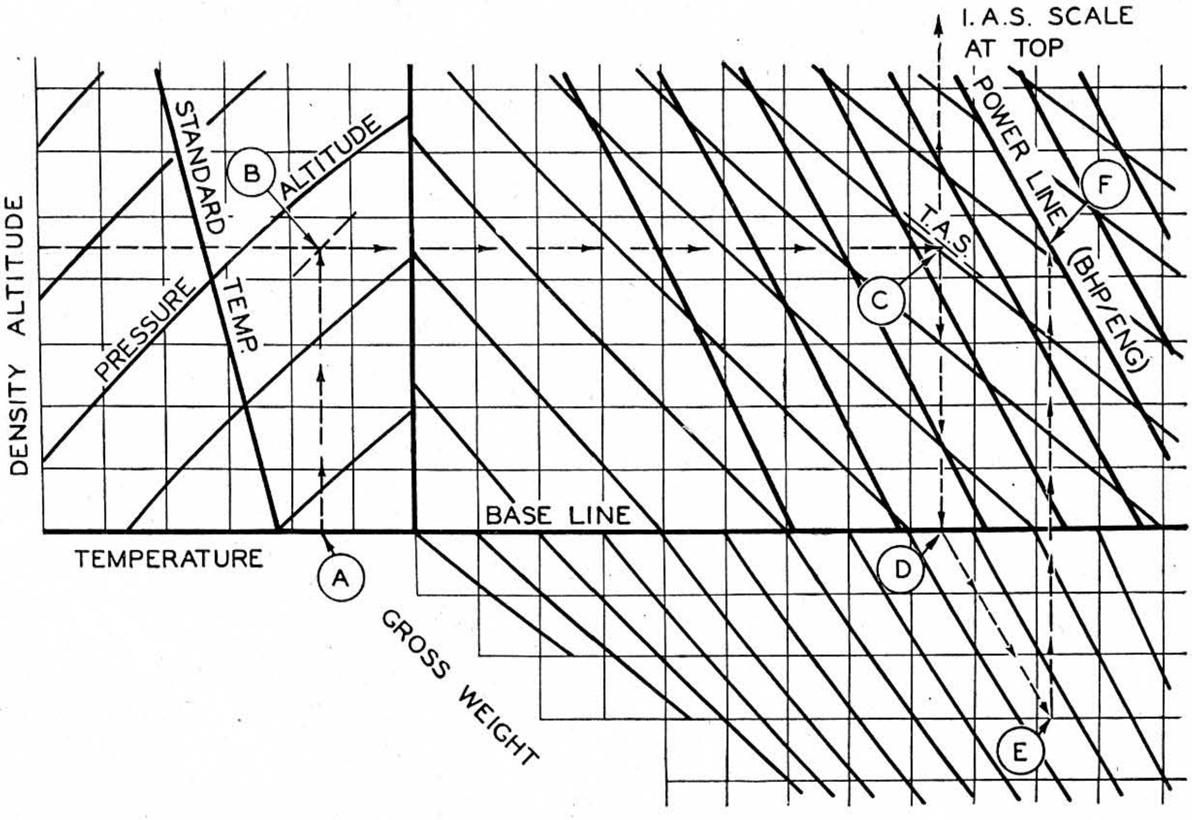
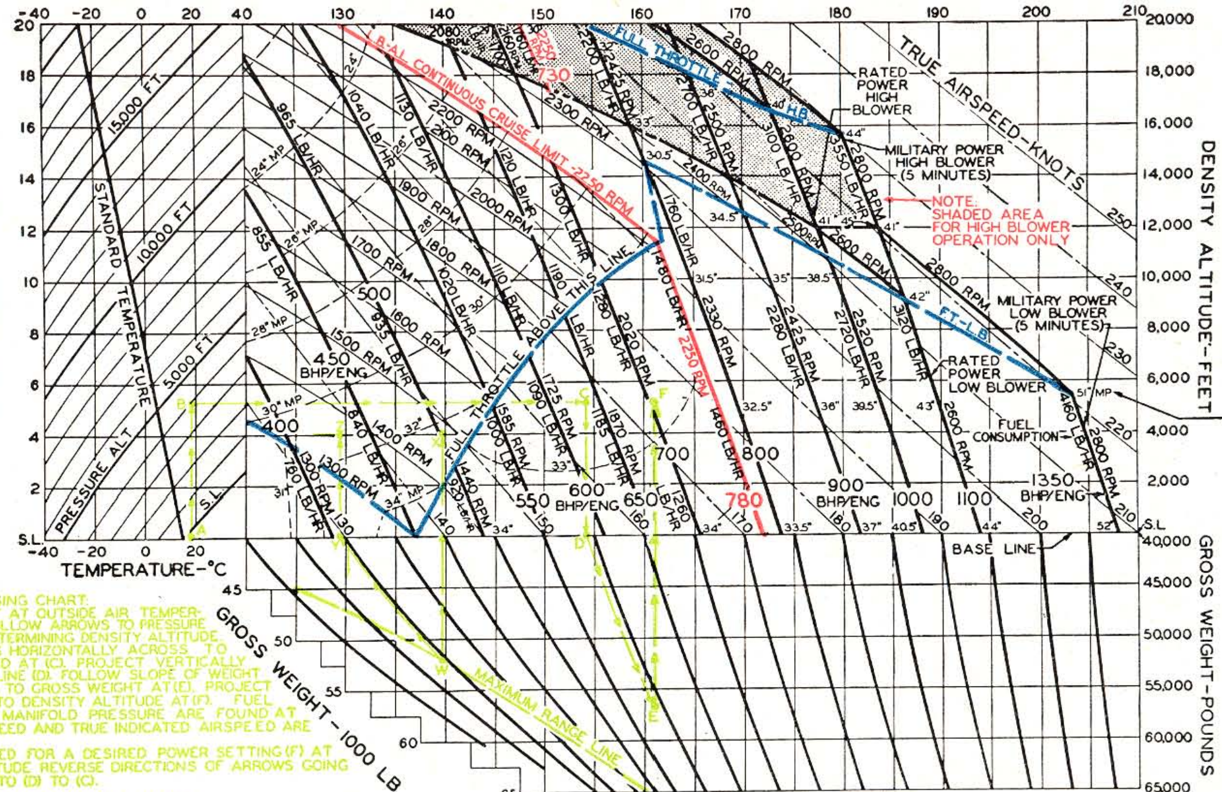


Figure 37—Density Altitude/Temperature/Gross Weight

COMPOSITE CRUISING CONTROL CHART MODEL PB4Y-2 FOUR-ENGINE OPERATION

TRUE INDICATED AIRSPEED (CALIBRATED) - KNOTS

NOTE THIS SPEED MUST BE CORRECTED FOR AIRSPEED STATIC POSITION AND INSTRUMENT ERRORS TO OBTAIN PILOT'S INDICATED AIRSPEED.



EXAMPLE FOR USING CHART:
ENTER CHART AT OUTSIDE AIR TEMPERATURE (A) AND FOLLOW ARROWS TO PRESSURE ALTITUDE (B). DETERMINING DENSITY ALTITUDE. FOLLOW ARROWS HORIZONTALLY ACROSS TO DESIRED AIRSPEED AT (C). PROJECT VERTICALLY DOWN TO BASE LINE (D). FOLLOW SLOPE OF WEIGHT VARIATION LINES TO GROSS WEIGHT AT (E). PROJECT VERTICALLY UP TO DENSITY ALTITUDE AT (F). FUEL FLOW, RPM AND MANIFOLD PRESSURE ARE FOUND AT (F). TRUE AIRSPEED AND TRUE INDICATED AIRSPEED ARE GIVEN AT (C).
TO FIND AIRSPEED FOR A DESIRED POWER SETTING (F) AT A DENSITY ALTITUDE REVERSE DIRECTIONS OF ARROWS GOING FROM (F) TO (E) TO (D) TO (C).

PROCEDURE FOR FLYING MAXIMUM RANGE.
ENTER CHART AT INTERSECTION OF GROSS WEIGHT AND MAXIMUM RANGE LINE (W). TO DETERMINE POWER, FUEL FLOW, RPM AND MANIFOLD PRESSURE PROJECT VERTICALLY UP TO FLIGHT DENSITY ALTITUDE (X). TO FIND TRUE INDICATED AIRSPEED FOLLOW SLOPE OF WEIGHT VARIATION LINES TO BASE LINE AT (Y). PROJECT TO DENSITY ALTITUDE AT (Z) TO FIND TRUE AIRSPEED

INCREASE MANIFOLD PRESSURE 0.5 IN. FOR EACH 6°C RISE (DECREASE 0.5 IN. FOR EACH 6°C DROP) OF CARBURETOR AIR TEMPERATURE FROM STANDARD SEE NOTE NO. 2, <u>FOR USE IN CRUISING FLIGHT.</u>

FUEL USED	0	500	1000	1500	2000	2500	3000	3500	3900	GALLONS
WEIGHT LOST	0	5000	10000	15000	20000	POUNDS				

TO OBTAIN GROSS WEIGHT AT ANY POINT DURING FLIGHT SUBTRACT WEIGHT OF FUEL USED FROM INITIAL GROSS WEIGHT

NORMAL RATED POWER = 4 x 1100 BHP - LOW BLOWER
= 4 x 1000 BHP - HIGH BLOWER

TAKE-OFF POWER: = 4 x 1350 BHP/2800 RPM/52 IN. MP. AUTO-RICH: LOW BLOWER ONLY.

IN LOW BLOWER: USE AUTO-RICH FOR 780 BHP AND ABOVE, AUTO-LEAN FOR 780 BHP AND BELOW.

IN HIGH BLOWER: USE AUTO-RICH FOR 730 BHP AND ABOVE, AUTO-LEAN FOR 730 BHP AND BELOW

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA
DOCUMENT NO. 100-1-2 — DECEMBER 11, 1944

NOTES

CHART IS BASED ON CONTRACTOR'S FLIGHT TEST DATA WITH THE AIRPLANE IN THE FOLLOWING CONFIGURATION:

1. <u>ENGINES</u>: R-1830-94 GEARED 16:9.
2. <u>PROPELLERS</u>: 11 FT 7 IN. DIAMETER THREE BLADED TYPE NO. 6353A-18.
3. <u>CARBURETORS</u>: PD-12F7 STOCK LIST NO. 395433 -5, -6 OR -7.
4. <u>COWL FLAPS</u>: CLOSED.
5. <u>WING FLAPS</u>: RETRACTED.
6. <u>ARMAMENT</u>: PATROL RECONNAISSANCE BOMBER WITH GUNS IN POSITION OF MINIMUM DRAG.
7. <u>RADIO AND RADAR</u>: STANDARD RADIO ANTENNA AND SPECIAL RADAR EQUIPMENT WITH <u>RETRACTABLE RADAR NACELLE IN THE CRUISING POSITION.</u>
8. <u>EXTERNAL FINISH</u>: CAMOUFLAGE PAINT

IMPORTANT

DO NOT OPERATE BETWEEN 1900 AND 2000 RPM. WHEREVER CHARTED VALUES SHOW OPERATION IN THIS RANGE, INCREASE RPM TO 2000 AND PULL BACK ON THROTTLE UNTIL CHARTED AIR SPEED IS OBTAINED. FUEL CONSUMPTION WILL BE INCREASED.

ENGINE CYLINDER TEMPERATURE LIMITATIONS:

CONDITION	MAX CYL HEAD TEMP	MAX CYL BARREL TEMP
TAKE-OFF (5 MIN)	260°C	168°C
RATED POWER (ONE HOUR)	260°C	168°C
CONTINUOUS CRUISING	232°C	168°C

FOR USE IN CRUISING FLIGHT

1. DETERMINE DENSITY ALTITUDE. SET POWER TO CHARTED VALUES AS GIVEN TO OBTAIN DESIRED AIRSPEED.
2. AIRSPEED WILL BE LOW IN HOT WEATHER, HIGH IN COLD, WHEN COMPARED TO CHARTED VALUES. JOCKEY POWER SLIGHTLY AS REQUIRED INCREASE MANIFOLD PRESSURE TO INCREASE SPEED (PART THROTTLE OPERATION) UNTIL CHARTED AIRSPEED IS OBTAINED. <u>DO NOT INCREASE MANIFOLD PRESSURE MORE THAN 2 IN. WITHOUT RAISING RPM.</u> <u>FOR FULL THROTTLE OPERATION SET POWER BY RPM SPECIFIED ON CHART. IF RESULTING SPEED IS TOO LOW, INCREASE RPM.</u>
3. IN NORMAL AUTO-LEAN OPERATION DO NOT EXCEED 2250 RPM, 780 BHP AND 150 BMEP FOR LOW BLOWER AND 2250 RPM, 730 BHP AND 140 BMEP FOR HIGH BLOWER.
4. BMEP = 433 x (BHP/RPM).
5. FOR STEADY CRUISING IT SHOULD NOT BE NECESSARY TO RESET POWER MORE OFTEN THAN EACH HOUR. EVERY 3 HOURS WILL PROBABLY BE SATISFACTORY.
6. MAXIMUM RECOMMENDED CARBURETOR AIR TEMPERATURE FOR SAFE OPERATION IN HIGH BLOWER IS 16°C.

Figure 38—Cruising Control Chart—4 Engine

is repeated until no further advance in throttle position can be obtained or when the throttle is fully open. The highest altitude at which full throttle occurs and where the horsepower which was obtained at sea level with the same r.p.m. may be maintained is termed the critical altitude. Any further increase in altitude would result in a loss of horsepower and decrease in manifold pressure. Thus, to maintain the same horsepower at a higher altitude than the critical altitude for the first r.p.m., a shift to a higher r.p.m. must be made. This process is continued as the altitude is increased until a limited r.p.m. is reached, such as 2250 r.p.m. in auto-lean operation or 2600 r.p.m. for rated power or 2800 r.p.m. for 5 minutes duration.

To illustrate: take for example the "700 BHP–ENG" power line on the chart. At part throttle for any altitude from sea level to 10,000 feet density altitude the recommended r.p.m. is given along the power line as 2020. To obtain 700 brake horsepower per engine at sea level the throttle would be set to give 34.0 inches on the manifold pressure gauge. If 700 brake horsepower were required at 2000 feet density altitude the throttle would be set to give a gauge reading of 33.5 inches. Thus the manifold pressure is obtained by interpolating between the 33.0 inch manifold pressure line at 4000 feet density altitude and the 34.0 inch manifold pressure line at sea level. If 700 brake horsepower were required at 10,000 feet density altitude, full throttle operation would be necessary; for 2020 r.p.m. the manifold pressure would be 32.0 inches. This is also the critical altitude for 2020 r.p.m. and 700 brake horsepower, therefore, to maintain 700 brake horsepower at a density altitude higher than 10,000 feet a higher r.p.m. must be used.

The new r.p.m. is obtained from the constant r.p.m. lines sloping from the top left to the lower right on the full throttle area on the chart. Thus it can be seen on the chart that the 2100 r.p.m. line intersects the 700 horsepower line at 11,600 feet density altitude and the 2200 r.p.m. line intersects the 700 horsepower line at 13,900 feet density altitude. If 700 horsepower were required at 12,500 feet density altitude the correct r.p.m. can be found by estimating or interpolating between the two r.p.m. lines to be 2130 r.p.m. Thus at standard conditions and at the particular density altitude of 12,500 feet, 2130 r.p.m. would result in 700 brake horsepower per engine at full throttle and the manifold pressure should be approximately 30 inches Hg. Operation in auto-lean is permissible up to 2250 r.p.m. Consequently, at 14,800 feet density altitude the operating limit in auto-lean is reached for 700 brake horsepower. If it were required to have 700 brake horsepower at 17,500 feet density altitude, 2300 r.p.m., auto-rich and full throttle would be the power settings. At 18,000 feet density altitude to obtain 700 brake horsepower it would be necessary to shift to high blower and 2160 r.p.m. with a corresponding part throttle operation to give approximately 29.5 inches manifold pressure with mixture set auto-lean.

EXAMPLE 1: Find power settings (brake horsepower per engine, r.p.m., manifold pressure and fuel consumption), true indicated air speed, true air speed and pilot's air-speed indicator reading for flying maximum range at 2000 feet pressure altitude and outside air temperature of 23° C. at a gross weight of 62,500 lbs.

SOLUTION: Enter chart at outside air temperature of 23° C. and project vertically to pressure altitude of 2000 feet determining density altitude of 3400 feet. Refer to the lower left hand corner of the weight correction section of the chart and enter at the intersection of the gross weight with the "Maximum Range Line." Project vertically up to 3400 feet density altitude and interpolate the brake horsepower per engine to be 640 b.h.p. Adjust the r.p.m. to give a tachometer reading of 1840 by interpolating between 1725 r.p.m. for 600 b.h.p. and 1870 r.p.m. for 650 b.h.p. By referring to the "Standard Temperature" line it can be seen that at 2000 feet pressure altitude the standard temperature should be 11° C. Actually the airplane is flying in air which is 12° C. above standard. Assuming that the carburetor air temperature is the same as the outside air temperature a correction for manifold pressure has to be made. A safe rule to observe is to increase manifold pressure 0.5 in. for each 6° C. rise (decrease 0.5 in. for each 6° C. drop) of carburetor air temperature from standard. *This applies for part throttle operation only* and *do not increase manifold pressure more than 2 in. without raising the r.p.m.* Consequently as the air is 12° C. above standard and part throttle is being used the manifold pressure should be adjusted for a 1.0 in. increase above the value of 33 in. as given on the chart or 34 in. for the gauge reading. The fuel consumption like the r.p.m. is interpolated to be 1165 pounds per hour. To find the true indicated air speed follow the slope of the weight variation line to the base line and read 139.5 knots. True air speed at 3400 feet density altitude is determined to be 147 knots. To find the pilot's air-speed indicator reading refer to the air-speed installation correction table. In this case add 4.0 knots for the position error to 139.5 to obtain 143.5 knots. The instrument error, depending upon the calibration of the indicator in each airplane, must also be added or subtracted to obtain the final figure. Jockey the power slightly as required to obtain the air-speed indicator reading. Air speed will be low in hot weather, high in cold weather, when compared to charted values. In part throttle operation increase manifold pressure to increase speed, and in full throttle operation increase speed by increasing r.p.m.

This table shows the instrument readings to be higher than the true indicated air speed. Therefore, the true indicated air speed is obtained by subtracting the correction from the instrument reading. Thus, the true indicated air speed obtained from the cruising control chart will be less than the instrument reading. To find what the instrument reading should be, it is necessary to add to the figure obtained from the cruising control chart.

AIR-SPEED INSTALLATION CORRECTION TABLE

I.A.S. (Instrument Reading)		CORRECTION		
Wing Flaps Retracted — Landing Gear Up — Radar Nacelle in Cruising Position				
120	Knots	Subtract	3.0	Knots
130	Knots	Subtract	3.5	Knots
140	Knots	Subtract	4.0	Knots
150	Knots	Subtract	4.5	Knots
160	Knots	Subtract	4.5	Knots
180	Knots	Subtract	5.0	Knots
200	Knots	Subtract	5.0	Knots
Wing Flaps Extended 20° — Landing Gear Down — Radar Nacelle Retracted				
95	Knots	Subtract	2.0	Knots
100	Knots	Subtract	2.5	Knots
110	Knots	Subtract	2.5	Knots
120	Knots	Subtract	3.0	Knots
130	Knots	Subtract	3.5	Knots
140	Knots	Subtract	4.0	Knots
Wing Flaps Extended Full Down — Landing Gear Down — Radar Nacelle Retracted				
85	Knots	Subtract	1.5	Knots
90	Knots	Subtract	2.0	Knots
100	Knots	Subtract	2.5	Knots
110	Knots	Subtract	2.5	Knots
120	Knots	Subtract	3.0	Knots
130	Knots	Subtract	3.5	Knots

EXAMPLE:

Air Speed Indicator Reading = 140 Knots
Correction = −4.0 Knots ± Instrument Error
True Indicated Airspeed = 140 − 4.0 ± Instrument Error
(Calibrated) = 136 Knots ± Instrument Error

EXAMPLE 2: Find the air speed for a power setting of 2500 r.p.m. (high blower), and full throttle, at a density altitude of 18,000 feet and at a gross weight of 50,000 lbs.

SOLUTION: By looking at the shaded area shown on the chart it can be seen that at 18,000 feet density altitude and full throttle in high blower, 2500 r.p.m. will give 900 brake horsepower per engine. Projecting vertically down to 50,000 lbs. gross weight and then parallel to the weight variation lines up to the base line and then vertically up to 18,000 feet density altitude will give a true air speed of 214 knots and a true indicated air speed of 161.5 knots.

WARNING

The minimum cruising r.p.m. is given on these charts as 1300. At this r.p.m. the generator develops a voltage that is lower than that of batteries. The batteries are, therefore, the only source of electrical power. Generator power is available only at engine speeds higher than 1550 r.p.m. For the foregoing reason, engine speeds below 1550 r.p.m. are not recommended except when maximum range or endurance are desired above all other considerations.

AAFMC-527 4-1-44

AIRCRAFT MODEL(S) PB4Y-2

FOUR-ENGINE TAKE-OFF, CLIMB & LANDING CHART

ENGINE MODEL(S) R-1830-94

TAKE-OFF DISTANCE FEET

GROSS WEIGHT LB.	HEAD WIND M.P.H.	HEAD WIND KTS.	HARD SURFACE RUNWAY AT SEA LEVEL GROUND RUN	HARD SURFACE AT SEA LEVEL TO CLEAR 50' OBJ.	HARD SURFACE AT 3000 FEET GROUND RUN	HARD SURFACE AT 3000 FEET TO CLEAR 50' OBJ.	HARD SURFACE AT 6000 FEET GROUND RUN	HARD SURFACE AT 6000 FEET TO CLEAR 50' OBJ.	SOD-TURF RUNWAY AT SEA LEVEL GROUND RUN	SOD-TURF AT SEA LEVEL TO CLEAR 50' OBJ.	SOD-TURF AT 3000 FEET GROUND RUN	SOD-TURF AT 3000 FEET TO CLEAR 50' OBJ.	SOD-TURF AT 6000 FEET GROUND RUN	SOD-TURF AT 6000 FEET TO CLEAR 50' OBJ.	SOFT SURFACE RUNWAY AT SEA LEVEL GROUND RUN	SOFT SURFACE AT SEA LEVEL TO CLEAR 50' OBJ.	SOFT SURFACE AT 3000 FEET GROUND RUN	SOFT SURFACE AT 3000 FEET TO CLEAR 50' OBJ.	SOFT SURFACE AT 6000 FEET GROUND RUN	SOFT SURFACE AT 6000 FEET TO CLEAR 50' OBJ.
45,000	0	0	1500	2520	1700	2820	2060	3330	1600	2620	1800	2920	2260	3530	1860	2880	2200	3320	2750	4020
	12	10	1190	2100	1350	2350	1610	2740	1280	2190	1430	2430	1810	2940	1480	2390	1770	2770	2240	3370
	23	20	930	1730	1050	1930	1270	2260	1000	1800	1100	1980	1390	2380	1130	1930	1370	2250	1780	2770
	35	30	690	1390	800	1550	960	1820	760	1460	840	1590	1040	1900	850	1550	1050	1800	1320	2180
55,000	0	0	2080	3200	2400	3700	3120	4530	2300	3420	2730	3980	3500	4910	2900	4020	3500	4750	4350	5760
	12	10	1650	2650	1980	3090	2590	3840	1820	2820	2240	3350	2860	4110	2400	3400	2850	3960	3620	4870
	23	20	1300	2180	1540	2510	2055	3175	1420	2300	1760	2730	2280	3400	1900	2780	2300	3270	2980	4100
	35	30	990	1740	1150	1990	1557	2537	1070	1820	1320	2160	1760	2740	1440	2190	1770	2610	2350	3330
65,000	0	0	3100	4480	3690	5210	4560	6280	3510	4890	4180	5900	5400	7120	4600	5980	5400	6920	8470	10190
	12	10	2600	3830	3040	4430	3880	5420	2900	4130	3440	4980	4600	6140	3840	5070	4520	5910	7330	8870
	23	20	2060	3160	2440	3670	3120	4510	2310	3410	2780	4170	3750	5140	3100	4200	3750	4980	6250	7640
	35	30	1590	2550	1900	3000	2470	3690	1790	2750	2200	3420	3000	4220	2450	3410	3000	4100	5190	6410

NOTE: INCREASE CHART DISTANCES AS FOLLOWS: 75°F + 10%; 100°F + 20%; 125°F + 30%; 150°F + 40%

OPTIMUM TAKE-OFF WITH 2800 RPM, 52 IN.HG. & 30 DEG.FLAP IS 80% OF CHART VALUES

DATA AS OF NOV. 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA ON HARD SURFACE RUNWAY AT SEA LEVEL WITH ZERO WIND

CLIMB DATA

GROSS WEIGHT LB.	AT SEA LEVEL BEST I.A.S. MPH	AT SEA LEVEL BEST I.A.S. KTS	AT SEA LEVEL RATE OF CLIMB F.P.M.	AT SEA LEVEL GAL. OF FUEL USED	AT 5000 FEET BEST I.A.S. MPH	AT 5000 FEET BEST I.A.S. KTS	AT 5000 FEET RATE OF CLIMB F.P.M.	AT 5000 FEET FROM SEA LEVEL TIME MIN.	AT 5000 FEET FROM SEA LEVEL FUEL USED	AT 10,000 FEET BEST I.A.S. MPH	AT 10,000 FEET BEST I.A.S. KTS	AT 10,000 FEET RATE OF CLIMB F.P.M.	AT 10,000 FEET FROM SEA LEVEL TIME MIN.	AT 10,000 FEET FROM SEA LEVEL FUEL USED	AT 15,000 FEET BEST I.A.S. MPH	AT 15,000 FEET BEST I.A.S. KTS	AT 15,000 FEET RATE OF CLIMB F.P.M.	AT 15,000 FEET FROM SEA LEVEL TIME MIN.	AT 15,000 FEET FROM SEA LEVEL FUEL USED	AT 17,500 FEET BEST I.A.S. MPH	AT 17,500 FEET BEST I.A.S. KTS	AT 17,500 FEET RATE OF CLIMB F.P.M.	AT 17,500 FEET FROM SEA LEVEL TIME MIN.	AT 17,500 FEET FROM SEA LEVEL FUEL USED	AT 20,000 FEET BEST I.A.S. MPH	AT 20,000 FEET BEST I.A.S. KTS	AT 20,000 FEET RATE OF CLIMB F.P.M.	AT 20,000 FEET FROM SEA LEVEL TIME MIN.	AT 20,000 FEET FROM SEA LEVEL FUEL USED
45,000	126	109	1330	90	126	109	1275	4.0	125	126	109	1090	8.0	160	126	109	910	13.5	210	126	109	725	17.0	240	126	109	540	21.0	270
55,000	138	120	1020	90	138	120	970	4.5	130	138	120	750	10.5	185	138	120	575	18.5	255	138	120	395	24.0	300	138	120	215	31.5	360
65,000	147	128	720	90	147	128	670	7.0	150	147	128	450	16.0	230	147	128	285	29.0	345	147	128	120	41.5	455					

DATA AS OF NOV. 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA

FUEL USED (U.S. GAL.) INCLUDES WARM-UP & TAKE-OFF ALLOWANCE

LANDING DISTANCE FEET

GROSS WEIGHT LB.	BEST IAS APPROACH POWER OFF MPH	POWER OFF KTS	POWER ON MPH	POWER ON KTS	HARD DRY SURFACE AT SEA LEVEL GROUND ROLL	HARD DRY AT SEA LEVEL TO CLEAR 50' OBJ.	HARD DRY AT 3000 FEET GROUND ROLL	HARD DRY AT 3000 FEET TO CLEAR 50' OBJ.	HARD DRY AT 6000 FEET GROUND ROLL	HARD DRY AT 6000 FEET TO CLEAR 50' OBJ.	FIRM DRY SOD AT SEA LEVEL GROUND ROLL	FIRM DRY SOD AT SEA LEVEL TO CLEAR 50' OBJ.	FIRM DRY SOD AT 3000 FEET GROUND ROLL	FIRM DRY SOD AT 3000 FEET TO CLEAR 50' OBJ.	FIRM DRY SOD AT 6000 FEET GROUND ROLL	FIRM DRY SOD AT 6000 FEET TO CLEAR 50' OBJ.	WET OR SLIPPERY AT SEA LEVEL GROUND ROLL	WET OR SLIPPERY AT SEA LEVEL TO CLEAR 50' OBJ.	WET OR SLIPPERY AT 3000 FEET GROUND ROLL	WET OR SLIPPERY AT 3000 FEET TO CLEAR 50' OBJ.	WET OR SLIPPERY AT 6000 FEET GROUND ROLL	WET OR SLIPPERY AT 6000 FEET TO CLEAR 50' OBJ.
40,000	110	95	105	91	1710	2380	1830	2490	1950	2620	1880	2550	2000	2680	2150	2830	4900	5550	5300	5960	5710	6400
56,000	121	105	115	100	2200	3620	2380	3800	2540	3960	2390	3930	2570	4100	2690	4300	6680	8090	7240	8650	7890	9290

DATA AS OF DEC. 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA ON HARD SURFACE RUNWAY AT SEA LEVEL WITH ZERO WIND

OPTIMUM LANDING IS 80% OF CHART VALUES

REMARKS:

NOTE: TO DETERMINE FUEL CONSUMPTION IN BRITISH IMPERIAL GALLONS, MULTIPLY BY 10, THEN DIVIDE BY 12

LEGEND

I.A.S. : INDICATED AIRSPEED

M.P.H. : MILES PER HOUR

KTS. : KNOTS

F.P.M. : FEET PER MINUTE

Figure 39—Four Engine Take-off, Climb, and Landing Chart

RANGE AND ENDURANCE PREDICTION CHARTS

(Document No. 100-5-2—For 1000 ft. Density Altitude—Four Engine Operation)
(Document No. 100-5A-2—For 5000 ft. Density Altitude—Four Engine Operation)
(Document No. 100-5B-2—For 10,000 ft. Density Altitude—Four Engine Operation)

The purpose of these charts is to show the range attainable at a constant altitude for speeds varying from the speed for maximum range to the speed at rated power.

Instructions for Use of Range and Endurance Prediction Charts

Refer to Figure 40.

(1) RANGE: NO BOMBS DROPPED—Enter chart with initial gross weight at point A and read R_1. A − B along weight scale = weight of fuel used during flight. Enter chart with final gross weight at point B and read R_2. $R_2 - R_1$ = Range for amount of fuel used.

(2) RANGE: BOMBS DROPPED—In this case bombs are dropped at some point during the flight.

C − D along weight scale = weight of fuel used before dropping bombs.

$R_4 - R_3$ = Range befose dropping bombs.

D − E along weight scale = weight of bombs dropped.

E − F along weight scale = weight of fuel used after dropping bombs.

$R_6 - R_5$ = Range after dropping bombs.

$(R_4 - R_3) + (R_6 - R_5)$ = Total range.

(3) ENDURANCE—Use same method as for range.

(1) Knowing the altitude of the flight, the quantity of fuel available, and the distance to be covered, the pilot in most cases may have a selection of several speeds. The final selection of speed will be based on the time limitation and on the amount of reserve or margin of safety desired. Direct inter-

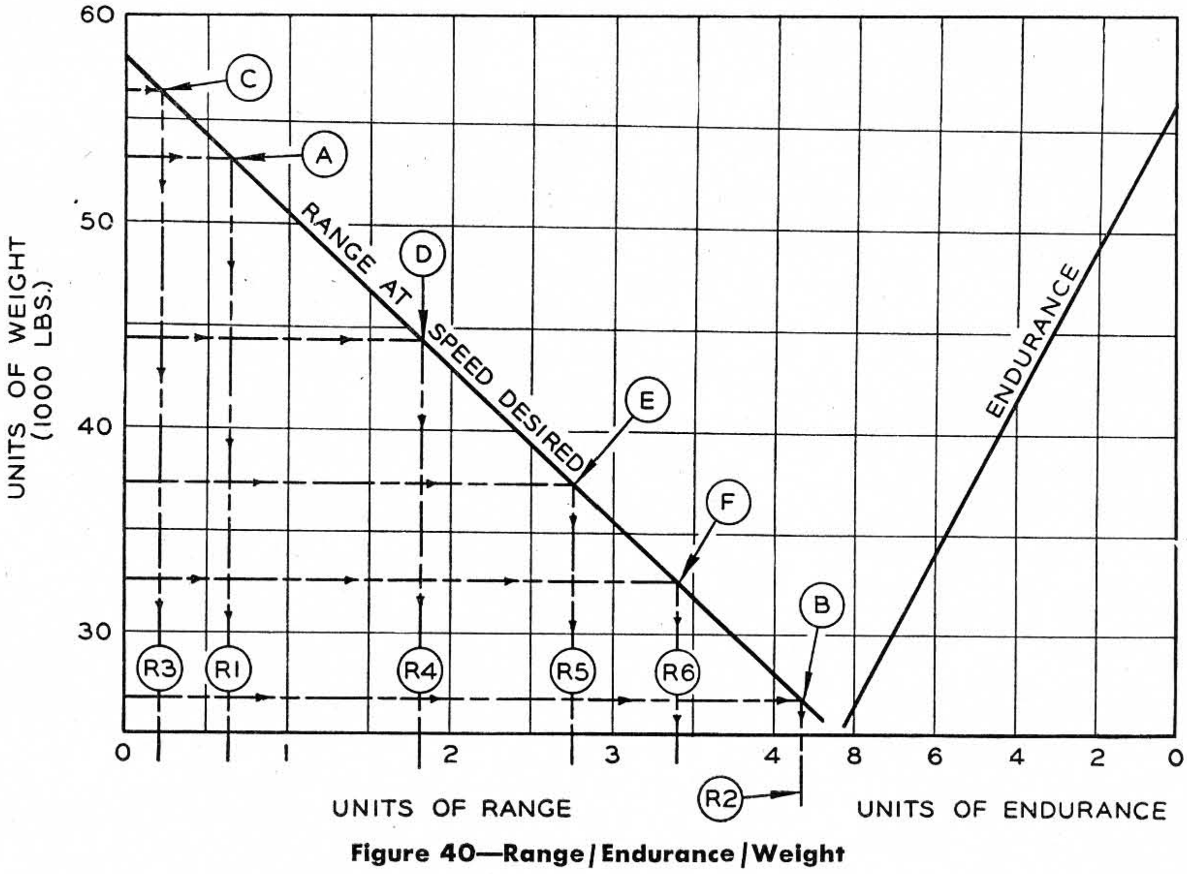


Figure 40—Range / Endurance / Weight

polation may be used to estimate the range and endurance for various speeds and altitudes not given on the charts. Upon reaching the altitude of flight, power should be set by using the power settings specified on the cruising control chart.

(2) In flight conditions, where the head temperatures exceed 232° C. but are under 260° C. with normal rated power, the maximum allowable use of normal rated power will be limited to one hour's duration. Therefore, the curve of range at normal rated power in these cases can be used only for the purpose of finding the decrease in weight for the time during which normal rated power is used.

(3) All charts must be based on certain established conditions. A separate chart would be required to consider every condition of wind, loading and altitude that might be encountered. Therefore, the charts are based on a no wind condition, and no allowances for fuel consumed in warm-up, take-off and climb to the altitude of flight have been made. If a head wind or a tail wind is anticipated, the gain or loss in true air speed will have to be considered in estimating the range and flying time. When an accurate determination of range is desired the fuel used in warm-up, take-off and climb should be subtracted from the initial amount of fuel on board to obtain the fuel available in flight and the weight of fuel used should be subtracted from the take-off gross weight to obtain the gross weight at which to enter the chart for finding R_1. Approximately 90 gallons of fuel may be allowed for warm-up and take-off and the fuel used in climb can be estimated from the Climb Control Chart, Figure 49.

EXAMPLE 1: Gross weight at 1000 ft. density altitude is 60,000 lb. with 2000 gallons of fuel available in flight. Find the maximum range attainable with no wind.

SOLUTION: Refer to the range and endurance prediction chart for 1000 ft. density altitude (Figure 41). Enter the chart at 60,000 lb. gross weight (point A) and read 650 nautical miles for R_1 on the line labeled "Maximum Range." As 2000 gallons of fuel are available for flying and since the weight of fuel is taken as 5.89 pounds per gallon, the weight of 2000 gallons of fuel that is to be consumed would be $5.89 \times 2000 = 11{,}780$ lb. Then the airplane would weigh 60,000 lb. $- 11{,}780 = 48{,}220$ lb. at the end of the flight (point B). Enter the chart at 48,220 lb. and read 2350 nautical miles for R_2 on the line labeled "Maximum Range." The maximum range for the airplane at a gross weight of 60,000 lb. and flying at a density altitude of 1000 feet with 2000 gallons of fuel available would then be $R_2 - R_1 = 2350 - 650 = 1700$ nautical miles.

The endurance or length of time for the trip is found in the same manner. Thus at 60,000 lb., E_1 is 4.5 hours and at 48,220 lb. E_2 is 17.5 hours. Then $E_2 - E_1 = 17.5$ hours $- 4.5 = 13.0$ hours.

EXAMPLE 2: Gross weight at 10,000 ft. density altitude is 62,000 lb. with a 6000 lb. bomb load and 2300 gallons of fuel available in flight. It is desired to bomb an objective 570 nautical miles distant and to reach the destination in three hours flying time with no wind. Determine if there is sufficient fuel remaining to make the return trip, flying the maximum range line.

SOLUTION: Refer to the Range and Endurance Prediction chart for 10,000 feet density altitude (Figure 43). To fly a distance of 570 nautical miles in three hours would require a speed of $570 \div 3 = 190$ knots. Enter the chart at 62,000 lb. and read R_3 to be 260 nautical miles on the line labeled "Range-True Speed 190 knots." The required distance of flight is 570 miles. Therefore, $R_3 + 570 = R_4 = 830$ nautical miles on the chart. Project vertically up at 830 miles intersecting the "190 knots" range line and read 55,900 lb. for the gross weight. In flying the 570 nautical miles the airplane consumed $62{,}000 - 55{,}900 = 6100$ lb. or 1035 gallons of fuel (at 5.89 lb. per gallon). At this point the bombs are dropped and the gross weight now becomes $55{,}900 - 6000 = 49{,}900$ lb. Enter the chart at 49,900 lb. and read R_5 on the "Maximum Range" line to be 2050 nautical miles. The return trip is 570 nautical miles so R_6 is then $R_5 + 570 = 2620$ nautical miles. Project vertically up at 2620 intersecting the "Maximum Range" line at 46,200 lb. gross weight. The amount of fuel burned on the return trip is $49{,}900 - 46{,}200 = 3700$ lb. (630 gallons). Since 1035 gallons are consumed in flying to the objective 1265 gallons are left for the return trip. Therefore, $1265 - 630 = 635$ gallons left over for reserve. The return trip would take 4 hours and consequently the entire flying time would be 7 hours. For this problem it can be seen that the return trip could be made at 190 knots, reducing the flying time.

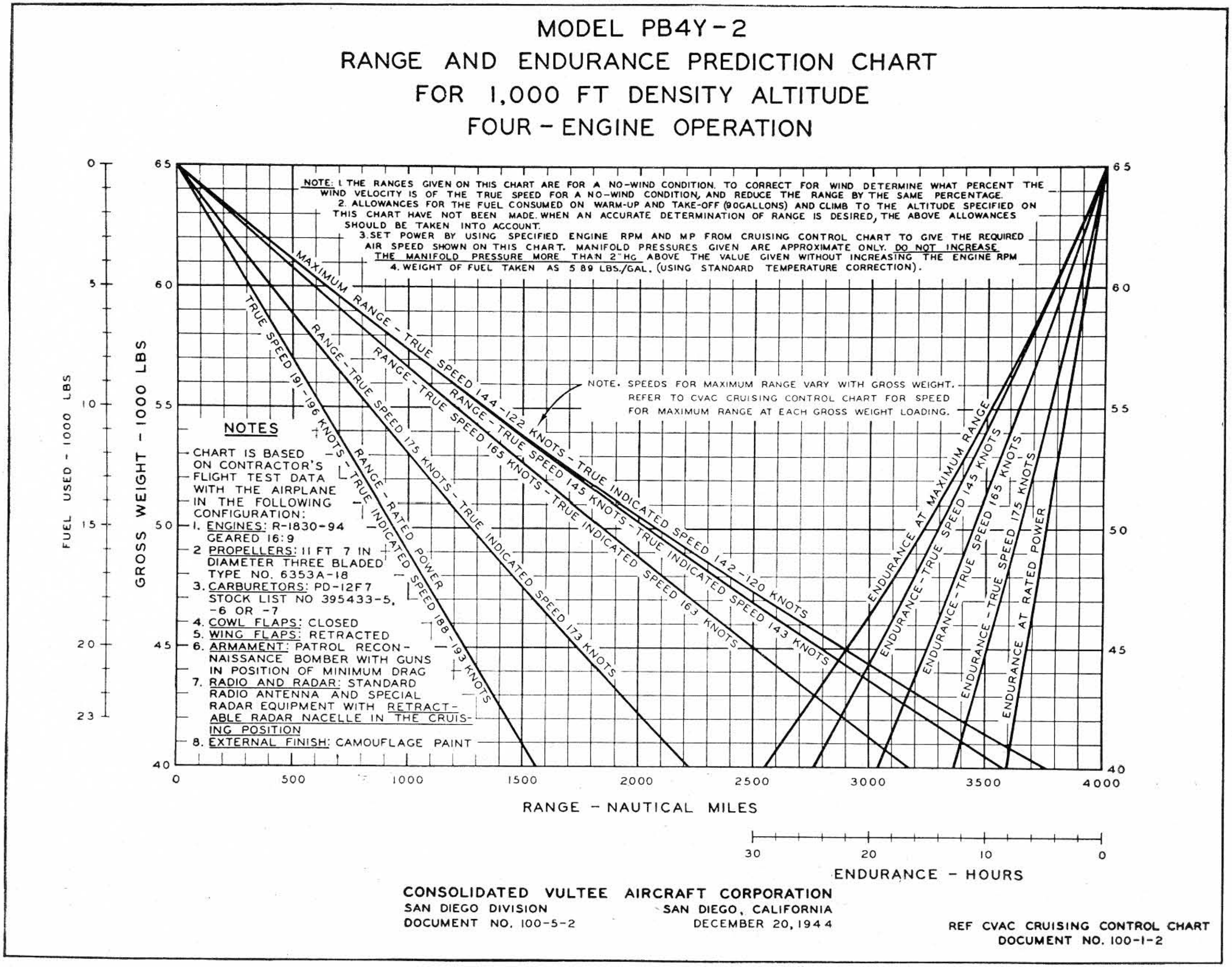


Figure 41—Range and Endurance Prediction Chart—1000 ft.—4 Engine

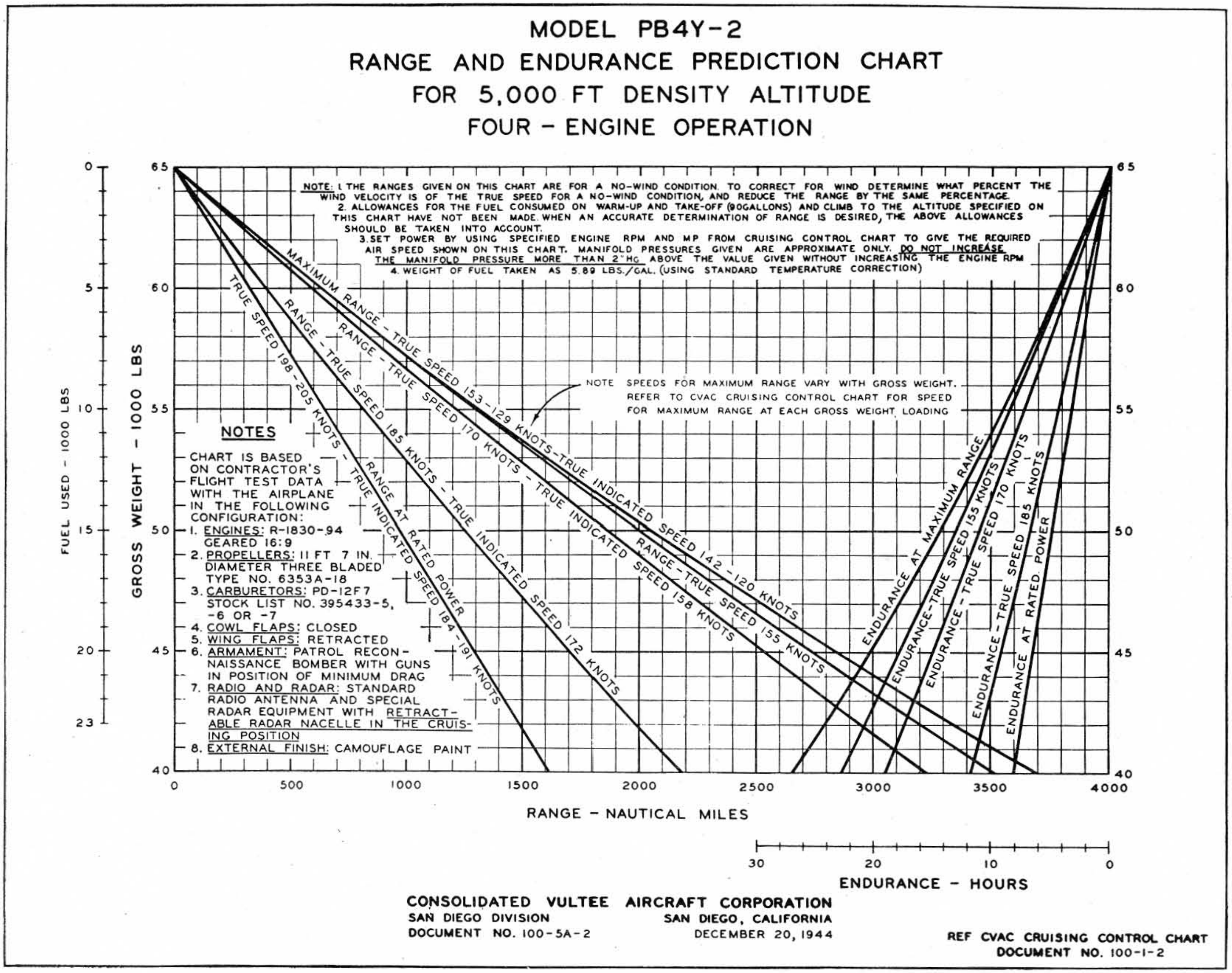


Figure 42—Range and Endurance Prediction Chart—5,000 ft.—4 Engine

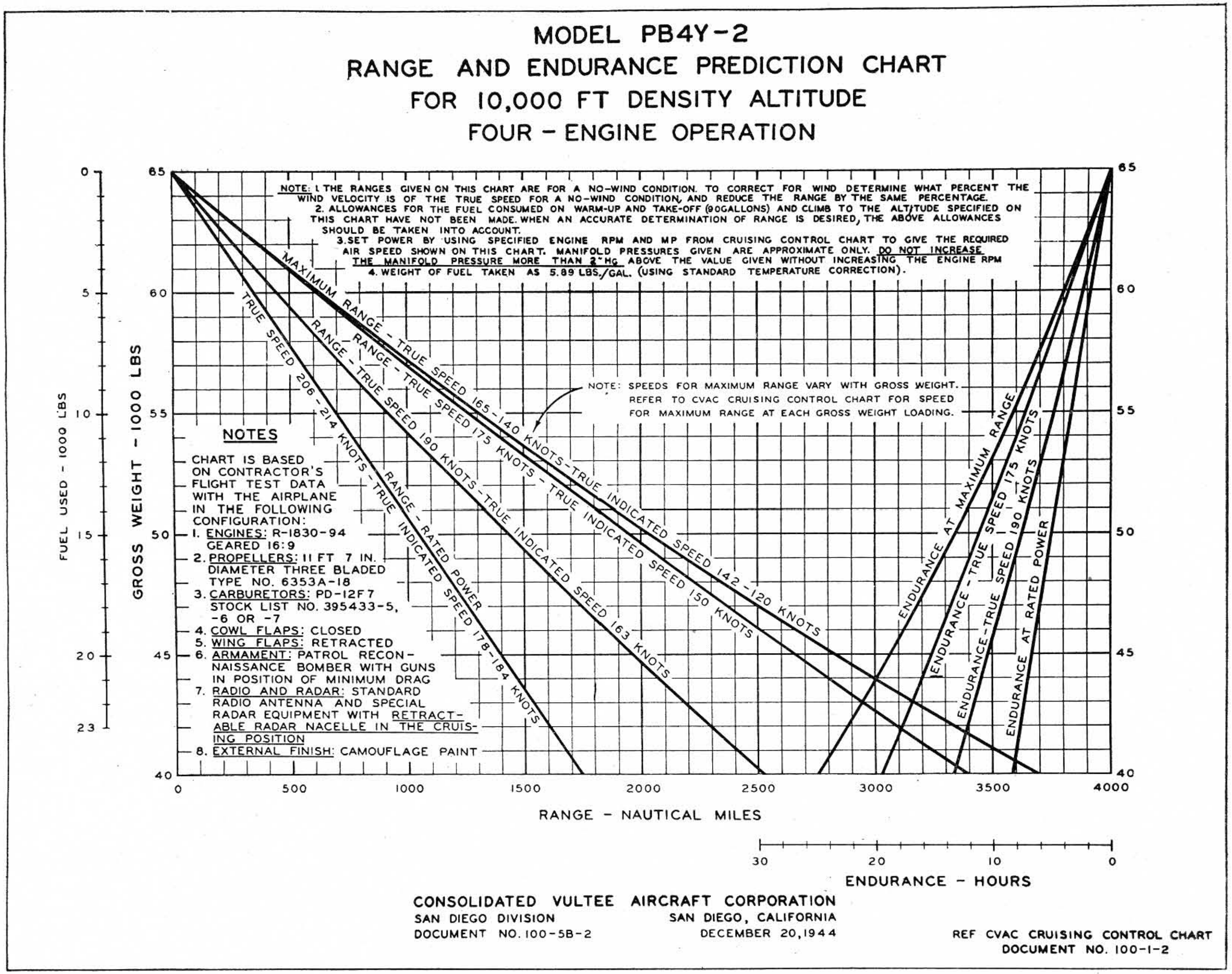


Figure 43—Range and Endurance Prediction Chart—10,000 ft.—4 Engine

EFFECT OF TEMPERATURE ON FUEL AND RANGE

Fuel expands and contracts with temperature changes. Thus one gallon of fuel would weigh more at a cold temperature and less at a warm temperature. Figure 44 indicates the weight per gallon of fuel at different temperatures and this chart may be used for accurately determining the weight of the fuel by knowing the temperature and number of gallons. It is usually assumed, for convenience in calculating, that fuel weighs 6.0 lb. per gallon. This assumption may be used for a quick and easy estimate. However, when large quantities of fuel are used it is quite important to calculate the weight correctly as it may sometimes mean a difference of several hundred pounds. For example 100 octane fuel at − 15° C. (5° F.) would weigh 6.105 lb. per gallon and 2000 gallons would then have a weight of 12,210 lbs. as compared to 12,000 lb. calculated on the 6.0 lb. per gallon assumption.

Calculations for the charts contained in this supplement are based upon a fuel weight of 5.89 lb. per gallon which is the weight per gallon of fuel at standard sea level temperature of 15° C. (59° F.). The range is proportional to the weight of fuel used, and as the fuel weight varies with temperature, the gallons of fuel should be corrected for any changes from the standard basis for an accurate calculation of the range. A quick and easy method of correcting for temperature is given by Figure 45.

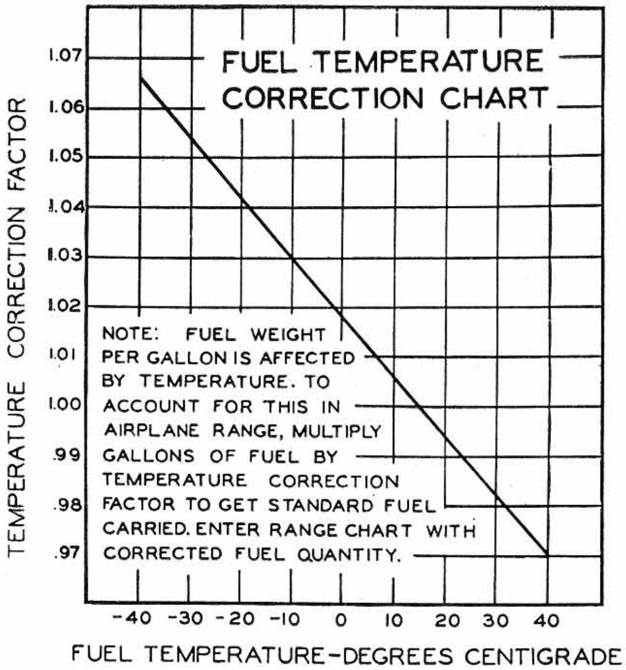


Figure 45—Fuel Temperature Correction Chart

EXAMPLE:

Fuel temperature = − 15° C. (5° F.)
Fuel in tanks = 2000 gallons
Correction factor = 1.036
Fuel quantity used to calculate range = 2000 × 1.036 = 2062 gallons

The fuel should be as cold as possible when the tanks are filled but expansion due to heat may cause the tanks to overflow. Figure 46 shows the percentage change in volume of fuel due to temperature change.

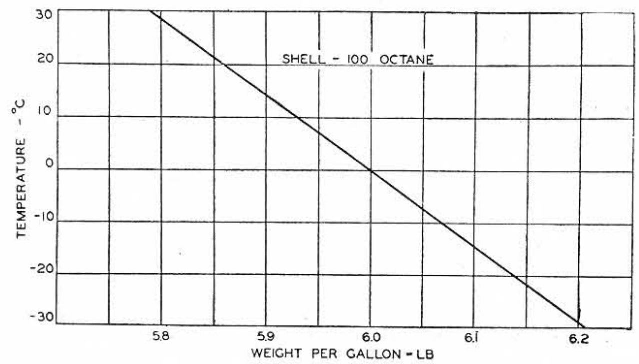


Figure 44—Fuel Weight/Temperature

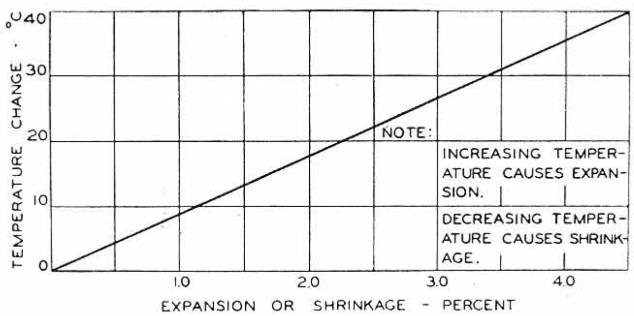


Figure 46—Fuel Expansion/Temperature

RATE OF CLIMB, TIME TO CLIMB, AND GROSS WEIGHT DECREASE CHARTS

(Document No. 100-13-1)
(Document No. 100-14-1)

The charts in Figures 47 and 48 are based on normal rated power climbs with cowl flap opening of 2½° topside and 5° bottom side, and wing flaps 0° to give the maximum rate of climb and minimum time to climb from sea level to a given density altitude. Rate of climb decreases with increasing gross weight, consequently time to climb increases with increasing gross weight. Increasing gross weight has the effect of lowering the service ceiling. The service ceiling is defined as that altitude at which the rate of climb is 100 ft. per minute for four-engine operation and 50 ft. per minute for less than four engine operation.

The speeds specified for the various gross weights are the ones that will give the best rates of climb. The climbing speed required increases with increasing gross weight. Climbing at speeds lower than those recommended may cause excessive engine overheating and climbing at faster than recommended speeds will reduce the rate of climb.

If a lower power than normal rated power is used for climb, the decrease in rate of climb can be approximated by using the following formula:

$$\text{Decrease in rate of climb (ft. per min.)} = \left[\frac{\left(\begin{cases}4000 \text{ for high blower}\\ \text{or}\\ 4400 \text{ for low blower}\end{cases} - \text{Total b.h.p. used}\right) \times 26{,}400}{\text{Initial Gross Weight}}\right]$$

EXAMPLE: Find the rate of climb at 5000 ft. density altitude for an airplane with an initial gross weight of 57,500 lb. climbing with 1000 brake horsepower per engine in low blower.

SOLUTION:

$$\text{Decrease in rate of climb} = \frac{(4400 - 4000) \times 26{,}400}{57{,}500} = 184 \text{ ft. per min.}$$

(Use 185)

Rate of climb at normal rated power from rate of climb chart = 900 ft. per min.

Rate of climb at 1000 brake horsepower per engine = 900 − 185 = 715 ft. per min.

The Gross Weight Decrease Chart makes allowance for 80 lb. fuel used as the approximate amount for take-off but does not include any allowance for fuel used in starting, warm-up and taxiing.

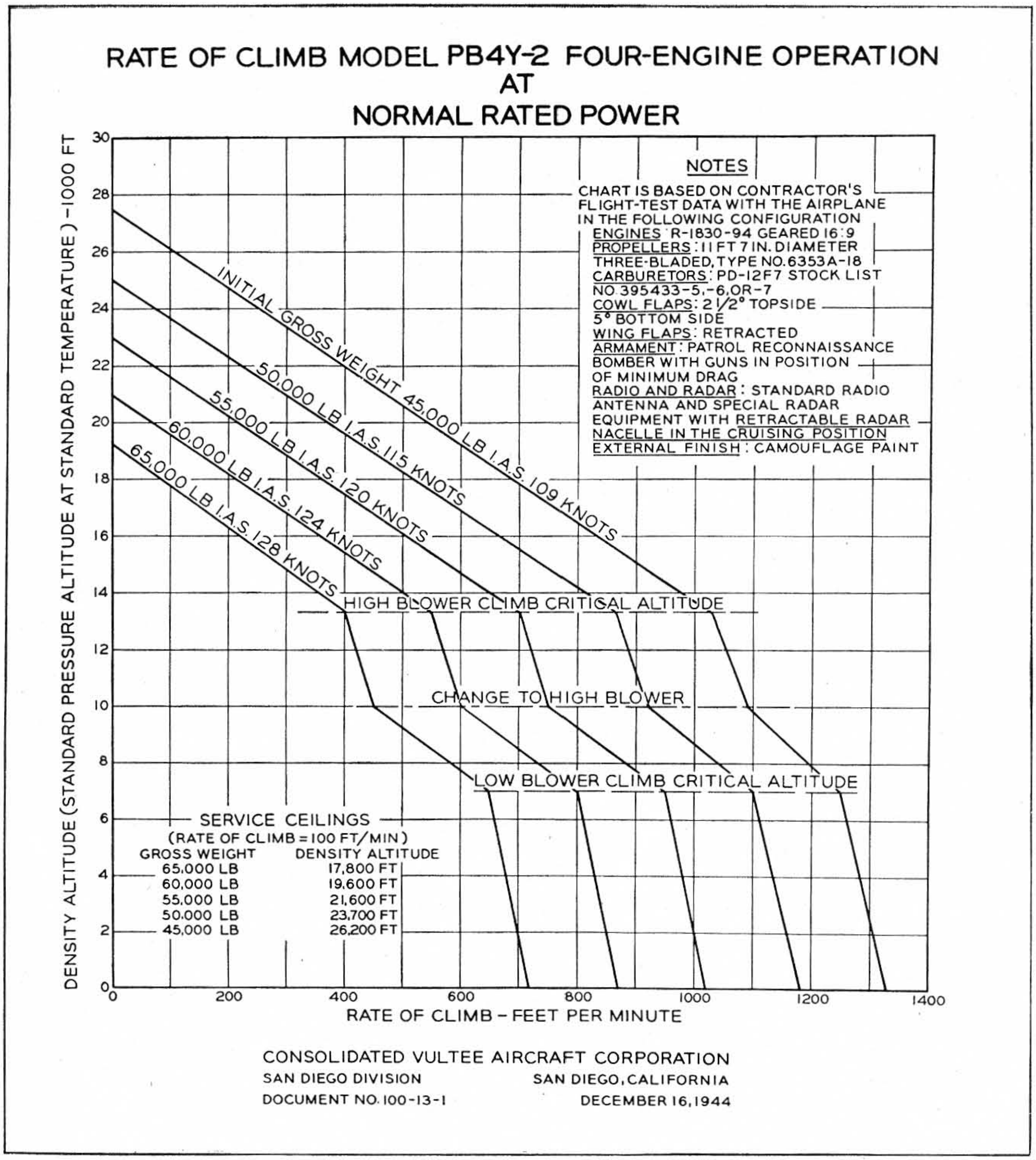


Figure 47—Rate of Climb—4 Engine

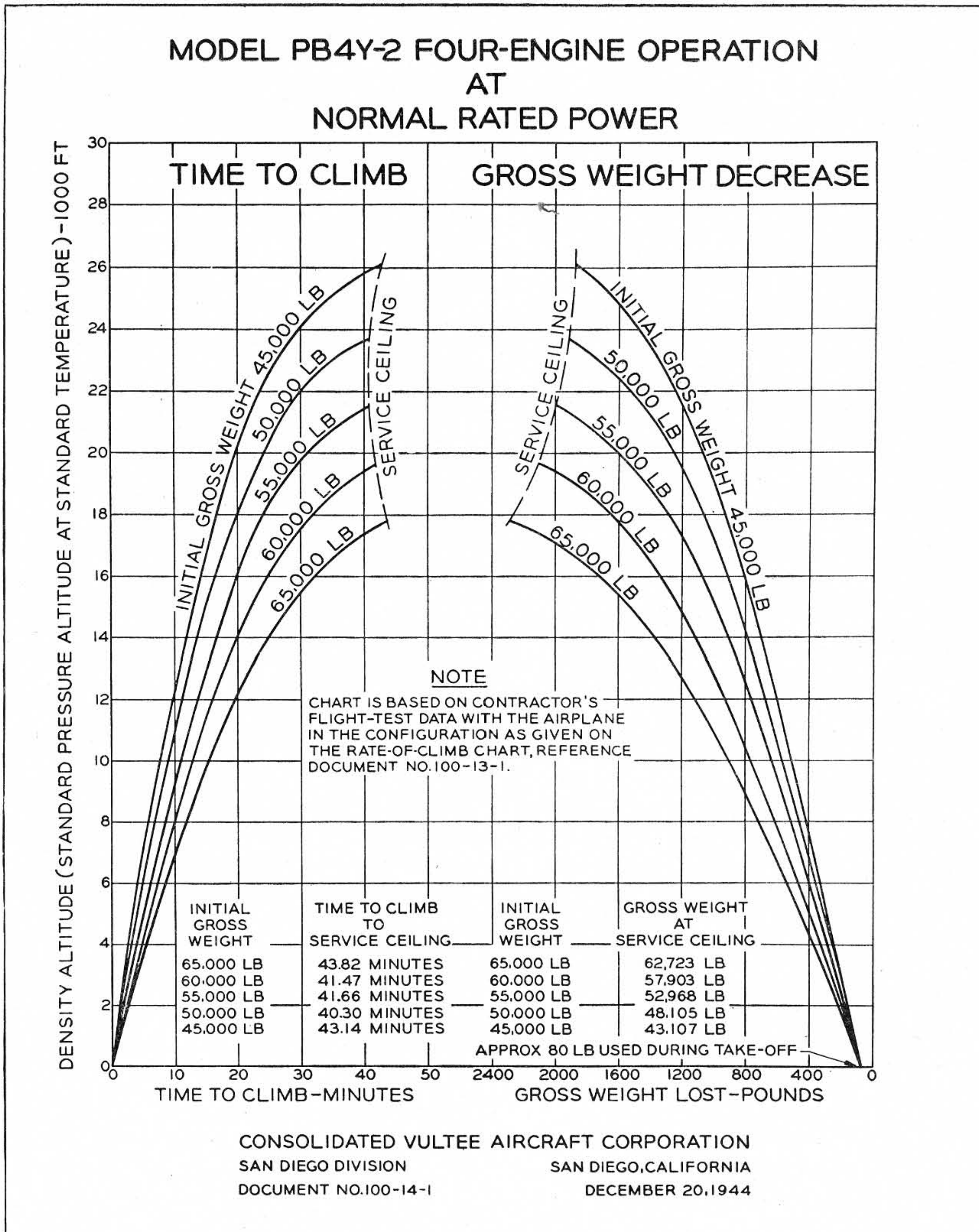


Figure 48—Time to Climb and Gross Weight Decrease—4 Engine

CLIMB CONTROL CHART

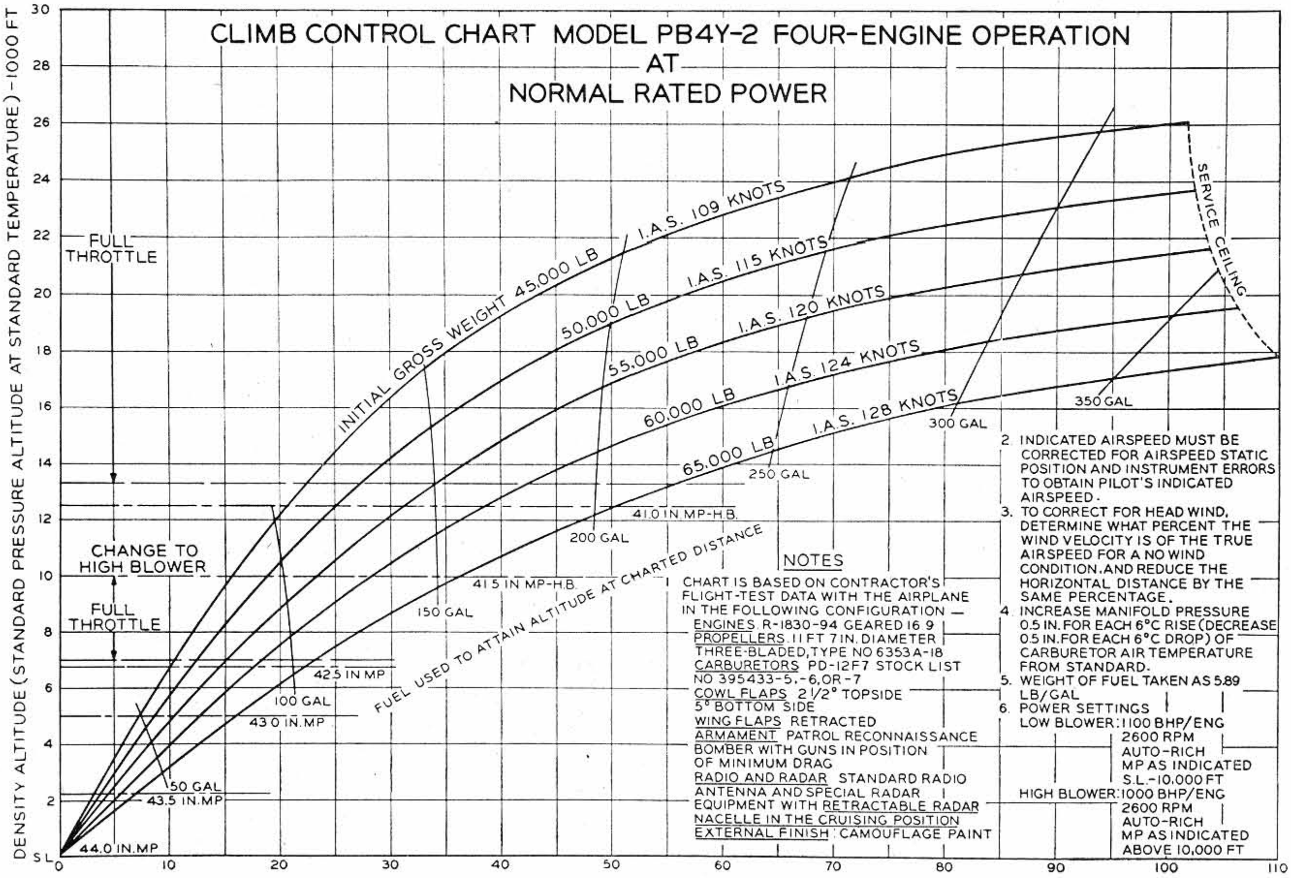
(Document No. 100-4-1)

The climb control chart (refer to Figure 49) shows the amount of fuel used and the distance traveled (with no wind) while climbing to altitude. No allowance for the fuel used in starting, warm-up and taxiing has been made on the chart.

The chart is calculated on the basis of rated power climb with cowl flap opening of 2½° top side and 5° bottomside. A minimum amount of fuel and time is used in attaining a given altitude if normal rated power is used for the climb. Climbing at powers lower than rated power will decrease the rate of climb and increase the total fuel consumed as well as the distance traveled during climb. Climbing at some speed faster than the values specified on the chart for a given gross weight will have the same effects as decreased power.

EXAMPLE: Determine horizontal miles traveled (with no wind) and fuel used to climb from sea level to 15,000 ft. density altitude with an initial gross weight of 62,000 lb.

SOLUTION: By interpolating between 65,000 lb. and 60,000 lb. initial gross weight the horizontal miles traveled at 15,000 ft. density altitude are approximately 57.5 nautical miles and the fuel consumed is approximately 225 gallons.

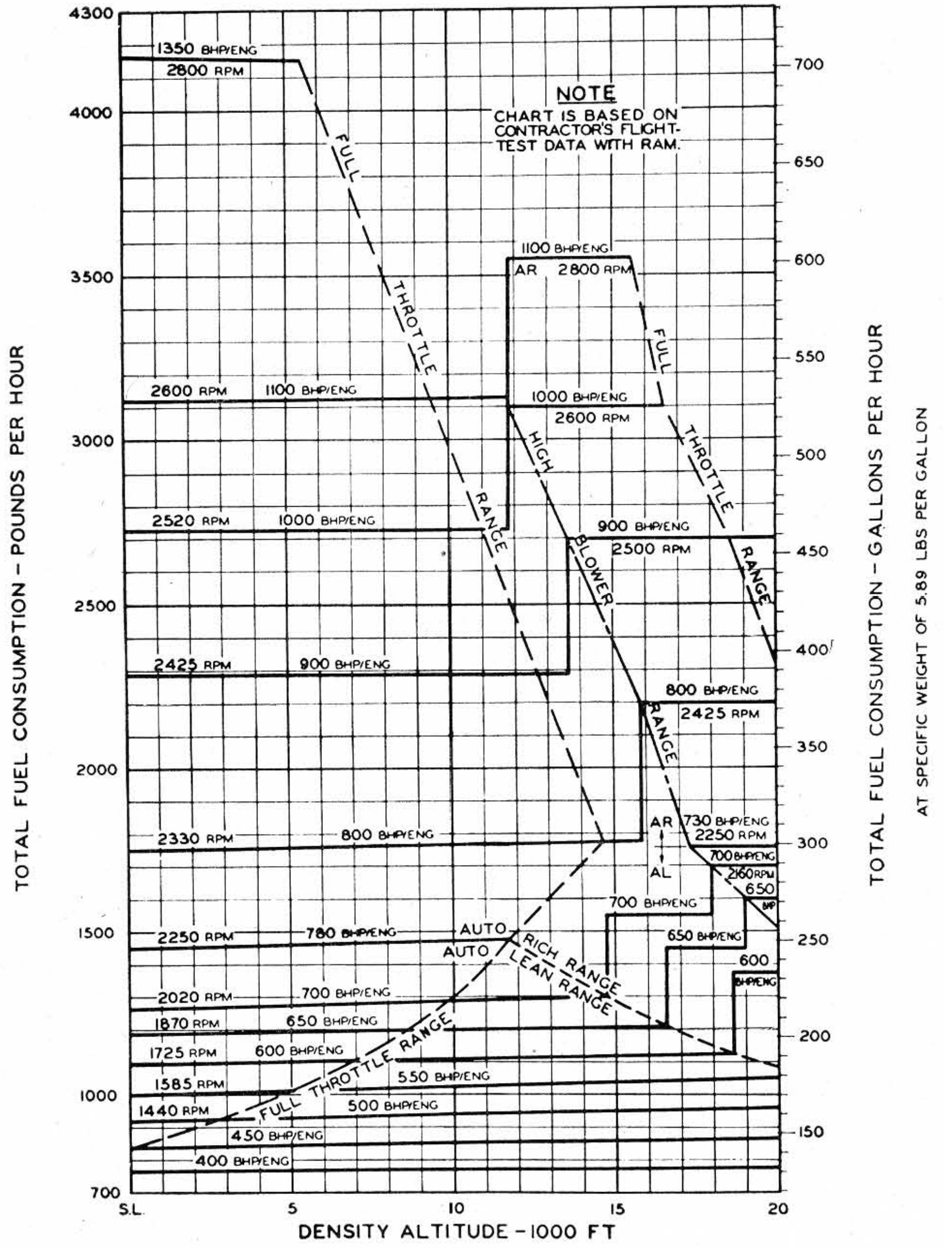


CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA
DOCUMENT NO. 100-4-1 — DECEMBER 13, 1944

Figure 49—Climb Control Chart—4 Engine

VARIATION OF FUEL CONSUMPTION WITH ALTITUDE
MODEL PB4Y-2
FOUR-ENGINE OPERATION

P & W R-1830-94 ENGINES
PD12F7 CARBURETOR
STOCK LIST NO. 395433-5,-6, OR-7



CONSOLIDATED VULTEE AIRCRAFT CORPORATION

SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA

DOCUMENT NO. 100-12-1 — NOVEMBER 22, 1944

Figure 50—Variation of Fuel Consumption with Altitude

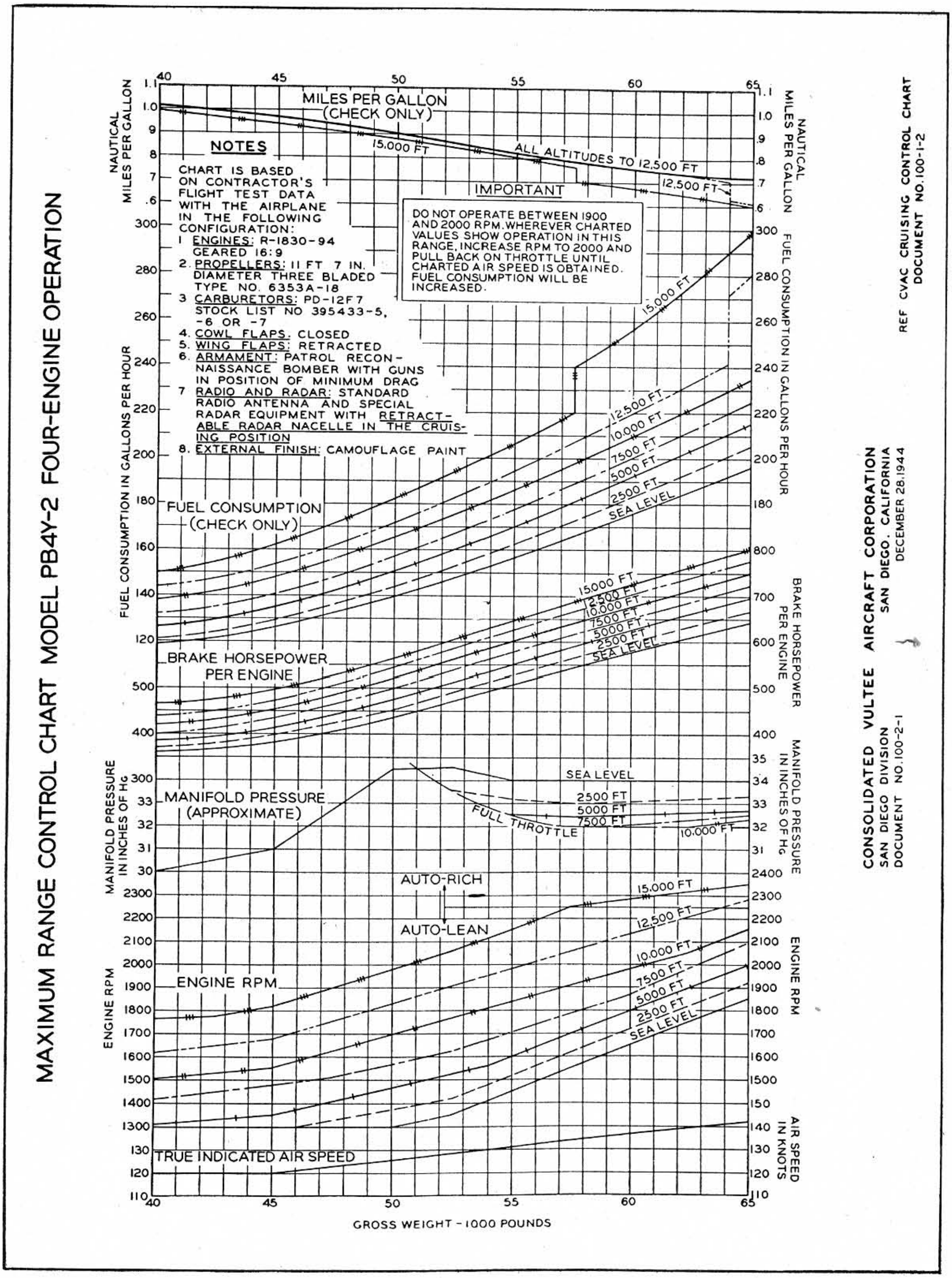


Figure 51—Maximum Range Control—4 Engine

MAXIMUM RANGE CONTROL CHART

(Document No. 100-2-1)

By using the Maximum Range Control Chart, Figure 51, the recommended true indicated air speed and power settings for obtaining maximum range are very easily and quickly read. The speeds and power settings given on this chart are determined from the cruising control chart and thus there is less chance for error as the weight correction has already been made.

Enter the chart with the desired gross weight, using the scale at the bottom of the chart. Project vertically, and at the proper altitude for each set of curves, read in turn:

1. True indicated air speed—To convert to pilot's indicated air speed correct for pitot position error and instrument error.
2. Engine r.p.m.
3. Manifold pressure.
4. Brake horsepower per engine.
5. Total fuel consumption (gallons per hour).
6. Miles per gallon.

Having picked off the conditions, in part-throttle operation, the r.p.m. is set first, then manifold pressure is varied to give the desired air speed. At charted speed and r.p.m., the manifold pressure will be high in hot weather, low in cold weather, when compared to charted values. *Manifold pressure should not be raised more than 2 inches above the charted value without raising r.p.m.*

In full throttle operation the r.p.m. is varied to give the charted air speed. For steady cruising it should not be necessary to reset power more often than each hour. Every three hours will probably be satisfactory.

EXAMPLE: (Taken from Maximum Range Control Chart, Figure 51).

GIVEN: Gross weight = 55,000 lbs.; Density altitude = 2500 ft.

SOLUTION: 1. True indicated air speed = 131 knots. To find the pilot's air-speed indicator reading turn to the air-speed installation correction *table previously given in this supplement. In this example, add 3.5 knots for the position error to obtain 134.5 knots. Assume a negligible instrument error.

2. Engine r.p.m. = 1520.

3. Manifold Pressure = 33.25 in. Hg (approximate).

4. Brake Horsepower = 52.5 b.h.p. per engine (approximate).

5. Fuel Flow = 162 gallons per hour (approximate).

6. Nautical Miles per gallon = .825 (approximate).

The Maximum Range Control Chart and the "Maximum Range Line" on the Cruising Control Chart are based upon air speeds which are recommended for operation with the automatic flight control. Occasions may arise wherein it is desirable to fly at a minimum speed with a minimum amount of power and fuel consumption. This condition is called Maximum Endurance and means staying in the air the longest possible time. Consequently, when the pilot wishes to fly at maximum endurance, he should switch to manual control, fly as slow as safety limitations and gross weight loading will permit by reducing engine power and go to the lowest safe altitude.

*This table shows the instrument readings to be higher than the true indicated air speed. Therefore, the true indicated air speed is obtained by subtracting the correction from the instrument reading. Thus, the true indicated air speed obtained from the maximum range control chart will be less than the instrument reading. To find what the instrument reading should be, it is necessary to add to the figure obtained from the maximum range control chart.

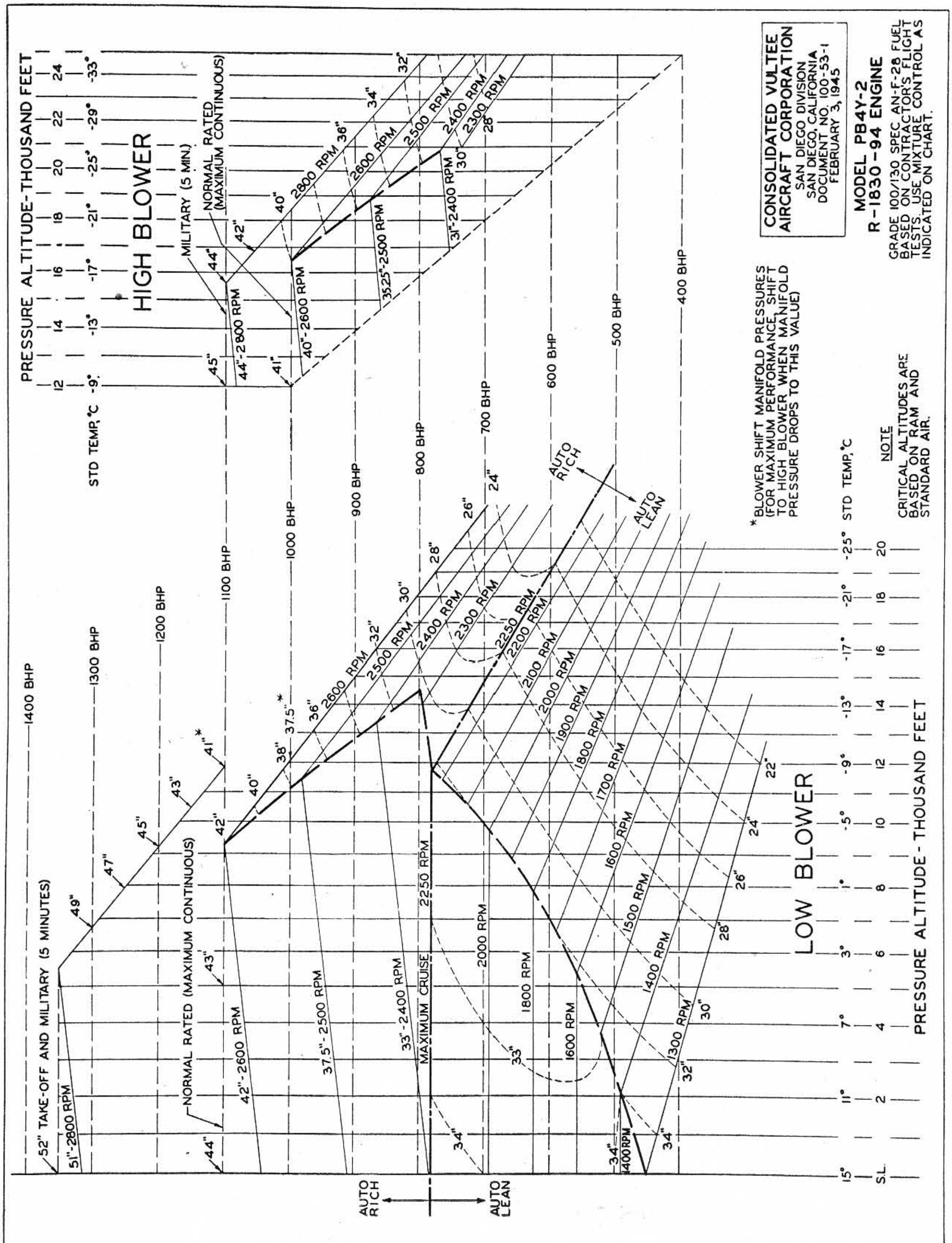


Figure 52—Engine Calibration Curves

ENGINE CALIBRATION CURVES

(Document No. 100-53-1)

The curves in Figure 52 can be used to set operating conditions or to determine engine power at any operating condition within the recommended operating limits of the engine. The curves to the left are for *low* blower operation; the curves to the right are for *high* blower operation. The horizontal dot-dash line indicates the limit for *Auto-Lean* mixture operation. Use *Auto-Rich* mixture above this line. Part-throttle conditions are those to the left of the oblique heavy dashed lines in both the *low* and *high* blower sections; full throttle conditions are those to the right of these lines.

High Power—*Auto-Rich* Mixture (Part-Throttle)

1. When high power climb is desired, operate along one of the constant manifold pressure-r.p.m. lines (sloping lines labeled with manifold pressure and *r.p.m.*). For constant rated power climb use 44 in. Hg at sea level decreasing to 43 in. Hg at 5000 feet.

2. Select level flight condition from a point on one of the designated lines, or, if an intermediate condition is desired, any manifold pressure-*r.p.m.* combination represented in the full throttle portions of the chart can be used for part-throttle operation.

Cruising Power—*Auto-Lean* Mixture (Part-Throttle)

1. For power conditions below the dot-dash line, the maximum recommended manifold pressures are independent of *r.p.m.*

To Determine Horsepower—Any Power Condition

1. Knowing *r.p.m.* and manifold pressure, spot the condition in the full throttle portion of the section of the chart for the blower ratio in which the engine is operating.

2. Draw a line through the point determined parallel to the constant manifold pressure-*r.p.m.* lines shown. Read horsepower at the intersection of this line with the observed pressure altitude.

3. Correct horsepower in accordance with carburetor air temperature (on an airplane not equipped with carburetor air temperature gauges use outside air temperature) by applying the following:

(a) Add 1 percent for each 6° C. decrease of carburetor air temperature from the standard temperature for the observed pressure altitude.

(b) Subtract 1 percent for each 6° C. rise of carburetor air temperature from standard.

The chart in Figure 53 is designed so that the pilot may determine quickly and easily the power settings for any desired BMEP up to the maximum permissible BMEP of 150 p.s.i. It also allows for correcting for variation of carburetor air temperature from standard.

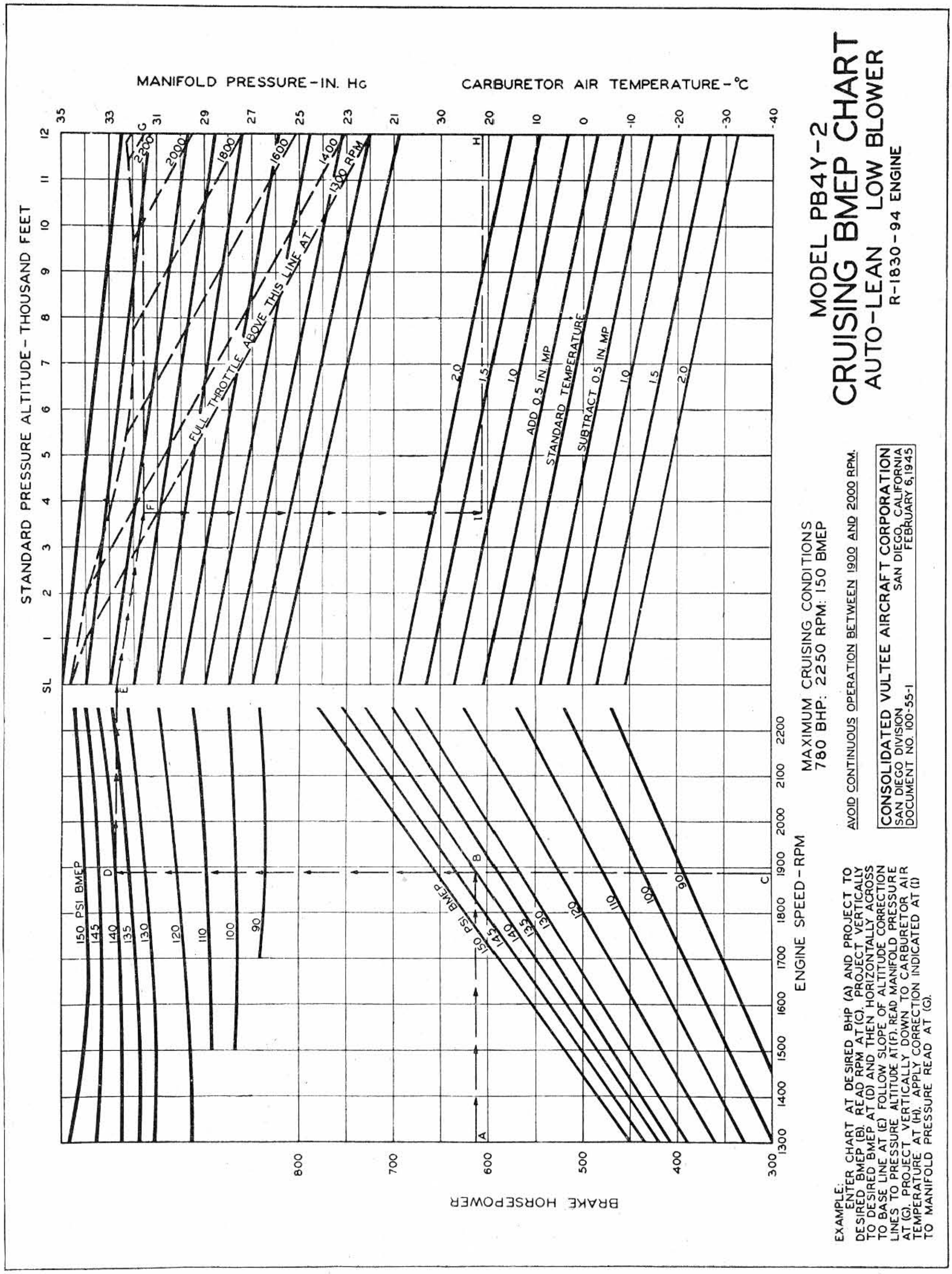


Figure 53—Cruising BMEP Chart—Auto Lean—Low Blower

CRUISING BMEP CHART—AUTO-LEAN—LOW BLOWER

(Document No. 100-55-1)

EXAMPLE: Find the power settings (r.p.m. and manifold pressure) to give 140 BMEP at 550 brake horsepower per engine at 7000 feet pressure altitude and 10° C. carburetor air temperature. (On airplanes not equipped with carburetor air temperature gauges assume the outside air temperature to be the same as the carburetor air temperature.)

SOLUTION: Enter chart at 550 brake horsepower and project to desired BMEP of 140. Read 1700 r.p.m. from the scale at the bottom. Project vertically to the curved line at the top left portion of the chart labeled "140." At this point project horizontally across to the base line or sea level altitude line and follow the slope of the altitude correction lines to the pressure altitude of 7000 feet. Read —— in. Hg manifold pressure horizontally across from the scale at the right. Project vertically down along the 7000 feet line until 10° C. outside air temperature is reached. This point lies in between the "add 0.5 in." and "1.0 in." manifold pressure correction lines; therefore add 0.75 in. to —— in. from the scale above to obtain —— in. as the manifold pressure gauge reading.

THREE-ENGINE OPERATION

{Document No. 100-31-1}

{Document No. 100-34-1}

{Document No. 100-34A-1}

{Document No. 100-34B-1}

{Document No. 100-36-1}

{Document No. 100-37-1}

{Document No. 100-32-1}

{Document No. 100-35-1}

The purpose of the three-engine flight operation charts is to show the performance attainable at this condition of flight. Three-engine operation is not recommended for normal use and these charts should be used only to determine the performance that may be expected in the event of the failure of one engine.

Flight tests were conducted on the airplane up to 10,000 feet density altitude with the No. 1 (left-hand outboard) engine inoperative and its propeller feathered. This is the worst condition for three-engine operation. As the three-engine charts included in this appendix are based upon the results of these flight tests, they should prove conservative for operation with either of the other three combinations of three engines operating.

The charts are similar to, and used in the same manner as, the charts included in the four-engine operation section. One new type of chart, however, is included. This is the Three-Engine Level Flight Ceiling Chart (see Figure 62). It is designed to show the ceiling or highest altitude at which level flight may be maintained at a given gross weight and power with the airplane flying only at the indicated air speed given on the scale at the bottom of the chart. Increasing the speed or lowering the angle of attach for the same condition of weight and power has the effect of reducing the ceiling.

THE FOLLOWING FACTS SHOULD BE KEPT IN MIND CONCERNING THREE-ENGINE OPERATION:

1. Air speed will be less than four-engine operation for a given total amount of power. Care should be exercised lest the head temperatures become excessive.

2. Since engine temperatures are likely to become critical at high altitudes, a gradual descent to the lowest practical level is recommended.

3. The r.p.m. and manifold pressure combinations which are used for normal operation should be satisfactory for the three-engine condition; but it has been found that cooling is improved somewhat by using higher r.p.m. and lower manifold pressure than those shown on the cruising control chart.

4. Note particularly on the Three-Engine Maximum Range Control Chart (see Figure 61) that in order to use the normal *Auto-Lean* mixture control limit, it is not possible to fly at high altitudes except at low gross weights. Conforming to an axiom "fly low and slow" will prove to give the best range and endurance with partial engine operation.

5. It is erroneous to assume that greater range and endurance can be obtained by flying on three engines instead of four. The drag of the airplane is increased with one engine dead and this, in turn, increases the power required to maintain flight under the same conditions. Even if there were no increase in drag, the added power required by the three operating engines to compensate for the loss of power of the fourth engine would increase or at least equal the total fuel flow with four engines so that the resulting miles per gallon would still be less than or equal to operation with four engines. An airplane weighing 55,000 lbs. is flying at the speed for maximum range at 5000 ft. density altitude with four engines operating. By referring to

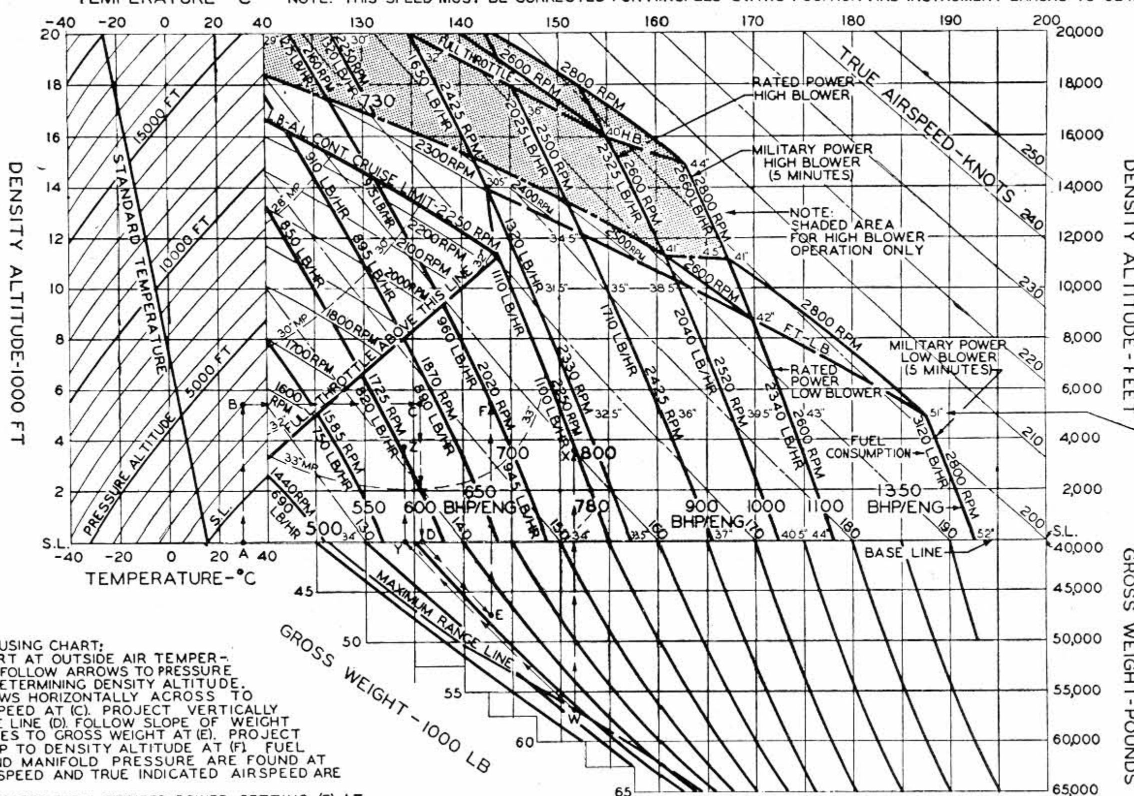
the four-engine cruising control chart or maximum range control chart the true air speed for maximum range for the above condition is determined to be 141 knots or 131 knots true indicated air speed. To maintain flight at this condition would require 550 brake horsepower per engine resulting in a fuel flow of 170 gallons per hour (1000 pounds per hour). This would result in 141 ÷ 170 = .83 nautical miles per gallon.

By referring to the Three-Engine Maximum Range Control Chart it can be seen that for the same conditions 750 b.h.p. per engine is required, resulting in 177 gallons per hour and .795 nautical miles per gallon.

COMPOSITE CRUISING CONTROL CHART MODEL PB4Y-2 THREE-ENGINE OPERATION

TRUE INDICATED AIRSPEED (CALIBRATED) - KNOTS

NOTE: THIS SPEED MUST BE CORRECTED FOR AIRSPEED STATIC POSITION AND INSTRUMENT ERRORS TO OBTAIN PILOT'S INDICATED AIRSPEED.



=51 IN. Hg MANIFOLD PRESSURE

NOTES

CHART IS BASED ON CONTRACTOR'S FLIGHT TEST DATA WITH THE AIRPLANE IN THE FOLLOWING CONFIGURATION:

1. ENGINES: R-1830-94 GEARED 16:9.
2. PROPELLERS: 11 FT 7 IN. DIAMETER THREE BLADED TYPE NO. 6353A-18
3. CARBURETORS: PD-12F7 STOCK LIST NO. 395433-5,-6 OR -7.
4. COWL FLAPS: CLOSED.
5. WING FLAPS: RETRACTED.
6. ARMAMENT: PATROL RECONNAISSANCE BOMBER WITH GUNS IN POSITION OF MINIMUM DRAG.
7. RADIO AND RADAR: STANDARD RADIO ANTENNA AND SPECIAL RADAR EQUIPMENT WITH RETRACTABLE RADAR NACELLE IN THE CRUISING POSITION.
8. EXTERNAL FINISH: CAMOUFLAGE PAINT.
9. DEAD ENGINE: NO 1 WITH PROPELLER FEATHERED.

IMPORTANT

DO NOT OPERATE BETWEEN 1900 AND 2000 RPM. WHEREVER CHARTED VALUES SHOW OPERATION IN THIS RANGE, INCREASE RPM TO 2000 AND PULL BACK ON THROTTLE UNTIL CHARTED AIR SPEED IS OBTAINED. FUEL CONSUMPTION WILL BE INCREASED.

ENGINE CYLINDER TEMPERATURE LIMITATIONS:

CONDITION	MAX CYL HEAD TEMP	MAX CYL BARREL TEMP
TAKE-OFF (5 MIN)	260°C	168°C
RATED POWER (ONE HOUR)	260°C	168°C
CONTINUOUS CRUISING	232°C	168°C

EXAMPLE FOR USING CHART:
ENTER CHART AT OUTSIDE AIR TEMPERATURE (A) AND FOLLOW ARROWS TO PRESSURE ALTITUDE (B). DETERMINING DENSITY ALTITUDE. FOLLOW ARROWS HORIZONTALLY ACROSS TO DESIRED AIRSPEED AT (C). PROJECT VERTICALLY DOWN TO BASE LINE (D). FOLLOW SLOPE OF WEIGHT VARIATION LINES TO GROSS WEIGHT AT (E). PROJECT VERTICALLY UP TO DENSITY ALTITUDE AT (F). FUEL FLOW, RPM AND MANIFOLD PRESSURE ARE FOUND AT (F). TRUE AIRSPEED AND TRUE INDICATED AIRSPEED ARE GIVEN AT (C).
TO FIND AIRSPEED FOR A DESIRED POWER SETTING (F) AT A DENSITY ALTITUDE REVERSE DIRECTIONS OF ARROWS GOING FROM (F) TO (E) TO (D) TO (C).

PROCEDURE FOR FLYING MAXIMUM RANGE:
ENTER CHART AT INTERSECTION OF GROSS WEIGHT AND MAXIMUM RANGE LINE (W). TO DETERMINE POWER, FUEL FLOW, RPM AND MANIFOLD PRESSURE PROJECT VERTICALLY UP TO FLIGHT DENSITY ALTITUDE (X). TO FIND TRUE INDICATED AIRSPEED FOLLOW SLOPE OF WEIGHT VARIATION LINES TO BASE LINE AT (Y). PROJECT TO DENSITY ALTITUDE AT (Z) TO FIND TRUE AIRSPEED

INCREASE MANIFOLD PRESSURE 0.5 IN. FOR EACH 6°C RISE (DECREASE 0.5 IN. FOR EACH 6°C DROP) OF CARBURETOR AIR TEMPERATURE FROM STANDARD. SEE NOTE NO. 2, FOR USE IN CRUISING FLIGHT

FUEL USED	0	500	1000	1500	2000	2500	3000	3500	3900	GALLONS
WEIGHT LOST	0	5000	10000	15000	20000					POUNDS

TO OBTAIN GROSS WEIGHT AT ANY POINT DURING FLIGHT SUBTRACT WEIGHT OF FUEL USED FROM INITIAL GROSS WEIGHT.

NORMAL RATED POWER: = 3 x 1100 BHP - LOW BLOWER
= 3 x 1000 BHP - HIGH BLOWER

TAKE-OFF POWER: = 3 x 1350 BHP/2800 RPM/52 IN MP. AUTO-RICH: LOW BLOWER ONLY.

IN LOW BLOWER: USE AUTO-RICH FOR 780 BHP AND ABOVE, AUTO-LEAN FOR 780 BHP AND BELOW.

IN HIGH BLOWER: USE AUTO-RICH FOR 730 BHP AND ABOVE, AUTO-LEAN FOR 730 BHP AND BELOW.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO DIVISION
DOCUMENT NO. 100-31-1
SAN DIEGO, CALIFORNIA
JANUARY 2, 1945

FOR USE IN CRUISING FLIGHT

1. DETERMINE DENSITY ALTITUDE. SET POWER TO CHARTED VALUES AS GIVEN TO OBTAIN DESIRED AIRSPEED.
2. AIRSPEED WILL BE LOW IN HOT WEATHER, HIGH IN COLD, WHEN COMPARED TO CHARTED VALUES. JOCKEY POWER SLIGHTLY AS REQUIRED. INCREASE MANIFOLD PRESSURE TO INCREASE SPEED, (PART THROTTLE OPERATION) UNTIL CHARTED AIRSPEED IS OBTAINED. DO NOT INCREASE MANIFOLD PRESSURE MORE THAN 2 IN. WITHOUT RAISING RPM. FOR FULL THROTTLE OPERATION SET POWER BY RPM SPECIFIED ON CHART. IF RESULTING SPEED IS TOO LOW, INCREASE RPM
3. IN NORMAL AUTO-LEAN OPERATION DO NOT EXCEED 2250 RPM, 780 BHP AND 150 BMEP FOR LOW BLOWER AND 2250 RPM, 730 BHP AND 140 BMEP FOR HIGH BLOWER.
4. BMEP = 433 x (BHP/RPM).
5. FOR STEADY CRUISING IT SHOULD NOT BE NECESSARY TO RESET POWER MORE OFTEN THAN EACH HOUR. EVERY 3 HOURS WILL PROBABLY BE SATISFACTORY.
6. MAXIMUM RECOMMENDED CARBURETOR AIR TEMPERATURE FOR SAFE OPERATION IN HIGH BLOWER IS 16°C.

Figure 54—Cruising Control Chart—3 Engine

AAFMC-527 4-1-44

AIRCRAFT MODEL(S) PB4Y-2

THREE-ENGINE TAKE-OFF, CLIMB & LANDING CHART

ENGINE MODEL(S) R-1830-94

TAKE-OFF DISTANCE FEET

GROSS WEIGHT LB.	HEAD WIND M.P.H.	HEAD WIND KTS.	HARD SURFACE RUNWAY AT SEA LEVEL GROUND RUN	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND RUN	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND RUN	TO CLEAR 50' OBJ.	SOD-TURF RUNWAY AT SEA LEVEL GROUND RUN	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND RUN	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND RUN	TO CLEAR 50' OBJ.	SOFT SURFACE RUNWAY AT SEA LEVEL GROUND RUN	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND RUN	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND RUN	TO CLEAR 50' OBJ.
40,000	0	0	3120	3980	3850	4980	4540	6280	3720	4560	4140	5240	5310	7040	5150	5990	6260	7360	7790	9500
	12	10	2400	3060	2980	3830	3570	4940	2850	3500	3200	4050	4180	5410	3940	4590	4850	5820	6130	7470
	23	20	1810	2300	2280	2720	2770	3820	2150	2640	2450	3100	3240	4300	2980	3470	3700	4350	4750	5800
	35	30	1260	1610	1625	2090	2020	2790	1500	1840	1750	2210	2360	3130	2080	2420	2650	3120	3460	4240
45,000	0	0	4400	5600	5310	7060	6410	9960	5170	6360	6130	7880			8440	9640	10660	12410		
	12	10	3420	4350	4190	5580	5110	7950	4040	4960	4840	6210			6570	7500	8410	9800		
	23	20	2640	3350	3280	4360	4040	6280	3110	3810	3780	4860			5060	5770	6590	7670		
	35	30	1900	2410	2400	3190	3010	4690	2240	2750	2760	3550			3650	4160	4820	5610		
50,000	0	0	6100	7800	7500	10650			7480	9170	9190	12320								
	12	10	4810	6150	6000	8520			5900	7240	7350	9850								
	23	20	3780	4840	4760	6760			4630	5690	5830	7830								
	35	30	2790	3560	3580	5070			3420	4210	4370	5860								

NOTE: INCREASE CHART DISTANCES AS FOLLOWS: 75°F + 10%; 100°F + 20%; 125°F + 30%; 150°F + 40% OPTIMUM TAKE-OFF WITH 2800 RPM, 52.0 IN.HG. & 30 DEG. FLAP IS 80% OF CHART VALUES

DATA AS OF DEC 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA ON HARD SURFACE RUNWAY AT SEA LEVEL WITH ZERO WIND AND NO. 1 PROPELLER FEATHERED

CLIMB DATA

GROSS WEIGHT LB.	AT SEA LEVEL BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	GAL. OF FUEL USED	AT 5000 FEET BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	FROM SEA LEVEL TIME MIN.	FUEL USED	AT 10,000 FEET BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	FROM SEA LEVEL TIME MIN.	FUEL USED	AT 15,000 FEET BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	FROM SEA LEVEL TIME MIN.	FUEL USED	AT 17,500 FEET BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	FROM SEA LEVEL TIME MIN.	FUEL USED	AT FEET BEST I.A.S. MPH	KTS	RATE OF CLIMB F.P.M.	FROM SEA LEVEL TIME MIN.	FUEL USED
45,000	126	109	705	70	126	109	660	7.0	115	126	109	455	16.0	175	126	109	325	28.0	255	126	109	180	38.5	325					
50,000	133	115	605	70	133	115	560	8.5	125	133	115	360	19.0	195	133	115	230	34.5	300	133	115	80	51.5	410					
55,000	138	120	510	70	138	120	460	10.0	135	138	120	260	23.0	220	138	120	130	46.5	380										

POWER PLANT SETTINGS: (DETAILS ON FIG. SECTION III):

DATA AS OF DEC 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA

FUEL USED (U.S. GAL.) INCLUDES WARM-UP & TAKE-OFF ALLOWANCE

LANDING DISTANCE FEET

GROSS WEIGHT LB.	BEST IAS APPROACH POWER OFF MPH	KTS	POWER ON MPH	KTS	HARD DRY SURFACE AT SEA LEVEL GROUND ROLL	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND ROLL	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND ROLL	TO CLEAR 50' OBJ.	FIRM DRY SOD AT SEA LEVEL GROUND ROLL	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND ROLL	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND ROLL	TO CLEAR 50' OBJ.	WET OR SLIPPERY AT SEA LEVEL GROUND ROLL	TO CLEAR 50' OBJ.	AT 3000 FEET GROUND ROLL	TO CLEAR 50' OBJ.	AT 6000 FEET GROUND ROLL	TO CLEAR 50' OBJ.
40,000	110	95	105	91	1710	2380	1830	2490	1950	2620	1880	2550	2000	2680	2150	2830	4900	5550	5300	5960	5710	6400
56,000	121	105	115	100	2200	3620	2380	3800	2540	3960	2390	3930	2570	4100	2690	4300	6680	8090	7240	8650	7890	9290

DATA AS OF DEC 1944 BASED ON: CALCULATIONS FROM FLIGHT TEST DATA ON HARD SURFACE RUNWAY AT SEA LEVEL WITH ZERO WIND

OPTIMUM LANDING IS 80% OF CHART VALUES

REMARKS:

1. TAKE-OFF WITH OUTBOARD ENGINE DEAD SHOULD BE LIMITED TO 50,000 POUNDS GROSS WEIGHT.
2. TAKE-OFF WITH INBOARD ENGINE DEAD SHOULD BE LIMITED TO 55,000 POUNDS GROSS WEIGHT.
3. TO DETERMINE TAKE-OFF DISTANCES WITH DEAD INBOARD ENGINE ADD 5000 POUNDS TO LISTED GROSS WEIGHTS AND USE CORRESPONDING CHARTED VALUES.
4. FOR THREE-ENGINE TAKE-OFF TECHNIQUE SEE SECTION II PARAGRAPH 8.

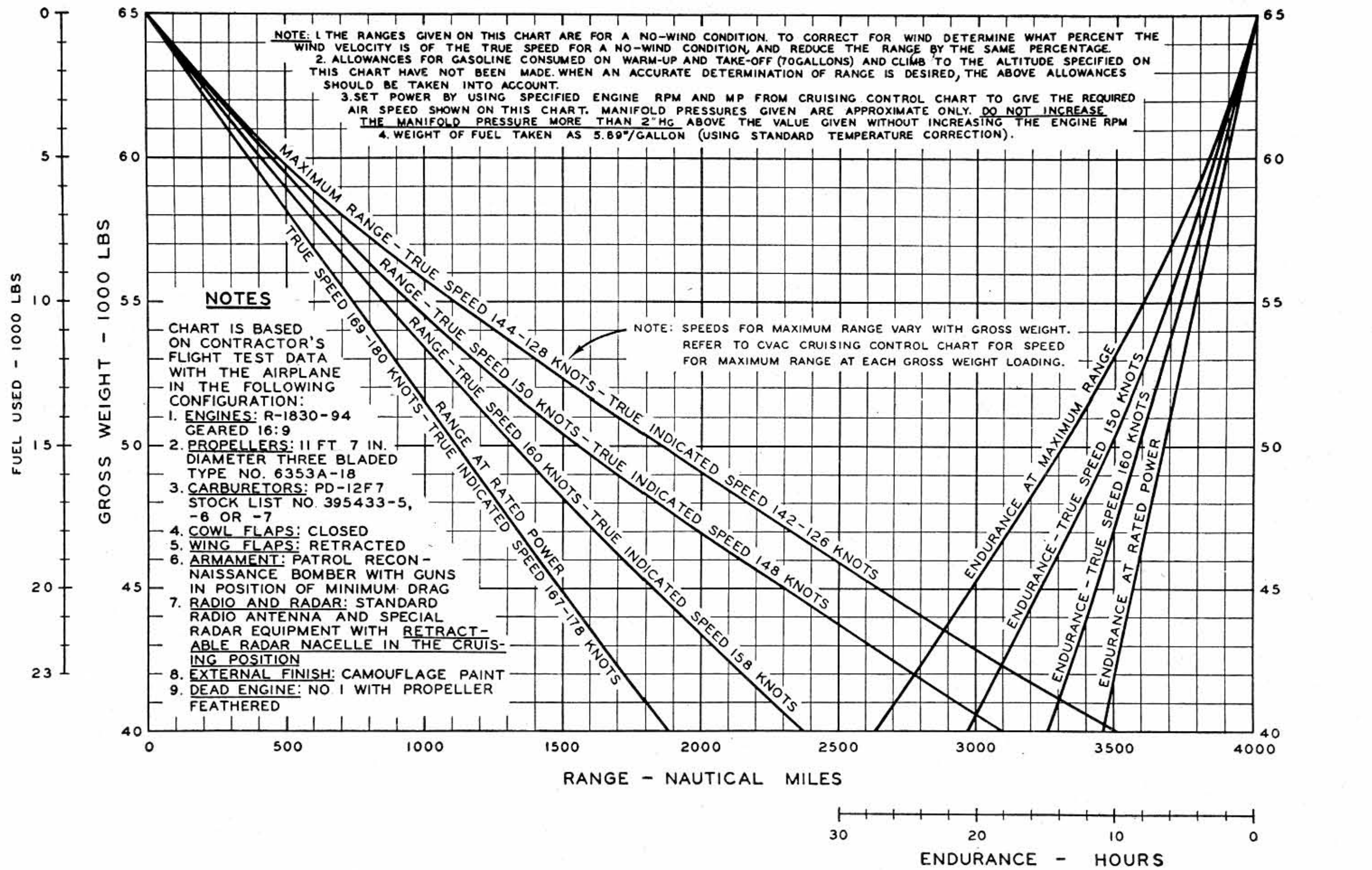
NOTE: TO DETERMINE FUEL CONSUMPTION IN BRITISH IMPERIAL GALLONS, MULTIPLY BY 10, THEN DIVIDE BY 12

LEGEND

I.A.S. : INDICATED AIRSPEED
M.P.H. : MILES PER HOUR
KTS. : KNOTS
F.P.M. : FEET PER MINUTE

Figure 55—Three Engine Take-off, Climb, and Landing

MODEL PB4Y-2
RANGE AND ENDURANCE PREDICTION CHART
FOR 1,000 FT DENSITY ALTITUDE
THREE - ENGINE OPERATION



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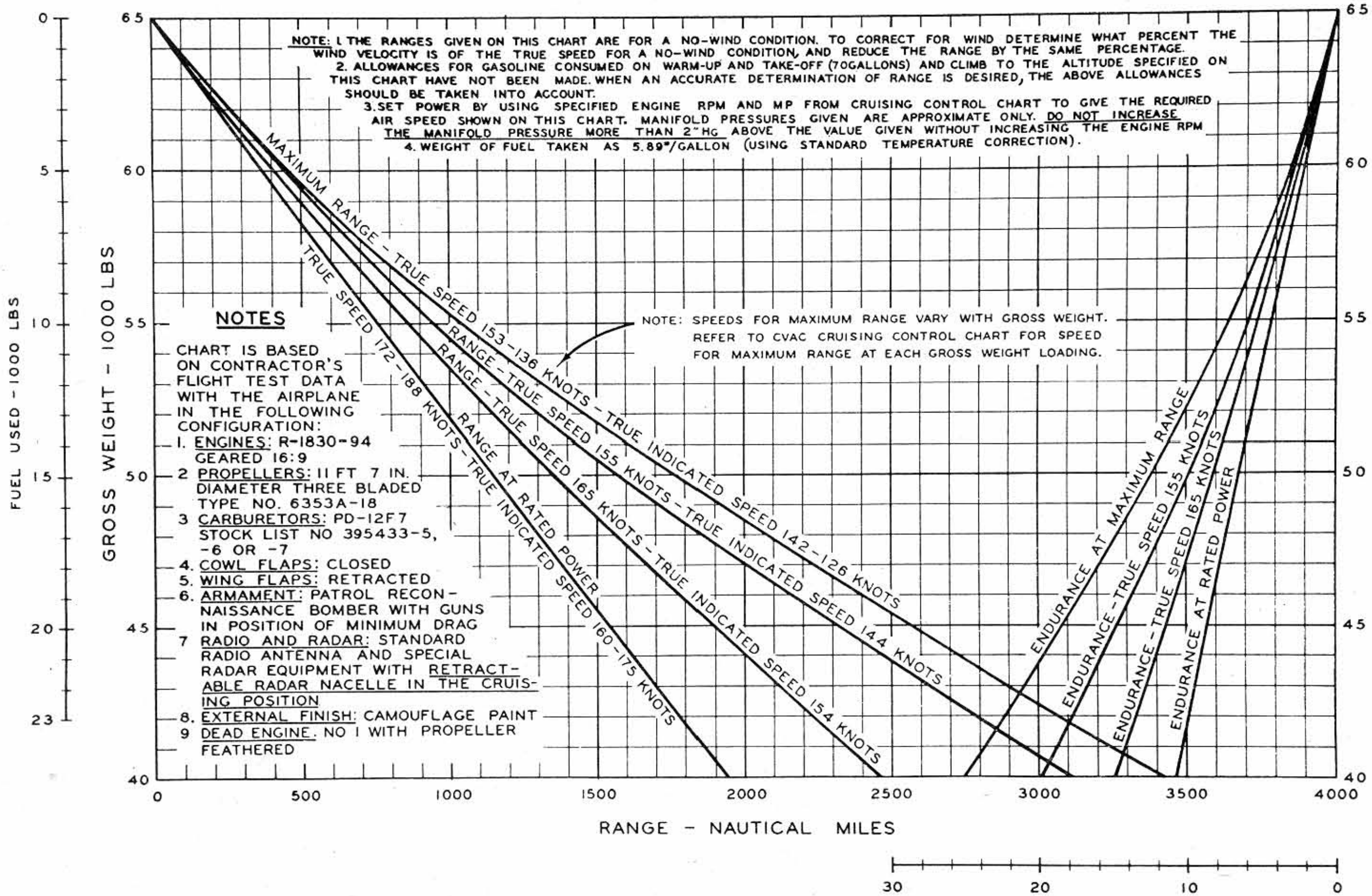
SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA
DOCUMENT NO. 100-34-1 — JANUARY 5, 1945

REF CVAC CRUISING CONTROL CHART
DOCUMENT NO. 100-31-1

Figure 56—Range and Endurance—1,000 ft.—3 Engine

MODEL PB4Y-2
RANGE AND ENDURANCE PREDICTION CHART
FOR 5,000 FT DENSITY ALTITUDE
THREE - ENGINE OPERATION



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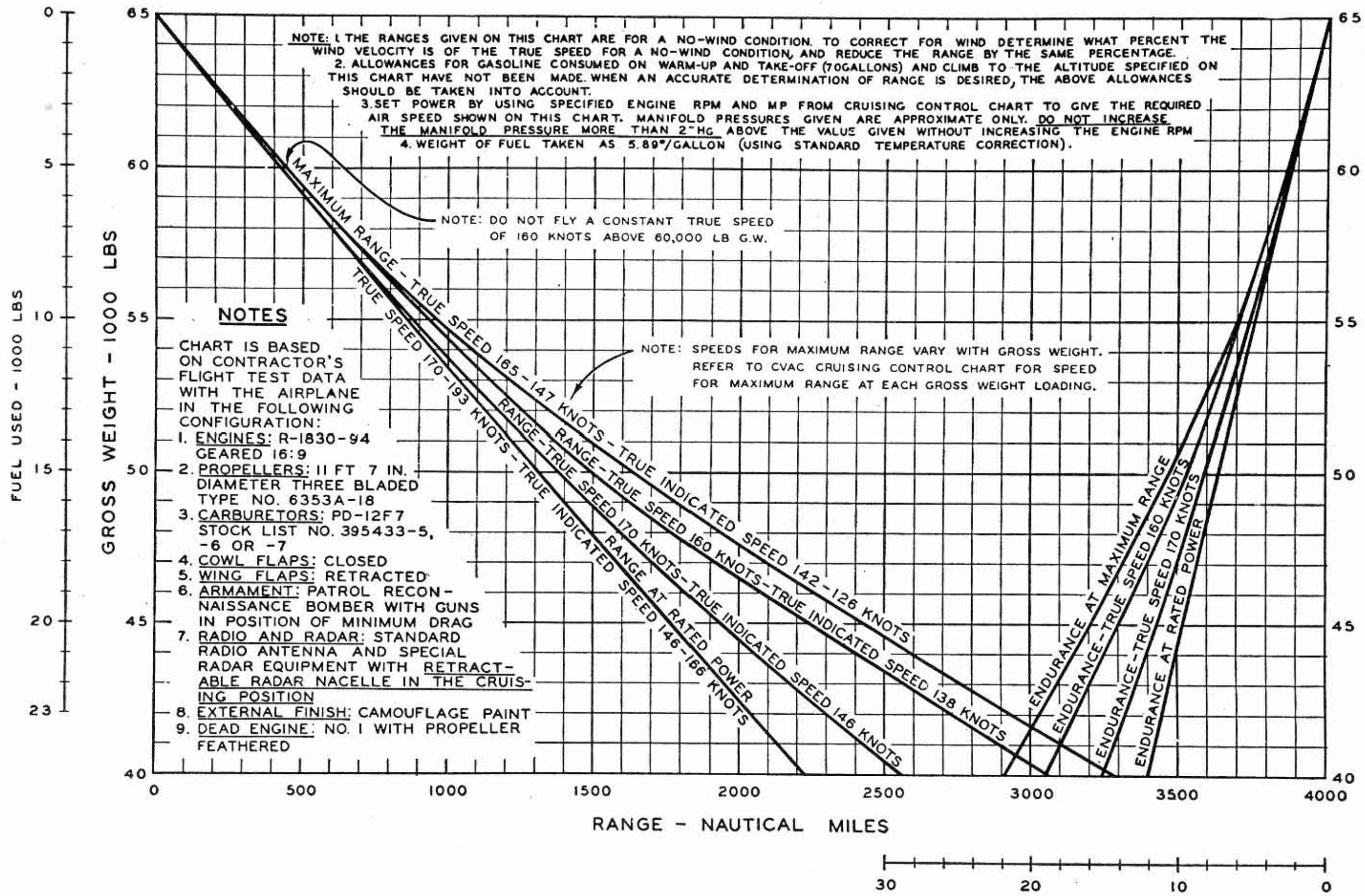
SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA
DOCUMENT NO. 100-34A-1 — JANUARY 5, 1945

REF CVAC CRUISING CONTROL CHART
DOCUMENT NO. 100-31-1

Figure 57—Range and Endurance—5,000 ft.—3 Engine

MODEL PB4Y-2
RANGE AND ENDURANCE PREDICTION CHART
FOR 10,000 FT DENSITY ALTITUDE
THREE - ENGINE OPERATION



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SAN DIEGO DIVISION — SAN DIEGO, CALIFORNIA
DOCUMENT NO. 100-34B-1 — JANUARY 5, 1945

REF CVAC CRUISING CONTROL CHART
DOCUMENT NO. 100-31-1

Figure 58—Range and Endurance—10,000 ft.—3 Engine

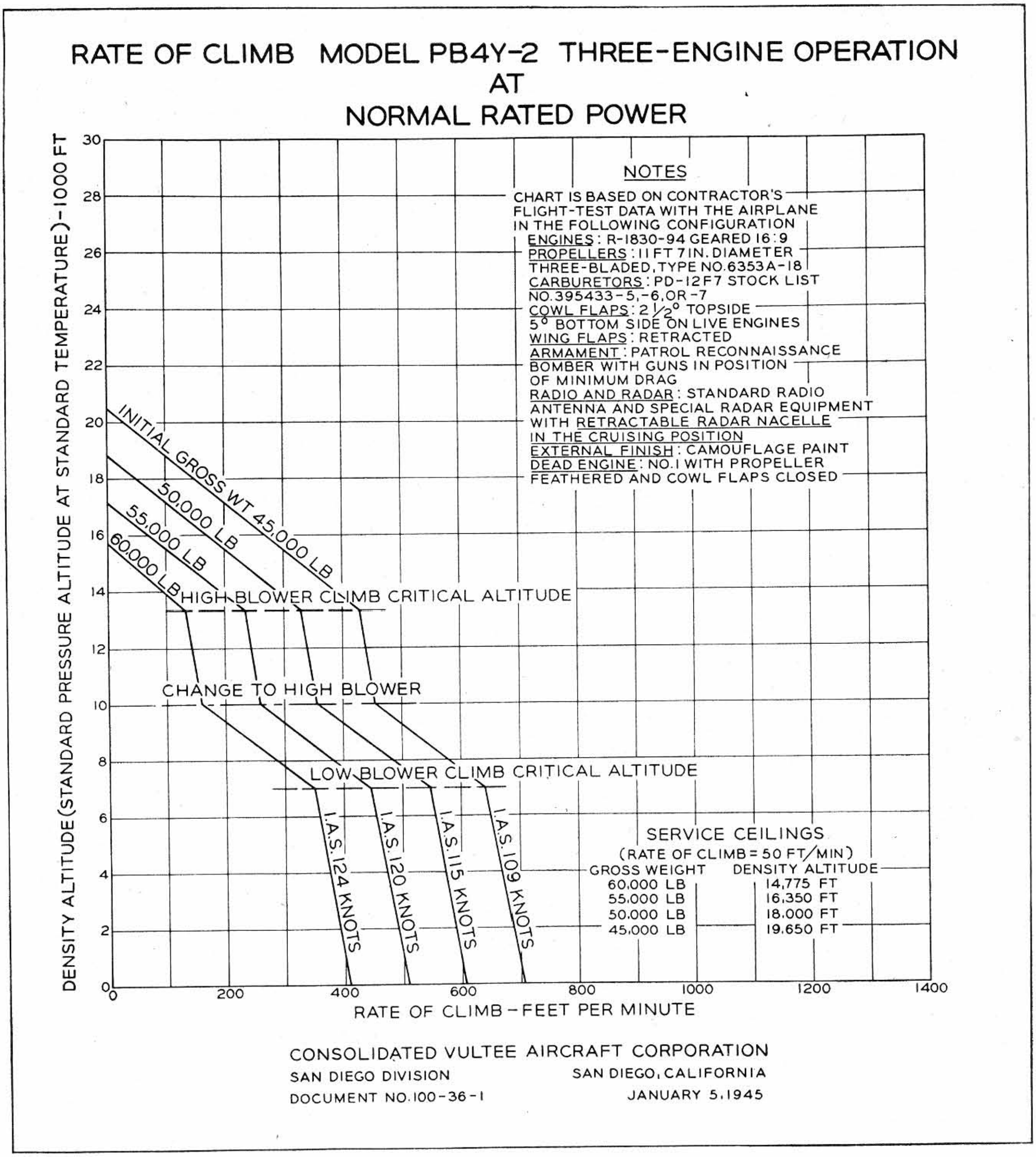

Figure 59—Rate of Climb—3 Engine

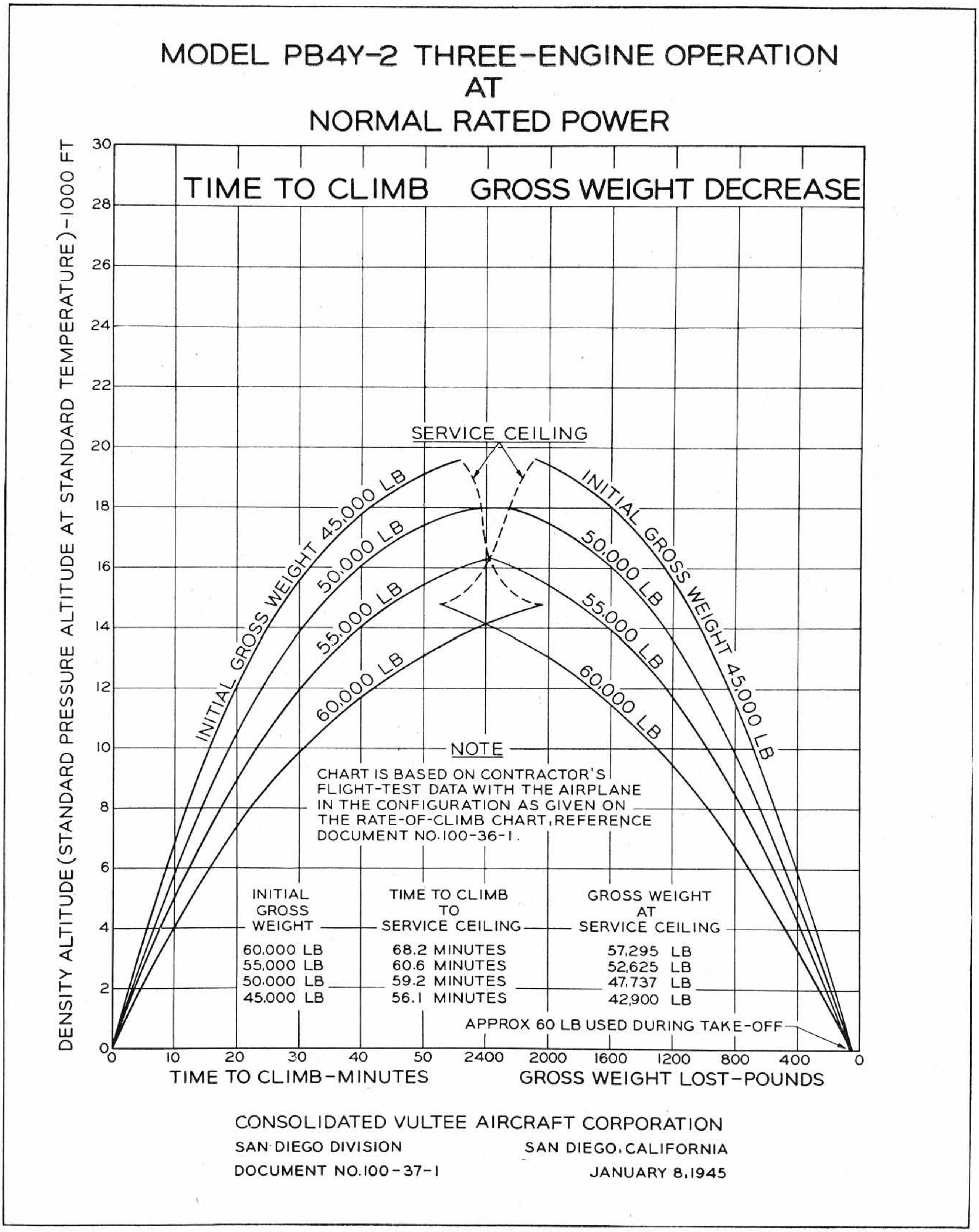

Figure 60—Time to Climb—3 Engine

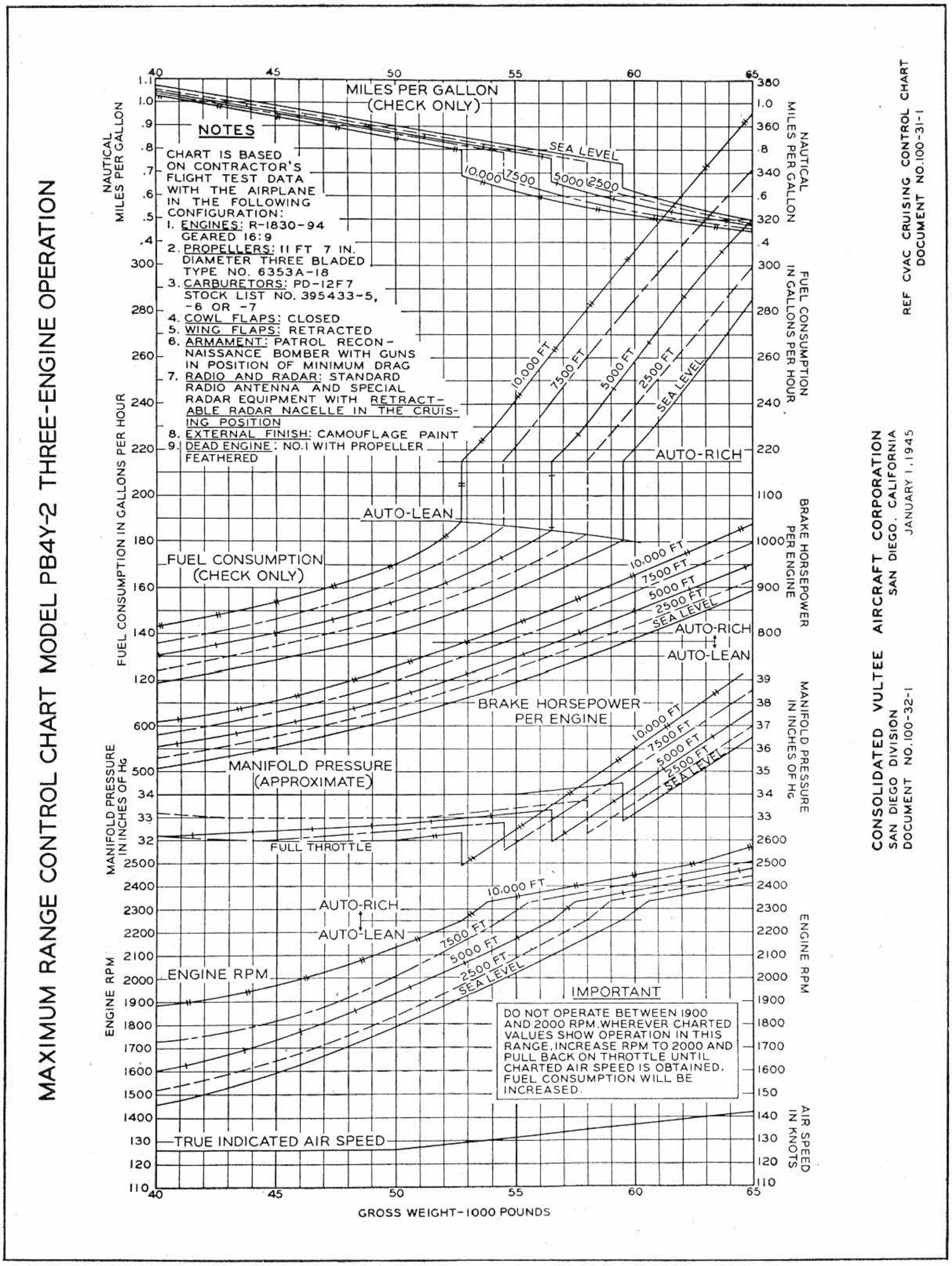

Figure 61—Maximum Range Control Chart—3 Engine

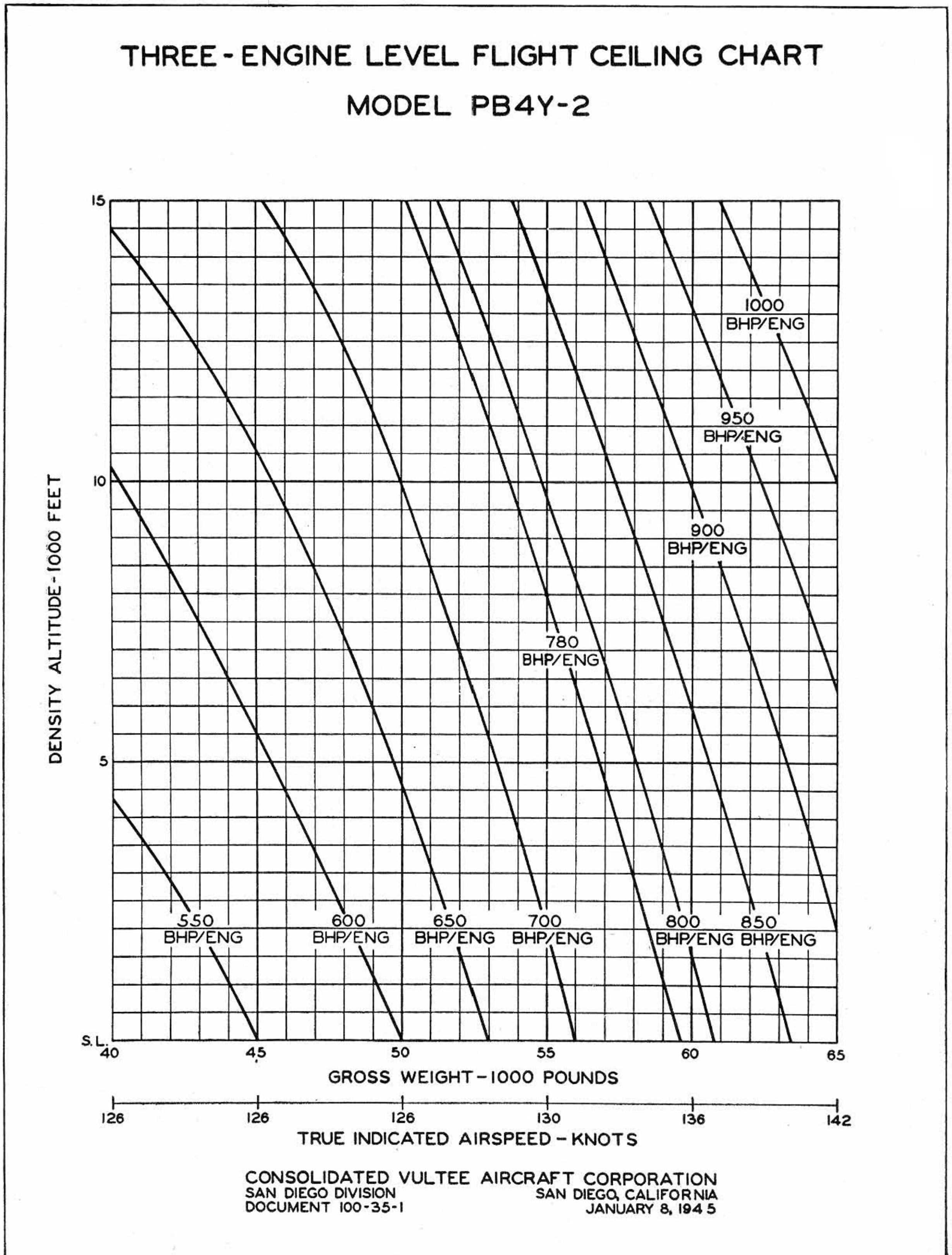

Figure 62—Three-Engine Level Flight Ceiling Chart

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