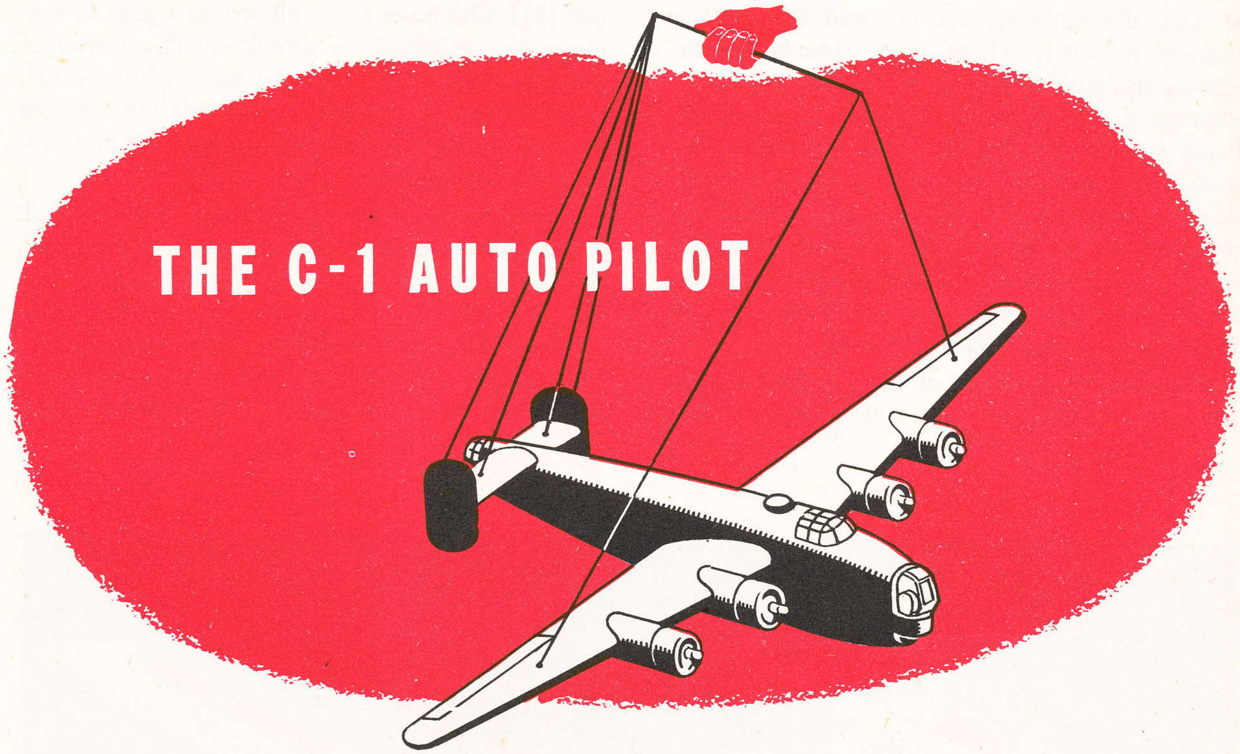


THE C-1 AUTO PILOT

The C-1 autopilot is an electromechanical robot which automatically controls the airplane in straight and level flight, or maneuvers the airplane in response to the fingertip control of the human pilot or bombardier.

Actually, the autopilot works in much the same way as the human pilot in maintaining straight and level flight, in making corrections necessary to hold a given course and altitude, and in applying the necessary pressure on the controls to turns, banks, etc. The difference is that the autopilot acts instantaneously and with a precision that is not humanly possible.

The precision of even the most skillful human pilot is limited by his own reaction time, i.e., the interval between his perception of a certain condition and his action to correct or control it. Reaction time itself is governed by such human fallibilities as fatigue, inability to detect errors the instant they occur, errors in judgment and muscle coordination.

The autopilot, on the other hand, detects flight deviations the instant they occur, and just as instantaneously operates the controls to correct the deviation. Properly adjusted, the autopilot will neither overcontrol nor undercontrol the airplane, but will keep it flying straight and level with all 3 control surfaces operating in full coordination.

How It Works

The C-1 autopilot consists of various separate units electrically interconnected to operate as a system. The operation of these units is explained in detail in AN-11-60AA-1. A general over-all understanding of their functions and relation to each other can be acquired by studying the accompanying illustration.

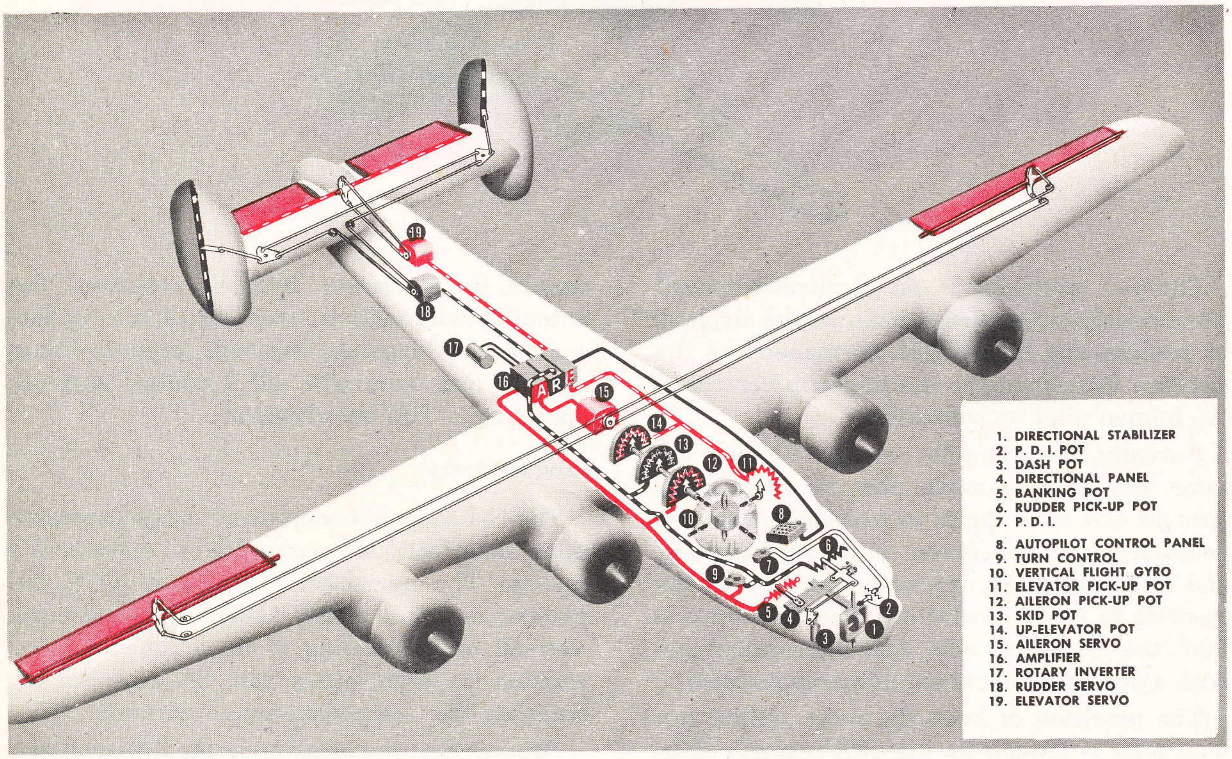
Assume that the airplane in the illustration is flying straight and level and that the autopilot is at work.

Suddenly turbulent air turns the airplane away from its established heading. The gyro-operated directional stabilizer (1) in the bombardier's compartment detects this deviation and moves the directional panel (4) to one side or the other, depending upon the direction of the deviation.

The directional panel contains 2 electrical devices, the banking pot (5) and the rudder pick-up pot (6), which send signals to the aileron and rudder section of the amplifier (16) whenever the directional panel is operated. These signals are amplified and converted (by means of magnetic switches or relays) into electrical impulses which cause the aileron and rudder Servo units (15 and 18) to operate the ailerons and rudder of the airplane in the proper direction and amount to turn the airplane back to its original heading.

Similarly, if the nose of the airplane drops, the vertical flight gyro (10) detects the vertical deviation and operates the elevator pick-up pot (11) which sends an electrical signal to the elevator section of the amplifier. The signal is amplified and relayed in the form of electrical impulses to the elevator Servo unit (19) which in turn raises the elevators the proper amount to bring the airplane to level flight.

If one wing drops appreciably, the vertical flight gyro operates the aileron pick-up pot (12), the skid pot (13), and the up-elevator pot (14). The signals caused by the operation of these units are transmitted to their respective (aileron, rudder, and elevator) sections of the amplifier. The resulting impulses to the



aileron, rudder, and elevator Servo units cause each of these units to operate its respective control surface just enough to bank and turn the airplane back to a level-flight attitude.

When the human pilot wishes to make a turn, he merely sets the turn control knob (9) at the degree of bank and in the direction of turn desired. This control sends signals, through the aileron and rudder sections of the amplifier, to the aileron and rudder Servo units which operate ailerons and rudder in the proper manner to execute a perfectly coordinated (non-slipping, non-skidding) turn. As the airplane banks, the vertical flight gyro operates the aileron, skid, and up-elevator pots (12, 13, 14). The resulting signals from the aileron and skid pots cancel the signals to the aileron and rudder Servo units to streamline these controls during the turn.

The signals from the up-elevator pot cause the elevators to rise just enough to maintain altitude. When the desired turn is completed, the pilot turns the turn control back to zero and the airplane levels off on its new course. A switch in the turn control energizes the directional arm lock on the stabilizer, which prevents the stabilizer from interfering with the turn by performing its normal direction-correcting function.

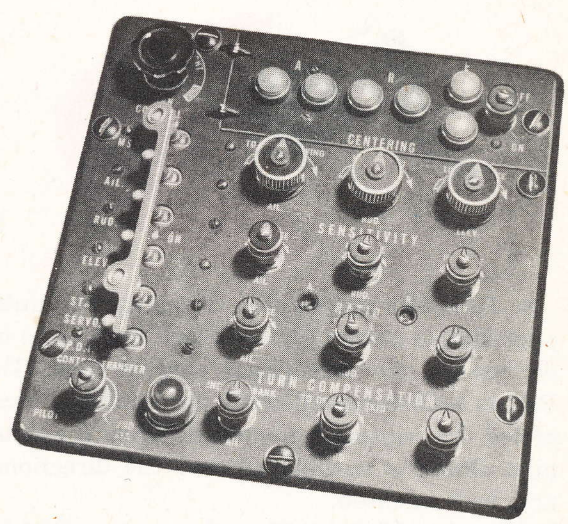
The autopilot control panel (8) provides the pilot with fingertip controls by which he can conveniently engage or disengage the system, adjust the alertness or speed of its responses to flight deviations, or trim the system for varying load and flight conditions.

The pilot direction indicator, or PDI (7), is a remote indicating device operated by the PDI pot (2). When the autopilot is used, the PDI indicates to the pilot when the system and airplane are properly trimmed. Once the autopilot is engaged, with PDI centered, the autopilot makes the corrections automatically.

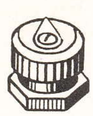
The rotary inverter (17) is a motor-generator unit which converts direct current from the airplane's battery into 105-cycle alternating current for operation of the autopilot.

HOW TO OPERATE THE C-1 AUTOPILOT

Before Takeoff

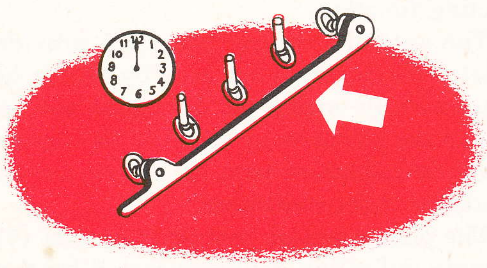


1. Set all pointers on the control panel in the up position.



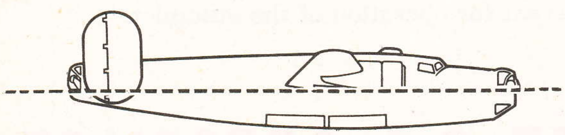
2. Make sure that all switches on the control panel are in the "OFF" position.

After Takeoff

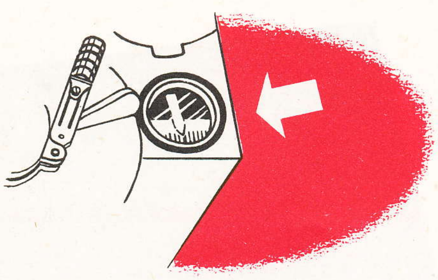


1. Turn on the master switch.

2. Five minutes later, turn on PDI switch (and Servo switch, if separate).

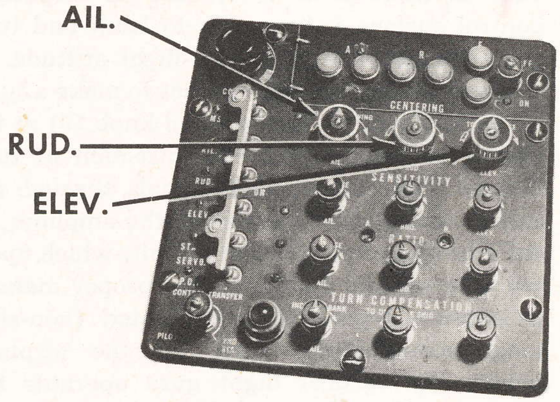


3. Ten minutes after turning on the master switch, trim the plane for level flight at cruising speed by reference to flight instruments.

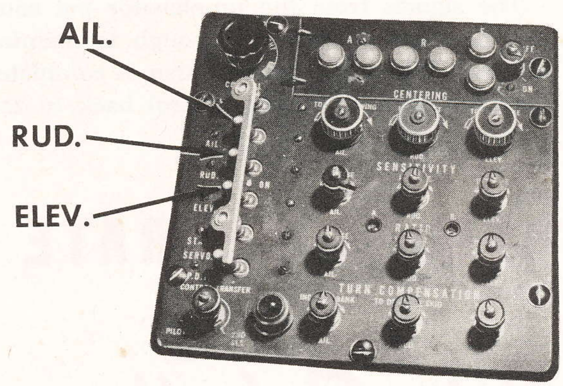


4. Have the bombardier disengage the autopilot clutch, center PDI and lock it in place by depressing the directional control lock. The PDI is held centered until the pilot has completed the engaging procedure. Then the autopilot clutch is re-engaged, and the directional arm lock released.

Alternate Method: The pilot centers PDI by turning the airplane in direction of the PDI needle. Then resume straight and level flight.



5. Engage the autopilot. Put out aileron telltale lights with the aileron centering knob, then throw on the aileron engaging switch. Repeat the operation for rudder, then for elevator.



6. Make final autopilot trim corrections. If necessary, use centering knobs to level wings and center PDI.

Caution:

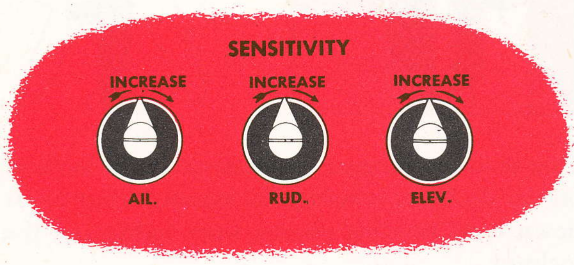
NEVER ADJUST MECHANICAL TRIM TABS WHILE THE AUTOPILOT IS ENGAGED

FLIGHT ADJUSTMENTS AND OPERATION

After the C-1 autopilot is in operation, carefully analyze the action of the airplane to make sure all adjustments have been properly made for smooth, accurate flight control.

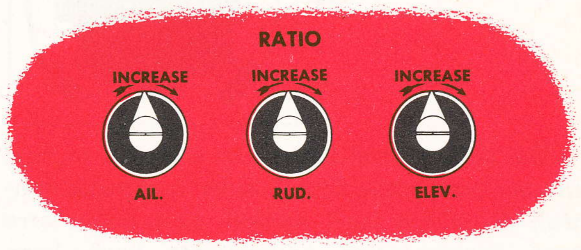
When both **tell-tale** lights in any axis are extinguished, it is an indication the autopilot is ready for engaging in that axis.

Before engaging, each **centering knob** is used to adjust the autopilot control reference point to the straight and level flight position of the corresponding control surface. After engaging, centering knobs are used to make small attitude adjustments.



Sensitivity is comparable to a human pilot's reaction time. With sensitivity set high, the autopilot responds quickly to apply a correction for even the slightest deviation. If sensitivity is set low, flight deviations must be relatively large before the autopilot will apply its corrective action.

Ratio is the amount of control surface movement applied by the autopilot in correcting a given deviation. It governs the speed of the airplane's response to corrective autopilot actions. Proper ratio adjustment depends on airspeed.



If ratio is too high, the autopilot will overcontrol the airplane and produce a ship hunt; if ratio is too low, the autopilot will undercontrol and flight corrections will be too slow. After ratio adjustments have been made, centering may require readjustment.

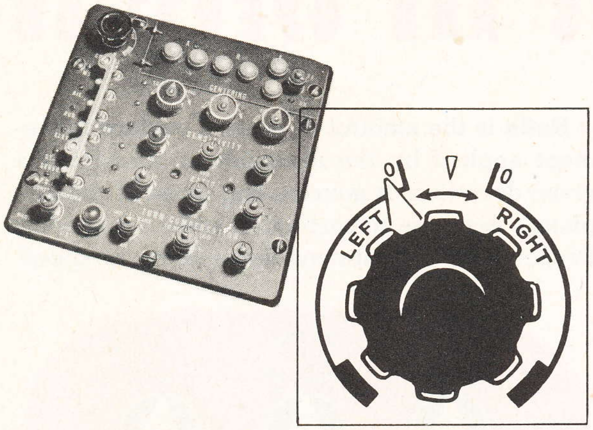
To adjust **turn compensation,** have bombardier disengage autopilot clutch and move engaging knob to extreme right or extreme left. Airplane should bank 18° as indicated by artificial horizon. If it does not, adjust aileron compensation (bank trimmer) to attain 18° bank. Then, if turn is not coordinated, adjust rudder compensation (skid trimmer) to center inclinometer ball. Do not use aileron or rudder compensation knobs to adjust coordination of turn control turns.

Emergency Use of Autopilot

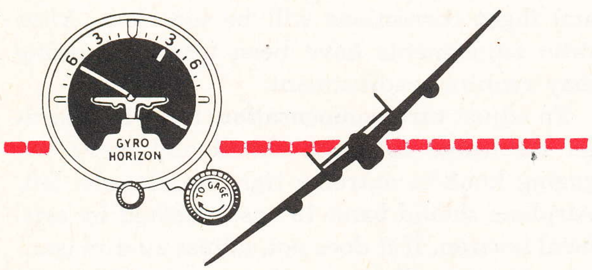
REMEMBER THE ROLE THAT THE AUTOPILOT CAN PLAY IN EMERGENCIES

1. If the control cables are damaged or severed between the pilot's compartment and the Servo units in the tail, the autopilot can bridge the gap. There have been many instances where the autopilot has been used thus to fly an airplane with damaged controls.

2. If the autopilot has been set up for level flight, it can be used to hold the airplane straight and level while abandoning ship.

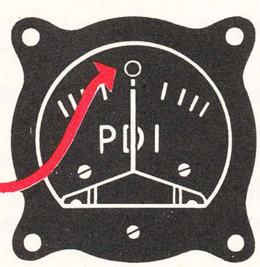


The **turn control** is used by the pilot to turn the airplane while flying under automatic control. To adjust turn control, first make sure turn compensation adjustments have been properly made, then set turn control pointer at beginning of trip-lined area on dial. Airplane



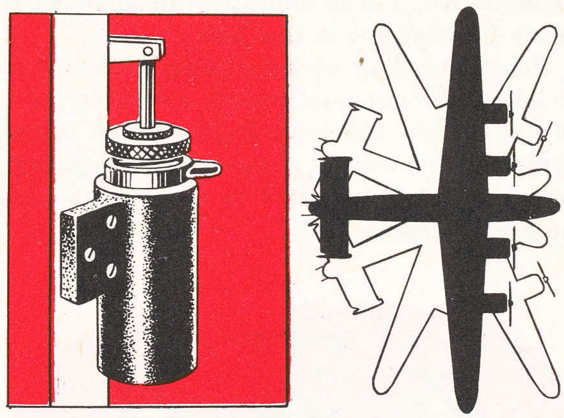
should bank 30°, as indicated by artificial horizon. If it doesn't, remove cap from aileron trimmer and adjust trimmer until a 30° bank is attained. Then, if turn is not coordinated (inclinometer ball not centered), adjust rudder trimmer to center ball. Make final adjustments with both trimmers and replace caps. Set turn control at zero to resume straight and level flight; then re-center.

Never operate the Turn Control without first making sure the PDI is centered



The **turn control transfer** has no effect unless the installation includes a remote turn control.

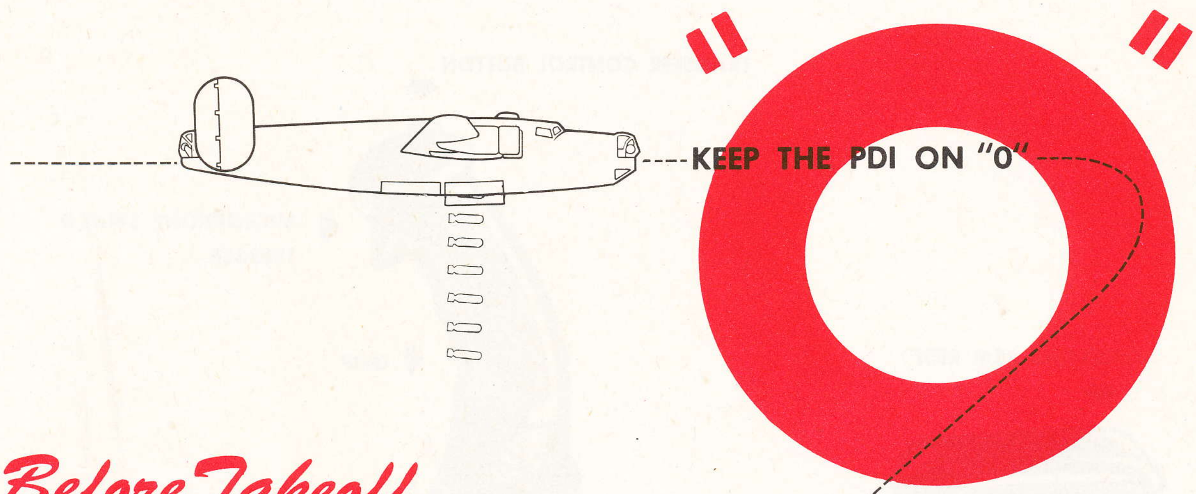
The **dashpot** on the stabilizer regulates the amount of rudder kick applied by the autopilot to correct rapid deviations in the turn axis. If a rudder hunt develops which cannot be eliminated by adjustment of rudder ratio or sensitivity, the dashpot may require adjustment.



This is accomplished by loosening the locknut on the dashpot, turning the knurled ring up or down until hunting ceases, then tightening the locknut.

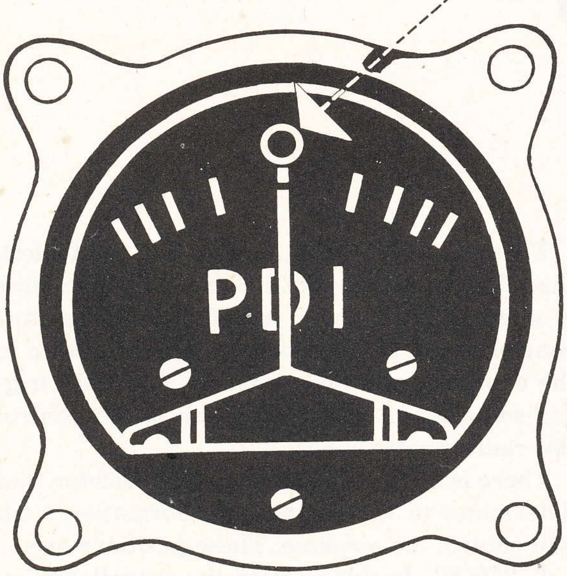
Cold Weather Operation—When temperatures are between –12° and 0°C (10° and 32°F) autopilot units must be run for 30 minutes before engaging. If accurate flight control is desired immediately after takeoff, perform the autopilot warm-up before takeoff by turning on the master switch during the engine run-up—but make sure autopilot is off during takeoff. If warm-up is performed during flight, allow 30 minutes after turning on master switch before engaging. When temperatures are below –12°C (10°F) units must be preheated for one hour before takeoff. Use special heating covers or blankets with heating tubes.

FLYING THE PDI MANUALLY



Before Takeoff

1. Check with bombardier for proper position of PDI needle for a left turn, right turn, and neutral or "0" position.
2. When bombardier's PDI is left, pilot's PDI is right, and vice versa.

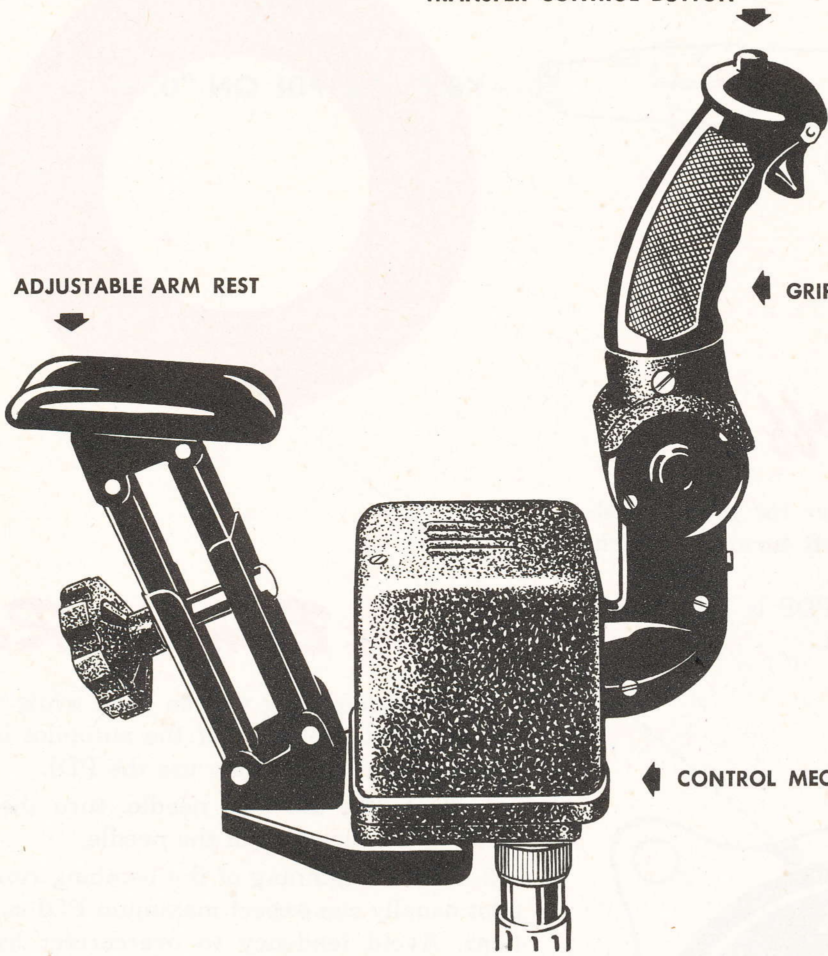


On the Bombing Run

Normally bombing will be done while using the autopilot. However, if the autopilot is not functioning the pilot may use the PDI.

1. To center the PDI needle, turn the airplane in the direction of the needle.
2. At the beginning of the bombing run, the pilot usually can expect maximum PDI corrections. Avoid tendency to overcorrect by refraining from leading the needle.
3. No matter how slight the deviation of the PDI needle from "0," the needle must be returned to "0" immediately.
4. Set turns must be coordinated aileron and rudder turns, in order to make the desired degree of turn more rapidly and to avoid any excessive sliding of the bombsight lateral bubble and induced precession of the gyro.
5. To avoid tumbling of the bombsight gyro, banks must never exceed 18°.
6. Keep PDI on "0" until bombardier calls "Bombs away."

THE FORMATION STICK

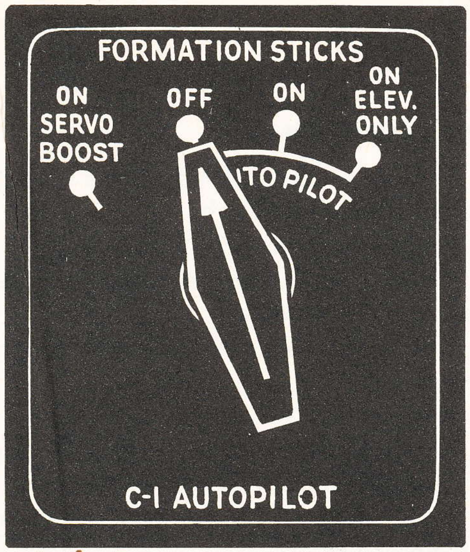


The formation stick is a miniature control stick, working through the autopilot, that enables you and your copilot to maneuver your airplane quickly and with a minimum of effort. You use the formation stick as you would the control stick of a primary trainer—forward and back for descents and climbs, sideways for banks. Sideways movement of the stick controls both ailerons and rudders in coordination, eliminating the need for separate rudder control. Movement of the stick electrically actuates the servo units of the autopilot, which in turn move the control surfaces.

There are two sticks, one on the pilot's left, the other on the copilot's right. Only one stick is engaged at a time; transfer switches shift control of the airplane from the pilot's stick to the copilot's, and vice versa. Push-to-talk trigger switches on both formation sticks control the radio microphones.

There is a four-position function selector that determines to what extent the formation stick will control the airplane. These positions are:

1. "OFF"—In this position the autopilot operates normally and flys the airplane, the stick having no control.



2. "ON SERVO BOOST"—The stick is in direct control of the autopilot servos and you must use it as if it were mechanically linked to the surface controls. Use this position when you want quick maneuvering, as in a wing position of a tight formation.

3. "ON ELEV. ONLY"—The stick provides only vertical control of the airplane, the autopilot controlling ailerons and rudder. The bombardier makes turns with the bombsight autopilot attachment, or the pilot can use the autopilot turn control. Use this position when the bombardier has control of the airplane.

4. "ON"—The autopilot is flying the airplane, with the stick working like the autopilot turn control, except that it provides vertical as well as bank control. Use this position when leading a formation, in a wing position of a loose formation, or in other situations where little maneuvering is required.

How to Use

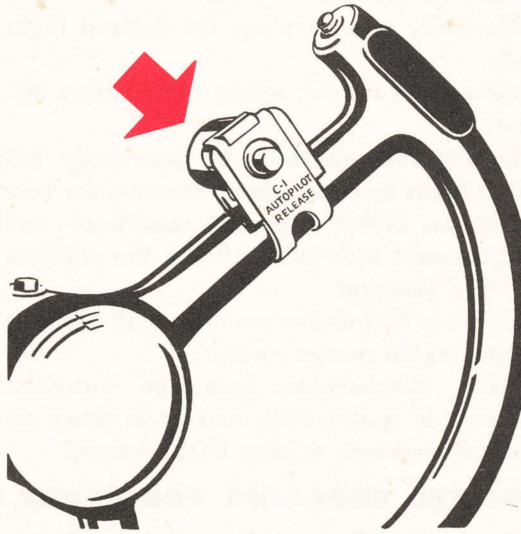
1. Before takeoff, check both autopilot master switch and the formation stick function selector in the "OFF" position.

2. In flight, when ready to use the formation stick, set up the autopilot in the normal manner.

3. Engage the formation stick by turning function selector to "ON," "ON SERVO BOOST," or "ON ELEV. ONLY," depending upon the type of operation desired.

To Transfer Control

To transfer control from pilot stick to copilot stick, push the button on top of the copilot stick. To regain control, the pilot pushes his button. If both buttons are pressed at the same time, the pilot gets control. When the formation stick is first engaged, the pilot has control automatically.



To Disengage Stick

An autopilot release switch on the wheel of each regular control column permits either pilot or copilot to return the airplane to manual control. Momentary pressure on either switch immediately disengages all three autopilot servos.

To re-engage the formation stick after the release switch has been used, turn off all autopilot switches, retrim the airplane, and then engage autopilot and formation stick in the normal manner.

However, if the release switch is pressed accidentally and **the formation stick has not been moved while the autopilot is disengaged,** you can re-engage the formation stick by snapping the autopilot switch off and then right on again, turning the other autopilot switches on without the usual adjustments. Do not use this method unless you are sure the formation stick has not been moved while the autopilot was off.

SUGGESTED ENGAGING PROCEDURE FOR LEAD AIRPLANE

1. After take-off, check that the function selector is in the "OFF" position.
2. Turn the tell-tale light shutter switch on.
3. Center the turn control knob.
4. Place the turn control transfer knob to "Pilot" position.
5. Turn on C-1 master switch.
6. Manually trim airplane for desired flight attitude.
7. Set all C-1 control knobs to "pointers up" position.

Note: All controls must be previously adjusted in flight by competent personnel for best performance under expected conditions and this adjustment indexed by fixing the pointers in the "Up" position.

8. Turn on PDI and servo switch 10 minutes after turning on master switch.
9. Have Bombardier disengage autopilot clutch arm to center PDI; and press down on directional arm lock to keep PDI centered.
10. Put out aileron tell-tale lights by adjusting aileron centering knob.
11. Snap aileron switch on.
12. Check gyro horizon and readjust aileron centering to level wings.
13. Put out rudder tell-tale lights with rudder centering knob.
14. Snap rudder switch on.
15. Have Bombardier re-engage autopilot clutch and release directional arm lock.
16. Readjust rudder centering knob to center PDI if necessary.
17. Put out elevator telltale lights with elevator centering knob.
18. Snap elevator switch on.
19. Readjust elevator centering if necessary.
20. Turn function selector to "ON" position. The formation sticks may now be used to make coordinated turns up to approximately 25° of bank and also to control the elevator.

SUGGESTED ENGAGING PROCEDURE FOR WING AIRPLANES

1. After take-off, turn the function selector to the "ON SERVO BOOST" position.
2. Turn the tell-tale light shutter switch on.
3. Center turn control knob.
4. Place turn control transfer knob in "Pilot" position.
5. Have bombardier disengage autopilot clutch, move clutch arm to center PDI, and press down on Directional Arm Lock to keep the PDI centered.
6. Turn on C-1 master switch. (This will lock the directional arm.)
7. Have bombardier re-engage autopilot clutch and remove hand from directional arm lock.
8. Manually trim airplane for desired flight attitude.
9. Set all C-1 control knobs to "Pointers Up" position.

Note: All controls must be previously adjusted in flight by competent personnel for best performance under expected conditions and this adjustment indexed by fixing the pointers in the "Up" position.

10. Turn on PDI and servo switch, not less than one minute after the master switch was engaged. Note: If Function Selector is left in the "ON SERVO BOOST" position, it is not necessary to wait ten minutes for the gyros to erect.
11. Put out aileron tell-tale lights by adjusting aileron centering knob.
12. Snap on aileron switch.
13. Use formation stick to maintain aileron control as soon as aileron switch is snapped on.
14. Put out rudder tell-tale lights by adjusting rudder centering knob.
15. Snap on rudder switch.
16. Use formation stick for both aileron and rudder control after rudder switch is snapped on.
17. Put out elevator tell-tale lights by adjusting elevator centering knob.
18. Snap on elevator switch. The formation

stick can now be used to control the flight of the airplane in all axis.

The function selector knob may be turned to any one of the four positions: "ON SERVO BOOST," "OFF," "ON," or "ELEV. ONLY" to give the desired control.

"ON SERVO BOOST" Position

This selector setting is to be used when flying a wing position in a tight formation or whenever quick maneuvering is desired.

To maneuver the airplane, move the stick in the same manner as a manual control stick would be moved.

The three centering knobs may be used to trim the airplane for the desired attitude with the stick in the normal center position.

Do not adjust the turn control trimmers during "ON SERVO BOOST" operation.

Aileron and rudder ratio may be adjusted to coordinate the controls for going into a bank or coming out of one but will have no effect while the controls are streamlined in the bank. Therefore, some slipping will be noticed in steep continuous banks.

Do not attempt to adjust the dashpot during "ON SERVO BOOST" operation since the dashpot has no effect on the operation of the autopilot with the directional arm lock engaged.

"OFF" Position

Whenever it is desired to fly an autopilot without using the sticks, turn the selector to "OFF."

"ON" Position

Use this selector position when leading a formation, in a wing position of a loose formation, or when very little maneuvering is desired, such as for course corrections on cross-country flights. In the "ON" position the stick is handled in the following manner:

1. For straight and level flights, leave the stick in center, and the autopilot will automatically maintain straight and level flight.

2. To climb or glide, move the stick backward or forward a distance sufficient to produce the desired change in attitude, and hold it there until ready to return to level flight. Release the stick or return it to center to return the airplane to level flight.

3. For a turn, move the stick from center in the desired direction a distance sufficient to produce the desired bank and turn. Maximum bank obtainable is approximately 25 degrees. Hold the stick in that position until the turn is complete. Return the stick to center to come out of the turn.

Streamlining of controls and application of up-elevator in the turn are automatically accomplished by the vertical flight gyro of the autopilot. More or less elevator may be applied by moving the stick forward or backward. Coordination of turns may be adjusted with the turn control trimmers.

Sensitivity and ratio adjustments may be made for flight conditions. If there is a tendency of the airplane to hunt in the turn axis, the dashpot may require adjusting.

Centering adjustments of the aileron, rudder, and elevator centering knobs may be used to adjust the attitude of the airplane. Make adjustments only with the stick centered.

"ON ELEV. ONLY" Position

Use this position when the bombardier has control. Hold the stick back to climb, in a forward position to dive. The rate of climb or dive will be governed by the distance the stick moved from center. Movement of the stick to right or left will have no effect. Turns may be made by the directional panel (bombardier) or the autopilot turn control.

Changing Function Selector Position

Always hold the airplane level while changing the selector from one position to another.

Make sure that the PDI is on zero before changing from any position to "ON SERVO BOOST." This is necessary to insure that the erecting cut-out switch in the directional panel is not closed when the directional arm is locked.

The autopilot master switch must have been on for at least 10 minutes before the function selector is moved from the "ON SERVO BOOST" position in order to give the autopilot gyros time to erect. If banks have exceeded 40 degrees the autopilot gyros may have tumbled and the function selector should not be moved from "ON SERVO BOOST" position for at least 10 minutes after the last steep bank.

TIPS ON USING FORMATION STICK

1. Make sure PDI is on zero before turning function selector to "ON SERVO BOOST" position. Otherwise an abrupt turn may result.

2. Remember that with the selector in "ON SERVO BOOST" position the autopilot has no control. Use the formation stick as if it were a manual control.

3. Don't use the autopilot turn control when the selector is in "ON SERVO BOOST" position.

4. Don't exceed 40° banks; the autopilot gyro may tumble. A tumbled gyro will not affect the flying characteristics while the selector is in "ON SERVO BOOST" position. However, when the function selector is moved to any other position a sudden maneuver results. If you do exceed a 40° bank fly the airplane straight and level for about 10 minutes to allow the gyro to right itself before turning the function selector from "ON SERVO BOOST" position.

5. Don't use the formation stick as a handhold or hat-rack. You can break it.

6. Don't use the formation stick for landing unless your manual controls fail. The stick doesn't provide separate aileron and rudder control, and provides less movement of control surfaces than manual operation.

7. Since the formation stick works through the autopilot, remember to observe the same precautions when using it as you do when using the autopilot alone.

8. Don't expect the formation stick to work properly unless the autopilot is functioning as it should. Use the autopilot ground checklist prior to flight.

PILOT'S GROUND CHECKLIST FOR FORMATION STICK

1. Complete the autopilot ground check, with the exception of the last step, leaving the autopilot engaged.

2. Set the formation stick function selector at "ON."

3. Move pilot's stick to the extreme right. The control wheel should turn clockwise, and the right rudder pedal should move forward. Make same check to the left.

With the stick held off center, have the directional arm lock on the directional stabilizer checked, to make sure that the arm is held securely. Then release the stick and see that it returns to center automatically, returning control wheel and rudder pedals to center as it moves.

With the formation stick in center, make sure the directional arm lock is released.

4. Move the formation stick forward, then back. The control column should follow the stick movement, and when stick is released both stick and control column should return to center automatically.

5. Press transfer button on top of copilot's stick, to give this stick control. Then repeat the above check. Transfer control back to pilot's stick.

6. Move the function selector to "ON SERVO BOOST." Then move the stick to each side and forward and back, making sure that all controls move in the proper directions. The control response should be the same as with the function selector at "ON," except that the aileron and rudder controls may not move as far.

7. Move function selector to "ON ELEV. BOOST." Then move pilot's stick backward and forward to check operation of elevator control. The control column should move only about one-third as far as it does with the function selector in the "ON" position. Movement of the stick sideways should not affect the ailerons or rudders.

8. Press the transfer button on the copilot's stick and move the stick to make sure that this stick now has control.

9. Press the autopilot release switch on the copilot's control wheel and check operations of controls to make sure they operate freely and autopilot is disengaged.

10. Snap the autopilot master switch "OFF," then immediately back "ON," and re-engage the remaining autopilot switches.

11. Move pilot's stick to make sure it has regained control.

12. Press autopilot's release switch on pilot's control wheel and check operation of controls to make sure they operate freely and autopilot is disengaged.

13. Check operation of pilot's and copilot's microphone switches. To check, turn radio control switch to "INTER-COM" position. Then squeeze trigger on each formation stick, while using microphone and listening on headset.

14. Move function selector to "OFF," and turn off autopilot master switch.

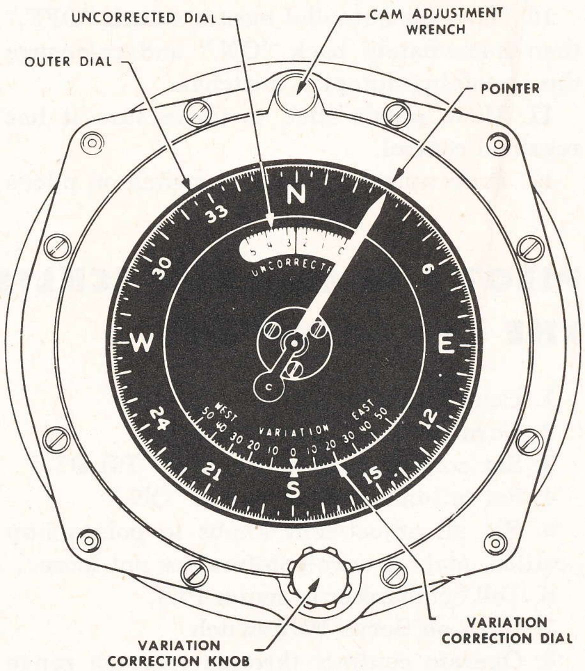
PILOT'S GROUND CHECKLIST FOR THE C-1 AUTOPILOT

1. Center turn control.
2. Turn on C-1 master switch bar.
3. Set control transfer knob at "PILOT."
4. Set tell-tale shutter switch "ON."
5. Set all adjustment knobs to pointers-up position, making sure pointers are not loose.
6. Tell bombardier to center PDI.
7. Turn on Servo PDI switch.
8. Operate controls through extreme range several times, observing that tell-tale lights flicker and go out as streamline position is reached from either direction.
9. Turn on aileron, rudder, and elevator switches.
10. Turn aileron centering knob clockwise, then counter-clockwise, observing that wheel turns to the right and then to the left.
11. Repeat Item 10 for rudder and elevator, observing action.
12. Have bombardier move directional arm for full right turn, then to left, observing to see if aileron and rudder move in proper direction.
13. Have bombardier center PDI and engage secondary clutch.
14. Rotate turn control knob for right and left turns, observing aileron and rudder controls for proper movement.
15. If all checks are satisfactory, turn the C-1 master switch bar "OFF."

THE GYRO FLUX GATE COMPASS

The gyro flux gate compass, remotely located in the wing or tail of the airplane, converts the earth's magnetic forces into electrical impulses to produce precise directional readings that can be duplicated on instruments at all desired points in the airplane.

Unlike the magnetic needle, it will not go off its reading in a dive, overshoot in a turn, hang in rough weather, or go haywire in polar regions.



Development of the Flux Gate

The gyro flux gate compass was developed to fill the need for an accurate compass for long-range navigation. The presence of so many magnetic materials (armor, electrical circuits, etc.) in the navigator's compartment made it almost impossible to find a desirable location for the direct-reading magnetic compass.

To eliminate this difficulty, it became necessary to place the magnetic element of the navigator's compass outside the compartment, **i.e., to use a remote indicating compass.** The unit which is remotely located is called the **transmitter.** The unit used by the navigator is the **master indicator.** For the benefit of the pilot and such other crew members as may have needs for compass readings, auxiliary instruments called **repeater indicators** may be installed in other parts of the airplane.

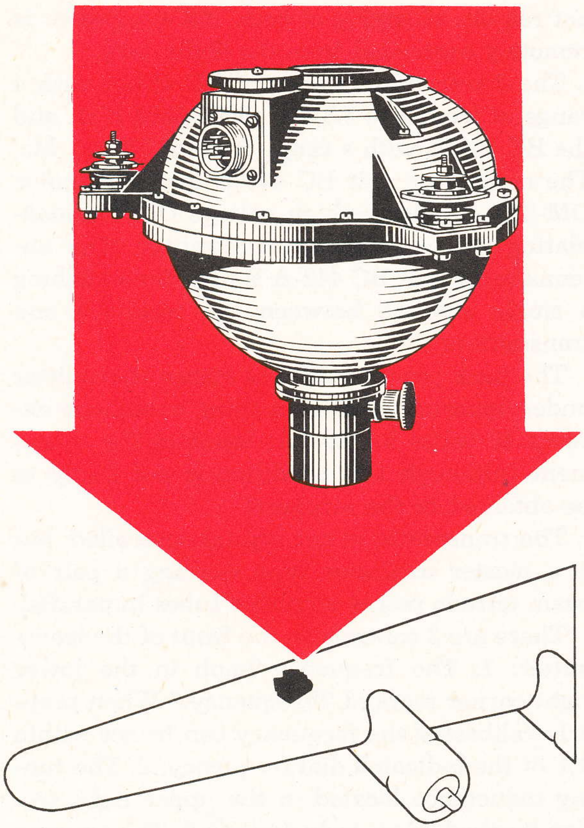
Units of the Flux Gate Compass

The gyro flux gate compass consists of 3 units which are analogous to the brain, heart, and muscles of the human body. The **transmitter,** located in the wing or tail of the airplane, is the brain of the instrument. The **amplifier** is the source of power for the compass and corresponds to the human heart. The **master indicator** does the work of turning a pointer and performs a function similar to that of the muscles in the human body.

1. **The Brain.**—Inside the remotely placed **transmitter** there is a magnetic sensitive element called the flux gate which picks up the direction signal by induction and transmits it to the **master indicator.** This element consists of 3 small coils, arranged in a triangle and held on a horizontal plane by a gyro. Each coil has a special soft iron core, and consists of a primary (or excitation) winding, and a secondary winding from which the signal is obtained.

Because each leg of the flux gate is at a different angle to the earth's magnetic field, and the induced voltage is relative to the angle, each leg produces a different voltage. When the angular relationship between the flux gate and the earth's magnetic field is changed, there is a relative change in the voltages in the 3 legs of the secondary. These voltages are the motivating force for the gyro flux gate compass master indicator which provides indications of the exact position of the flux gate in relation to the earth's magnetic field.

Each coil is a direction sensitive element; but one alone would provide an ambiguous reading because it could tell north from east, for instance, but not north from south. Therefore, it



is necessary to employ 3 coils and combine their output to give the direction signal.

2. **The Heart.**—The amplifier furnishes the various excitation voltages at the proper frequency to the transmitter and master indicator. It amplifies the autosyn signal which controls the master indicator and serves as a junction box for the whole compass system.

Power for the amplifier comes from the airplane's inverter and is converted to usable forms for other units. The input of the amplifier is 400-cycle alternating current and various voltages may be used depending upon the source available.

3. **The Muscle.**—The master indicator is the muscle of the system because it furnishes the mechanical power to drive the pointer on the main instrument dial. The pointer is driven through a cam mechanism which automatically corrects the reading for compass deviation so that a corrected indication is obtained on all headings. The shaft of the pointer is geared to another small transmitting unit in the master indicator which will operate as many as six repeat indicators at other locations.

The amplifier, master indicators and repeaters all are unaffected by local magnetic disturbances.

How to Operate the Compass

1. Leave the toggle switch on the flux gate amplifier "ON" at all times so that the compass will start as soon as the airplane's inverter is turned on.

2. Leave the caging switch in the "UNCAGE" position at all times except when running through the caging cycle.

3. About 5 minutes after starting engines, throw caging switch to "CAGE" position. Leave it there about 30 seconds and then throw to "UNCAGE" again.

4. With the new push button-type caging switch, depress it for a few seconds until a red signal light goes on. Then release the switch and the caging cycle is automatically completed, at which time the red light goes out.

5. Set in the local variation on the master indicator if you wish the pointer to read true heading.

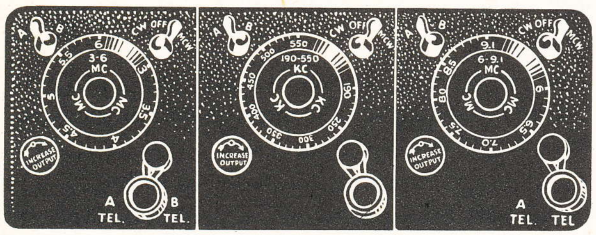
6. If at any time during flight the compass indications lead you to suspect that the gyro is off vertical, run through the caging cycle when the airplane is in normal flight attitude, especially when leveling off after climb.

Note: For further details concerning functions, operation and flight instructions, see Technical Order No. 05-15-27.

RADIO EQUIPMENT

Command Receiver Equipment

The receiver equipment consists of 3 individual 6-tube superheterodyne receivers BC 453-A, BC 454-A, and BC 455-A, which cover the following frequency bands: (1) 3 to 6 Mc (3000-6000 Kc); (2) 190 to 550 Kc; (3) 6 to 9.1 Mc (6000-9100 Kc).



Command receivers are generally operated by the pilot for airplane-to-ground communication. The receiver control head unit BC 450-A is located within easy reach of both the pilot and copilot. In the upper left hand corner of this control head unit there is a channel selector switch with positions "A" and "B." When this switch is in position "A," the person can hear the output of the receiver in any of the interphone boxes or in any Tel A jack, but if the channel selector switch is in position "B" the output from that receiver can only be heard by plugging the earphones into the Tel B jack on the bottom of control head unit or on the Tel B jack in receivers themselves.

Considerable care should be taken in the antenna alignment of each individual receiver, and the antenna alignment control on the lower left hand corner of the receiver itself should be adjusted for maximum signal strength at the high-frequency end of the dial.

Command Transmitter Equipment

Command transmitter equipment consists of 2 transmitters of set frequency ranges and does not require changing of coils. All equipment is remotely controlled from the flight deck.

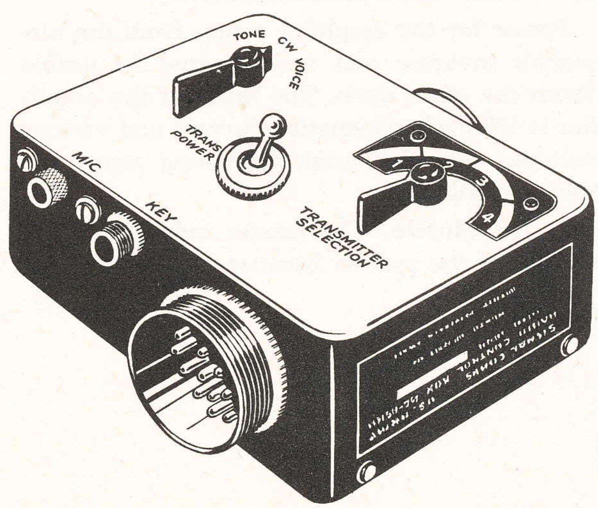
The 2 transmitters are the BC 457-A with a range of from 3 to 5.3 Mc (3000-5300 Kc), and the BC 458-A with a range of from 5.3 to 7 Mc. The modulator unit BC 456-A and dynamotor DM-33A supply the high-voltage DC and modulating power to either transmitter. The antenna relay unit BC 442-A is used for switching a single antenna between the receivers and transmitters.

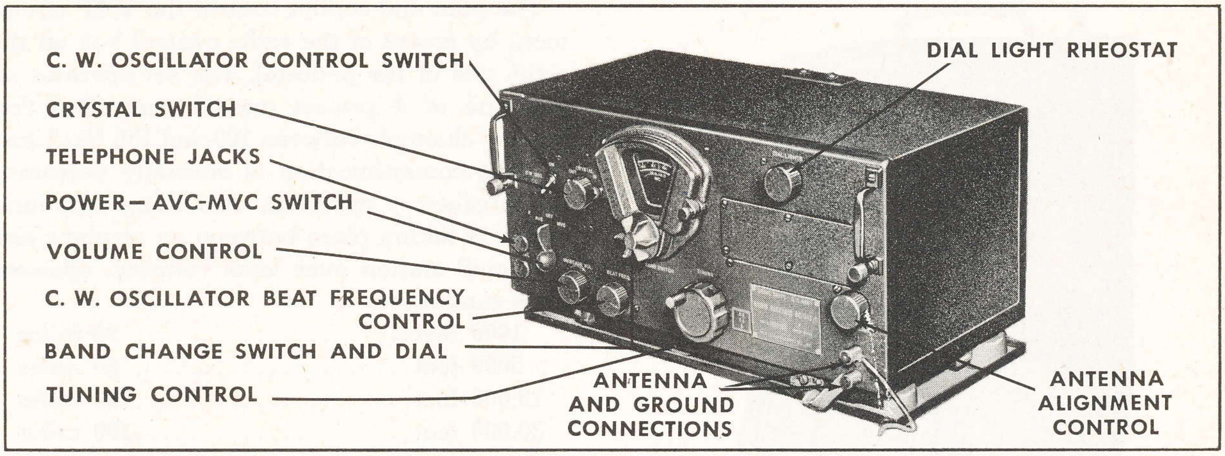
The peak power output of either transmitter under optimum antenna loading conditions exceeds 40 watts for 28-volt input to the equipment (although this condition is not likely to be obtained in the airplane).

The transmitter is not crystal controlled, but is a master oscillator type exciting a pair of beam tetrode power amplifier tubes in parallel.

There are 3 controls on the front of the transmitter: 1. The frequency knob in the lower right corner marked "Frequency." When properly calibrated the frequency can be set within 3% of the indicated dial frequency; 2. The tuning inductance located in the upper right section marked "Ant. Inductance"; 3. The antenna coupling control located in the middle left side marked "Ant. Coupling."

Important: Transmitters must be tuned up with the emission switch of the radio control box 451-A in the "CW" position, and must not be readjusted in any way after switching to "VOICE" or "TONE."





LIAISON RADIO RECEIVER

Liaison Receiver

The liaison receiver consists of an 8-tube superheterodyne communications receiver BC 348-C or BC348-H. The BC348-H has 7 frequency bands covering frequencies from 200 to 500 Kc and from 1.5 to 18 Mc. Be familiar with the following controls on the receiver:

1. The antenna alignment knob should always be tuned for maximum background noise in the headset.
2. The crystal switch on the "IN" position cuts out interference and increases selectivity but decreases the sensitivity of the signal.
3. The CW oscillator switch is turned to "ON" position for code signals and to "OFF" position for voice reception.
4. MVC means that the receiver is in manual volume control and that the signal will fade in and out; whereas AVC means that the receiver is in automatic volume control and that the signal will not fade. MVC is used generally for code and AVC for voice.
5. The beat frequency knob can be used on CW reception as a trimmer and tone-variation control. It has little effect on voice reception.

Most pilots are familiar with frequency in terms of kilocycles but much of the aircraft equipment is calibrated in terms of megacycles. To change Mc to Kc, add three zeros to the megacycle reading (3 Mc equals 3000 Kc).

The liaison receiver is the radio operator's receiver used by him in conjunction with the liaison transmitter to carry on communication from the airplane. The receiver can be used to calibrate the liaison transmitter in flight when flight conditions prevent the use of the frequency meter.

Liaison Transmitter

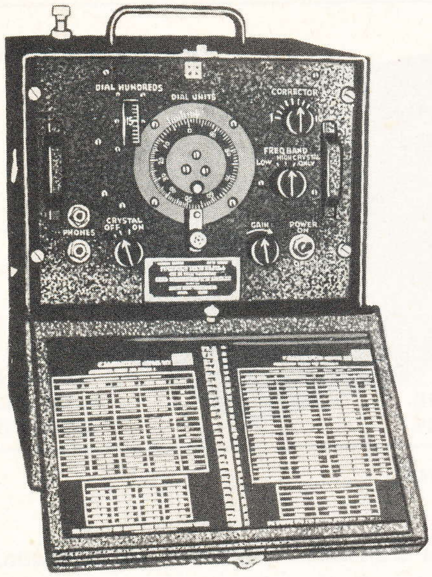
The liaison transmitter equipment consists of one medium-range transmitter, a dynamotor, antenna, antenna variometer, and 7 tuning units which lock into the bottom of the transmitter. All of the equipment is under the control of the radio operator, though the pilot and copilot can operate the transmitter remotely through their interphone switch boxes.

The transmitter is a master oscillator, power amplifier type with a class B modulator. Since it is not crystal-controlled, its frequency must be carefully calibrated against some stable frequency measuring device such as the frequency meter.

FREQUENCY METER

The frequency meters commonly used in large bombers provide a means of accurately calibrating a transmitter or receiver on any given frequency between 125 Kc and 20,000 Kc.

Most calibration charts on the front of aircraft transmitters cannot be relied upon to be accurate because of vibration and many other factors, and if the radio operator uses these charts as his only means of setting the fre-



FREQUENCY METER SET SCR-211-D

quency of the transmitters, often he will be from 1 to 50 Kc off of his desired frequency.

The frequency meter is a crystal-controlled precision instrument which can be relied upon to be accurate within ½ of 1 Kc over its entire frequency range; therefore the radio operator should use the frequency meter with practically every transmitter tuning. It is a 3-tube receiver-transmitter combination which is capable of receiving a radio signal on a given frequency and at the same time transmitting a signal on that frequency.

The circuit employed in the frequency meter consists of a self-excited heterodyne oscillator and a crystal oscillator. The broad frequency range is obtained by varying the self-excited oscillator, and the frequency accuracy is obtained by beating the self-excited oscillator against the highly accurate crystal oscillator. Its power source consists of self-contained A and B batteries.

VHF EQUIPMENT

The SCR 522 VHF (very high frequency) transmitter-receiver provides 2-way communication between aircraft and ground stations. Provision is made for voice communication and continuous audio tone modulation.

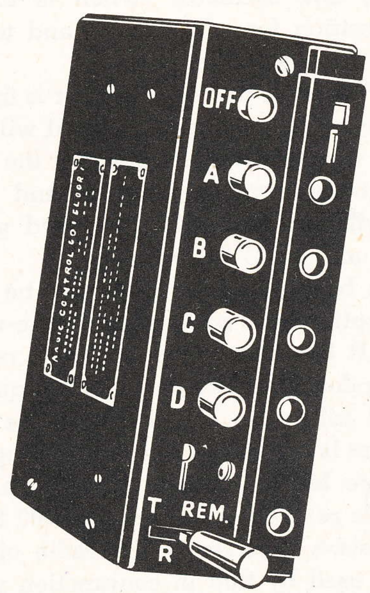
The pilot and copilot control the VHF equipment by means of the radio control box on the right side of the pedestal. The set operates on any one of 4 pre-set crystal controlled frequency channels between 100 and 156 Mc. Line-of-sight communication is normally necessary for satisfactory operation. Assuming communication is taking place between an airplane and a ground station over level country, approximate ranges are:

1000 feet	30 miles
5000 feet	80 miles
10,000 feet	120 miles
20,000 feet	180 miles

Radio Control Box

The radio control box provides the only complete remote control of communication functions. Five red buttons are the means by which any one of the 4 channels is selected and the power turned off. Pressing the "OFF" button turns off the dynamotor. The buttons are interconnected so that not more than one channel can be selected at a time. A light opposite each button indicates which channel you are using.

The "T-R-REM" switch (transmit-receive-remote) is normally in the "REM" position, permitting press-to-talk operation with the microphone switch on the control wheel, which when depressed switches the equipment from receive



to transmit. In the "T" position the transmitter is in continuous operation. In the "R" position the receiver is in continuous operation.

The lever tab directly above the "T-R-REM" switch, when lowered, blocks the switch from "REM" position and spring-loads the switch lever so that unless it is held in the "T" position it will return to "R."

The small lever tab opposite the "OFF" button is a dimmer mask to reduce the lamp glare. The lamp opposite the "T-R-REM" switch is on when receiving and off when transmitting.

Transmitter-Receiver Assembly

The transmitter and receiver units are in a single case. The transmitter employs a crystal-controlled oscillator circuit and operates in the frequency range of 100-156 Mc on any of the 4 pre-set channels, A, B, C, or D. Average output power of the transmitter is 8 to 9 watts, using a total power input of 11.5 amps at 28 volts.

The receiver is a sensitive superheterodyne unit employing a heterodyne oscillator whose frequency is controlled by any one of 4 quartz crystals. Thus the 4 crystal-controlled channel frequencies are available for instantaneous selection at the remote control position. For reception the total input current is 11.1 amps at 28 volts.

Dynamotor Unit

The dynamotor operates on the 28-volt power circuit and supplies 3 regulated voltage sources (300-volt DC, 150-volt DC, and 13-volt DC) required for operation of the VHF assembly.

Operation

The "T" and "R" positions of the control box permit transmission and reception without the use of the press-to-talk button. However, some aircraft are modified to eliminate the "T" and "R" positions, or have the control safetied in the "REM" position. It is advisable to use the "REM" position at all times.

To operate: See that the switch is in the "REM" position (if not safetied there).

Select a channel by pressing button A, B, C, or D.

To receive: Under these conditions the receiver is normally in continuous operation.

To transmit, depress the press-to-talk button and talk into the mecrophone.

To receive again, release the press-to-talk button.

To shut off the equipment, press the "OFF" button.

Precautions During Operation

Avoid prolonged use of the radio on the ground to conserve the batteries and avoid overheating the dynamotor.

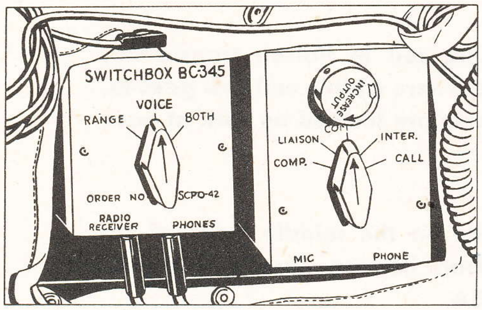
If the transmitter and receiver fail to operate when a channel button is pressed, press another channel button, then again press the button for the desired channel. Transmission and reception should then be possible.

LOCATION OF RADIO EQUIPMENT

Liaison transmitter	On flight deck under the radio operator's table
Liaison receiver	On flight deck on top of radio operator's table
Liaison dynamotor	Under flight deck on right side (sometimes on floor of flight deck)
Liaison junction box	On flight deck behind transmitter
Liaison monitor normal switch	To right of liaison receiver
Interphone amplifier	Behind copilot's seat
Interphone junction boxes	13 positions throughout the ship
Interphone dynamotor	On right side of liaison transmitter
Command transmitters	Right forward side of half deck
Command receiver remote control head	Roof of flight deck between pilot and copilot
Command receivers	Center forward section of half deck
Command modulator power unit	Right side of half deck
Command antenna relay	Above the command transmitters
VHF transmitter-receiver and dynamotor	Right side of half deck
VHF remote control unit	Right side of control pedestal
Compass receiver	Right side of half deck, facing center of ship
Compass control head (navigator's)	In nose of ship above the navigator's table
Compass control head (pilot's)	On flight deck above the pilot's head
Compass panel	On aft side of compass receiver
Compass loop antenna	Top side of fuselage near bulkhead No. 6
Compass whip (sense) antenna	Top side of fuselage forward of loop antenna
Marker beacon receiver	In bomb bay on left side of bulkhead No. 5
Marker beacon antenna	Under catwalk on bottom center of ship

INTERPHONE EQUIPMENT

The interphone amplifier consists of a single dual-purpose tube amplifier powerful enough to allow adequate communication between all members of the airplane crew.



FILTER SWITCH BOX AND INTERPHONE CONTROL

The individual 13 interphone station boxes are located in these positions in late B-24's:

1. Tail gun position.
2. Camera hole position.
3. Side gun position (right side).
4. Side gun position (left side).
5. Bottom turret gun position.
6. Bomb bay.
7. Top gun position.
8. Radio operator's position.
9. Pilot's position.
10. Copilot's position.
11. Navigator's position.
12. Bombardier's position.
13. Nose gunner's position.

Steps for operating the interphone system:

1. The interphone system turns on when the main line and battery switches are turned on.
2. Plug your earphones in the phone jack at bottom of station box or in its extension cord.
3. Turn the selector switch A to "COMP" and you hear the compass receiver if it is on.
4. Turn the selector switch A to the "LIAISON" position and you hear the radio operator's liaison receiver if it is on. Press the microphone and you transmit over the liaison transmitter. (Only the pilot, copilot, radio operator's and navigator's interphone boxes will operate the liaison transmitter.)
5. Turn the selector switch A to the "COMMAND" position and you hear the command receiver. Press the microphone button and you transmit over the command transmitter (from any position).
6. Turn the selector switch A to "INTER" and press the microphone button and you talk to any person in the ship who has his box on "INTER" position.
7. Turn the selector switch A to "CALL" position and manually hold it there while you call any interphone position in the ship. The person talking on "CALL" position will be heard throughout the ship no matter what position the other interphone boxes are turned to.

Filter System

Pilot and copilot are provided with the FL-8A filter and switch box assembly. The filter is used for separating the voice (weather reports, etc.) from the beacon signal. Switching selector B to "RANGE" permits the reception of the beacon signal only. "VOICE" position permits reception of spoken messages only and "BOTH" permits beacon signal and spoken messages to be heard simultaneously.

Trouble Shooting Steps for the B-24 Radio Equipment:

1. Check all the switches to see that the equipment is properly turned on.
2. Check all fuses in defective circuit.
3. Note whether there is input to the equipment by checking to see that the tubes in the equipment are lighted.
4. Tap radio tubes (in a defective circuit) and push them firmly in their sockets.
5. Remove the cover cap over each cable plug which connects into the defctive circuit and check soldering connection on each wire.
6. Check the bonding from the defective equipment to the body of the ship.

LOCATION OF RADIO FUSES

LIAISON TRANSMITTER FUSE—Pull out sliding coil in liaison transmitter. Fuse is in center section above where sliding coil unit goes in. Value is .5A 1000V. (Two spares are located on rack at base of coil unit.)

LIAISON RECEIVER FUSE—Unscrew two posts on the middle sides of receiver and pull the receiver from its case. Fuse is in bottom center of receiver. Value is 15A.

LIAISON DYNAMOTOR FUSE—Release 4 locks on dynamotor top casing and pull casing upward from dynamotor. Fuses are 1A 1000V, 60A-250V, and 30A-250V. (Dynamotor spare fuses are located in top of the dynamotor lid.)

COMMAND TRANSMITTER AND COMMAND DYNAMOTOR FUSES—Located above the bomb bay, between bulkheads Nos. 5 and 6, in the modulator power unit on the starboard side. Values are 20A each. (Two spares are located in the fuse cup on the port side of the modulator power unit.)

COMMAND RECEIVER FUSES—Located in fuse cup behind each receiver. Value is 10A. (One spare is located next to it.)

COMPASS RECEIVER FUSES—Located in compass panel which is on aft side of compass receiver. Values are 2A and 15A. (One spare is located next to each.) AC inverter power has to be on before compass receiver will work. AC power radio fuse will be found on flight deck in copilot's fuse box.

VHF FUSES—Located on right wall of half deck, behind transmitter-receiver unit.

MARKER BEACON RECEIVER FUSE—Run on power from compass receiver; uses compass fuses.

RADIO COMPASS SCR-269

This radio equipment enables a pilot to obtain the following three conditions:

1. Aural reception of non-directional radio signals using a whip antenna. This condition is obtained on the "ANT" position of the pilot's remote control head.

2. Aural reception of radio signals using a shielded loop antenna. The loop antenna picks up considerably less snow and rain static but the volume is slightly less than that on "ANT" position. This condition is obtained on "LOOP" position of the pilot's remote control head.

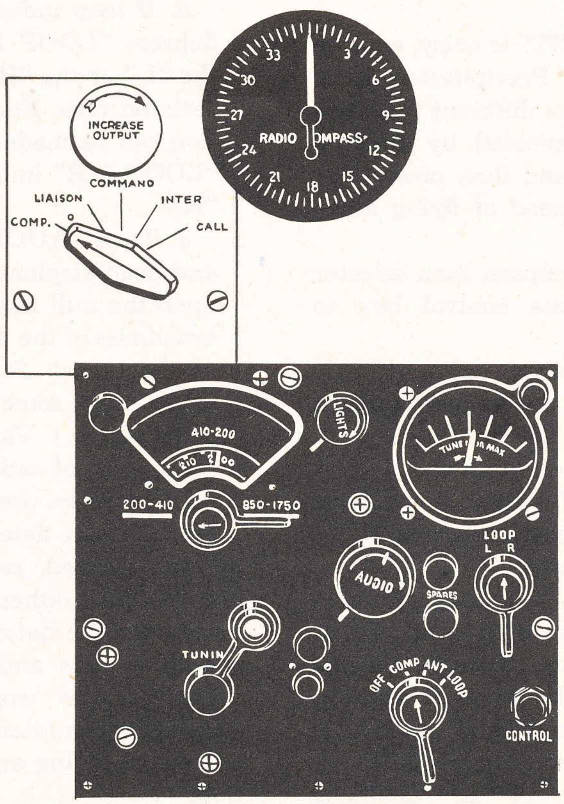
3. Aural reception of radio signals using both the whip and loop antenna with a pointer to indicate the bearing of the station from the airplane. This condition is obtained on the "COMP" position of the pilot's remote control head.

When the radio compass is used as a homing device, the indications are such that the aircraft will ultimately arrive over the radio station antenna regardless of the probable drift due to crosswind. However, the flight path will be a curved line, and coordination with ground fixes or landing fields along the route will be either difficult or impossible. Consequently, it is often expedient to fly a straight-line course by offsetting the aircraft's heading to compensate for wind drift. To do this, determine the wind drift, either with a drift sight or by noting the change in magnetic compass reading over a period of time, and making allowances for drift.

The radio compass operates on AC power and will not work if there is inverter failure.

How to Operate the Radio Compass

To assume control at either pilot's or navigator's station, turn selector switch on radio



Radio Compass Controls

compass control box to type of operation desired and press "CONTROL" button until green indicator lamp on control box lights. (Adjust dial lamps with "LIGHTS" control and headset volume with "AUDIO" control.)

Select station frequency with band selector switch and tuning crank. Move tuning crank to position producing greatest clockwise indication of tuning meter.

Note: Provision is made for reception of CW signals. Control of this feature is provided by the "CW-VOICE" switch on the panel of the radio compass receiver, located over the rear bomb bay.

1. To operate as a receiver only, using the vertical sense antenna:

a. Set selector switch on "ANT."

b. Push "CONTROL" button if indicator lamp does not indicate position control.

c. Set band selector switch to desired band and tune in desired stations by means of tuning crank, making final adjustment by referring to tuning meter.

d. Regulate headset volume by adjusting "AUDIO" control.

Note: If reception on "ANT" is noisy, operate on shielded loop antenna. Precipitation static existing in air-mass fronts at different temperatures can sometimes be avoided by crossing the front at right angles, and then proceeding on the desired course, instead of flying along the air-mass front.

e. To turn off radio compass, turn selector switch on radio compass control box to "OFF."

2. To operate as a receiver only, utilizing the shielding provision of the loop antenna to reduce precipitation static noises:

a. Set selector switch on "LOOP."

b. Push "CONTROL" button if indicator lamp does not indicate position control.

c. Tune in desired station.

d. Depress "LOOP L-R" knob, on radio compass control box and turn it to "L" or "R," rotating loop to obtain maximum signal strength, as indicated by headset volume. Release "LOOP L-R" knob and make final adjustment of loop position at slow speed by turning the knob to "L" or "R." Changing course will affect signal strength, and necessitate readjustment of loop position.

e. Regulate headset volume with "AUDIO" knob.

Note: If loop is in null (minimum signal) position when flying on a radio range course, the signal may fade in and out, and possibly be mistaken for a cone of silence. When operating on "LOOP," cone-of-silence indications from radio range stations employing loop-type radiators (shown on radio facility chart) are not reliable. The signal may increase in volume to a strong surge when directly over the station, instead of indicating a silent zone.

f. To turn off radio compass, turn selector switch on radio compass control box "OFF."

3. To operate as an aural null homing device, utilizing the directional characteristics of the loop antenna:

a. Set selector switch on "LOOP."

b. Push "CONTROL" button if indicator lamp does not indicate position control.

c. Tune in desired (preferably clear channel) station.

d. If loop indicator pointer is not at zero, depress "LOOP L-R" knob and turn it to the "L" or the "R" position until the pointer rests on zero. Final adjustment of loop position can be made at slow speed by releasing "LOOP L-R" knob and turning it to "L" or "R."

e. Turn "AUDIO" control fully clockwise and head airplane in proper direction, based upon the null indicated in the headset. (The broadness of the null depends on the strength of the signal. Strong signals produce very sharp nulls, sometimes as small as one-tenth of a degree.) Vary "AUDIO" control until the null is of satisfactory width. The tuning meter may be used as a visual null indicator.

Note: When determining direction of flight by this method, remember that the airplane may be flying either directly toward or directly away from the station. If direction of flight with regard to this ambiguity is not known and radio compass won't work on "COMP," a standard orientation procedure must be executed before flying any great distance along the null.

f. To turn off radio compass, turn the selector switch on radio compass control box to "OFF" position.

4. To operate as a homing compass, utilizing the unidirectional characteristics of the radio compass when operating with the vertical and loop antenna:

a. Set selector switch on "COMP."

b. Push "CONTROL" button if the control indicator lamp does not indicate position control.

c. Tune in desired station.

d. Apply rudder in direction shown by radio compass indicator until pointer centers on zero. This indication is unidirectional; as long as pointer rests on zero, the airplane is headed toward the transmitting antenna of the radio station.

Note

The airplane's flight path toward the antenna may be a curved line unless its direction is offset to compensate for wind drift, as determined by the drift sight or by noting the change in magnetic compass reading while homing on the radio compass.

e. Regulate headset volume by adjusting "AUDIO" control.

f. Since a pronounced AVC action may be present when operating the radio compass on "COMP," aural indications received on this position should not be used when homing on a radio range station.

g. To turn off radio compass, turn selector switch on control box to "OFF."

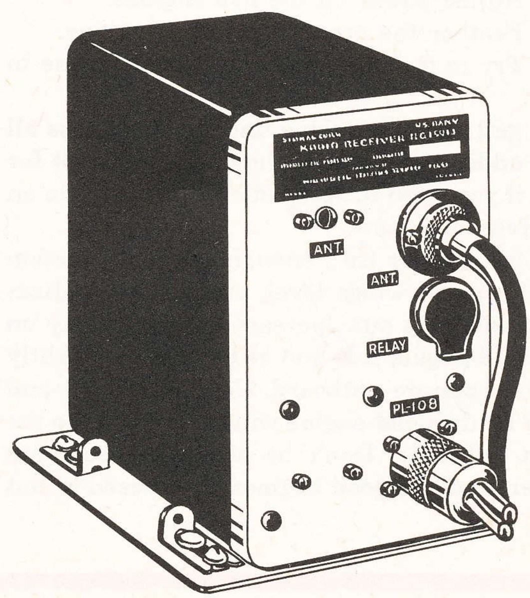
IMPORTANT

There are many uses of the radio compass which are invaluable to the airplane commander. An excellent description of its uses will be found in T. O. 30-100B-1, Instrument Flying Advanced With Radio Aids.

MARKER BEACON RECEIVER

The marker beacon receiver picks up 75 Mc signals used in radio navigation and landings and reproduces them visually through a light on the instrument panel. When the airplane is over a keyed transmitter, such as a CAA marker, or certain types of Army transmitters, the indicator lamp on the panel flashes the identifying signal of the transmitter. The receiver unit is installed in the bomb bay.

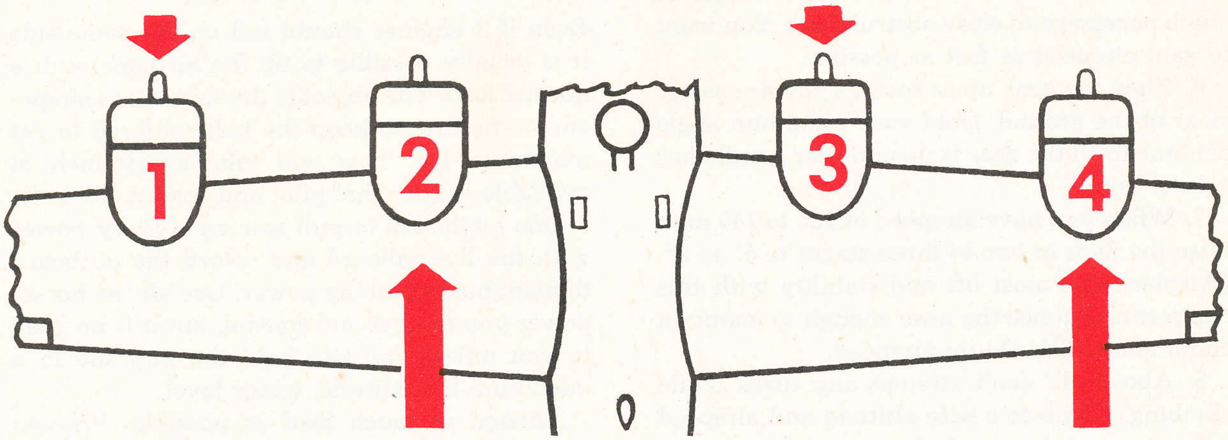
The receiver operates automatically on power drawn from the radio compass; hence, for marker beacon reception, your radio compass must be on and operating.



WHAT YOU LOSE WHEN YOU LOSE AN ENGINE

No. 1 Dead—You lose generator and vacuum pump which affects all gyro instruments and de-icer boots. Switch vacuum to No. 2 to restore suction for gyros and for de-icer boot operation.

No. 3 Dead—You lose generator, heaters for bombardier, navigator and radio operator and you lose the engine-driven hydraulic pump. This affects flaps, gear, brake accumulators and bomb doors.



No. 2 Dead—You lose generator, heaters (for pilot, copilot and top turret gunner) and vacuum pump. Switch vacuum to No. 1.

No. 4 Dead—You lose generator affecting electrical system.

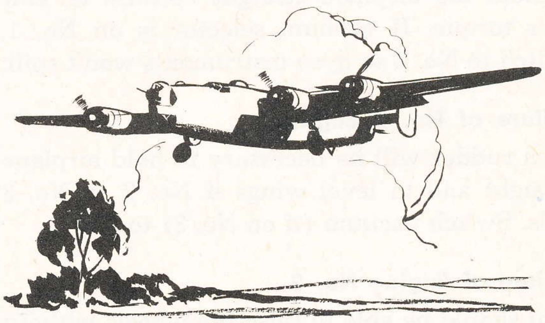
NOTE: GYROS SPILL WITHIN 3 TO 5 MINUTES WITHOUT SUCTION.

ENGINE FAILURE ON TAKEOFF

The value of an engine-failure procedure is the fact that it prepares a pilot in advance for emergencies. It gives you a plan of action that will help you to do the right thing at the right time, smoothly and efficiently.

Procedure

1. If there is room enough, the best thing is to throttle back and stop the take off.
2. If it is too late to stop (as is usually the case), use all available runway to build up flying speed.
3. As long as yaw is less than that of a windmilling propeller, without excessive vibration or dangerous instrument indications, don't be in a hurry to feather. (See Feathering.) Feather only when you **know** you have located the failing engine.



4. Get and keep control with rudder and minimum aileron. Insufficient rudder and too much aileron will put you in a forward slip and you

will be unable to gain airspeed or altitude. Use as much power as you need to clear obstructions, but no more than you can fully control. When you have good control and a safe altitude, trim rudder to relieve yaw, level the wings and center the ball to get maximum flying efficiency. Provided airplane was properly trimmed beforehand, you will not need aileron trim.

5. Hold the nose at the minimum angle of climb necessary to clear obstructions. You want to gain airspeed as fast as possible.

6. Start the gear up as soon as you are safely clear of the ground. Hold your minimum angle of climb until the gear is up and gear handle has kicked out.

7. When you have airspeed of 135 to 140 mph raise the flaps in two to three stages to 5° to 9°. (Airplane has most lift and stability with this flap setting.) Raise the nose enough to maintain climb and still build up airspeed.

8. Above all, don't attempt any turns while climbing. Climb to a safe altitude and airspeed and get up on the step before starting a turn.

9. Request emergency landing clearance from the tower, preferably with a pattern that will permit you to make turns with the live engines on the inside of the turn. Avoid any violent maneuvers. Make shallow turns and remember that you'll have a longer radius of turn because of unbalanced power.

Failure of Engine No. 1

If No. 1 fails and you are using maximum takeoff power, it will require all available rudder to hold the airplane straight because of yaw plus torque. If vacuum selector is on No. 1, switch to No. 2 so gyro instruments won't spill.

Failure of No. 2 Engine

Less rudder will be necessary to hold airplane straight and to level wings if No. 2 or No. 3 fails. Switch vacuum (if on No. 2) to No. 1.

Failure of Engine No. 3

You should be able to raise the wheels without using the auxiliary hydraulic pump if the engine is delivering any power at all or even if it is windmilling.

If you have feathered the propeller, the engine-driven hydraulic pump will not operate. Then, have engineer turn on the auxiliary hydraulic pump switch and open the star valve to get the gear and flaps up. Then turn the start valve off until needed to get the gear and flaps down.

Second Engine Failure on Takeoff (This shouldn't happen to a dog)

Even if 2 engines should fail on the same side it is usually possible to fly the airplane with a normal load. The object is the same as in single-engine failure: to keep the ball centered to get maximum lift. This will take every inch of available rudder that pilot and copilot can hold.

One method is to pull war emergency power with the live inboard and retard the outboard to maximum climbing power. Use all the horsepower you can get and control, but it is no good to you unless you can hold the airplane in a maximum-lift attitude, wings level.

Jettison as much load as possible. Proceed as in a single-engine failure. As soon as you have gear and flaps up, and a safe airspeed, you can probably maintain a shallow climb with less power. Do your climbing straight ahead.

If 2 engines fail on opposite sides, you will have no serious problem maintaining direction and can use more balanced power settings.

Caution: Under no condition try to turn back to the field. If the airplane is sinking too much, execute a landing straight ahead. Warn the crew in advance and carry out the procedure for crash-landing on land as far as time permits.

Remember: Don't slack off on rudder and use ailerons. You are better off with a little less power and an efficient flying attitude. Wait until after you have gained control to trim. Don't attempt to get control with trim.

Don't try to turn back to the field.

Use all your strength on rudder and then use as much power as you can hold. Center the ball if you want the airplane to fly.

After flaps are at 5° to 9°, never let the airspeed get below 145 mph even if you have to sacrifice altitude.

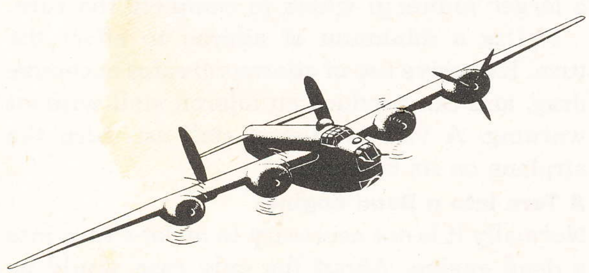
Smooth application of controls is vital. Use gradual, steady pressures. Nurse 'er, brother, nurse 'er and she'll fly!

ENGINE FAILURE IN LEVEL FLIGHT

The same principles apply here as in other situations when an engine is losing power. However, you have more time in which to regain control of the airplane, your wheels and flaps are up, and it is seldom necessary to use excessive power for any extended period.

There is nothing critical about an engine failure in the B-24. If you know how to get the airplane under control, how to use power and when and when not to feather, you can bring 'em back alive from a long way out. Combat pilots are doing it all the time. Sincere concentration and a desire to learn in ground school, on the flight line, and in the air, and thoughtful study of the airplane and technical orders, will rapidly prepare you to meet any situation. Know everything this manual has to tell you and you'll feel secure in most situations.

POWER SETTINGS FOR 3-ENGINE CRUISING



Normally, with one engine dead, maximum cruise power settings will easily maintain level flight. When the engine first fails, you may want to use maximum climbing power and, in combat, danger from the enemy or maintaining position in formation will govern your actions. But don't pour the power on unreasonably. Second and third engine failures too often are induced by using power improperly. Handle your power with kid gloves to avoid failures.

Refer to the 3-Engine Cruise Control Chart for power settings, airspeed and fuel consumption.

Inboard or Outboard Failure

For cruising purposes, it makes little difference whether an inboard or an outboard engine fails. An outboard will require a little more rudder pressure to regain control, especially if No. 1 fails. Remember, if No. 1 or No. 2 fails, to switch vacuums at once. You need your gyro instruments to fly a B-24, especially with an unbalanced power condition or if you are on instruments.

Failure of No. 1 or No. 2 When De-Icers Are Working

When cruising in icing conditions with de-icers working, failure of No. 1 or No. 2 cuts off half of the pressure to de-icers. When you switch vacuum to the live engine, there is full pressure for inflating de-icers but there is no vacuum for deflation and you have to depend on external air pressure for deflating boots. You can divert all the suction to deflating by switching vacuum to the dead engine for 30 seconds periodically and then back to the live engine to maintain proper suction for gyro instruments. You'll only need to do this under severe icing conditions. It takes 45 seconds for the complete cycle of inflation and deflation of de-icer boots.

Failure of 2 Engines in Flight

If 2 engines fail, it is possible to fly the airplane in all gentle maneuvers within engine power limits. Normally, "AUTO-RICH," 2300 rpm and 34″ manifold pressure will suffice. Don't forget the sequence for increasing power.

Based on 50,000-lb. weight, 5000 feet density altitude and 1200 gallons of fuel available, this power setting will maintain level flight at 152 mph indicated (164 true airspeed), and will give a maximum range of 970 miles with no wind. Under the same conditions except cruising at 10,000 feet your airspeed would be 143 mph indicated, 167 mph true airspeed, and range would **increase** to 1030 miles. You could not maintain altitude at 15,000 feet with 2 engines dead, and would want to descend to 10,000 feet.

If 2 engines are out on one side, you may have to increase power with a resultant sacrifice in range. In this case, your immediate problem will be to regain directional control and keep the dead-engine wing from dropping below level flight. This will call for all possible rudder pressure and maximum smoothness in flying. Get control, center the ball, hold and trim. If you can't trim out all the yaw, slightly increase rpm and power on the live inboard and decrease power and rpm on the live outboard to assist in trimming. You will still have to hold some rudder. Remember that you probably can't maintain altitude with both landing gear and flaps down. (See 2-Engine Landing.)

Caution: If you continue to lose altitude with 2 engines dead there are several choices. First try 5° to 9° of flaps. This will usually reduce descent 200 to 300 feet a minute. Then jettison all possible cargo. You should be able to maintain altitude with 5° to 9° of flaps and 145 mph. If still losing altitude at 2000 feet above the terrain, bail out the crew.

Concealed Engine Failure

During cruising flight it is not always apparent that an engine is failing. Yaw may be slight if the guilty engine is an inboard and if the turbo-supercharger is not operating. A windmilling propeller can maintain engine readings on the tachometer, oil pressure, and manifold pressure dials within operating limits, concealing the failure.

Assume throttles are open, turbo-superchargers are operating and an engine fails. Manifold pressure for that engine will immediately drop to approximately atmospheric pressure for the altitude which you are flying. However, if turbo-superchargers are not engaged, manifold pressure would show no substantial drop when an engine fails.

Fuel pressure will remain normal in a regularly functioning fuel system. Low temperature readings of cylinder-head temperature and oil temperature gages may be the only symptoms of such a failure. Cylinder-head temperatures are the first to react and should be closely observed. If you are inexplicably losing airspeed and or altitude, you may be experiencing such a failure.

On automatic pilot, controls will suddenly get busy and tend to cross, and airspeed will fall off, in addition to engine indications.

Turns With Dead Engines

Warning: Never attempt turns unnecessarily while climbing with one or more engines dead.

1. Be sure the airplane is under control and trimmed, and, if necessary, power balanced. Then, with one engine dead, or an engine dead on each side, even though one is an outboard and the other an inboard, you won't have trouble controlling the airplane in the turn if you keep banks shallow and maintain airspeed.
2. Plan ahead so you have a world of room in which to make the turn and so you will turn into the live engines.
3. Use shallow banks, not to exceed standard rate one-needle-width turns.
4. Use smooth but strong application of rudder. The airplane will resist the turn because you are turning **against power** and will require a larger radius in which to complete the turn.
5. Use a minimum of aileron to effect the turn. Excessive use of ailerons creates excessive drag, and can produce an aileron stall without warning. A violent aileron stall can turn the airplane on its back.

A Turn Into a Dead Engine

Normally it is not necessary to make a turn into a dead engine. About the only case would be if an engine failed on the side toward the field on the base leg. If that should happen, it would probably be better to turn into the dead engine to line up on final approach than to turn through 270° in the opposite direction. You can make a shallow turn into a dead engine safely, provided the airplane is flown in a coordinated manner (center the ball). Remember not to allow the nose to get up, and maintain 145 mph with 5° to 9° of flaps.

ENGINE FAILURE IN TRAFFIC

It is one thing to approach traffic with altitude to spare, dead engine feathered, gear up and time to plan. It is a somewhat different problem to be flying in traffic and have an engine fail. Assume that you have just started on the downwind leg, wheels down, and have started the checklist and an engine fails—then what?

Your first step is to get complete control of the airplane, increasing power if needed, mixtures to "AUTO-RICH," props to 2550, power to give full control. If there is violent vibration, feather as soon as you can be sure which engine is at fault. At the earliest possible moment notify the tower to clear traffic—you don't want to have to go around if it can be avoided. Immediately order gear up to reduce drag. If No. 3 has failed, have the engineer switch on the auxiliary hydraulic pump and open the star valve to bring the gear up. Gear will come up in 30 to 40 seconds. After gear is up and flaps are at 5° to 9°, turn off the switch but leave the star valve open ready to bring the gear and flaps down when you again start pump on final approach. Now complete the checklist. From there on, use the same procedure as in other dead-engine landings, keeping your base leg close in and lowering gear on final approach when you know you can make the field, lowering flaps when the gear handle has kicked out, etc. (Gear will come down and lock in approximately 25 seconds.)

If the failure occurs close enough to the field so that your position and altitude permit a normal landing, don't raise the gear. Use enough power to bring you safely into final approach.

LANDING WITH ONE OR MORE ENGINES DEAD

Pilots with average ability can safely land the B-24 with one or 2 engines dead if they plan ahead properly and follow correct procedures.

Approaching Traffic

It is most important that you notify the tower well in advance that you have a dead engine and want to make an emergency landing. Request a traffic pattern which will keep the dead engine high on all turns. The tower should get other ships out of the pattern and give you the right of way.

Procedure for 3-Engine Landing

1. Approach traffic and fly the traffic pattern 500 feet higher than normal at an airspeed of 150 mph.
2. Otherwise place and fly the downwind leg in the normal manner, except **keep the gear up** until final approach. On the downwind leg complete other items of the checklist as usual, including 5° to 9° of flaps to stabilize and improve the lift characteristics of the airplane.
3. Shorten the distance you fly out on the last part of the downwind leg in order to keep your base leg in closer so that there will be less danger of undershooting on final approach.
4. Start your turn substantially earlier, because against power the radius of turn will be greater. **Don't** get the nose up and **do** maintain airspeed in the turn at 150 mph if you have to lose a little altitude to do so.
5. Again start your turn earlier than usual from base leg into final approach. If necessary, retard the throttle slightly on the outboard nearest the field to help turn. Start the final-approach checklist in the turn. Procedure is the same as usual except for gear and flaps.
6. Roll out of the turn with rudder and line up for final approach. Judge your distance carefully and be sure you can make the field before ordering the gear down. Maintain 140 mph until gear is down and locked. Engineer won't be

able to check the main gear locked because you have 5° to 9° of flaps, but he can and must check the nose gear.

7. As soon as the gear handle kicks out (and not before) and when you are sure you can make the field, call for full flaps. This noticeably increases lift and tends to lengthen your glide, so as flaps come down, reduce airspeed to 125 mph by reducing power. It is a good idea to use 5 to 10 mph higher airspeed than this on final approach if the length of runway permits.

8. As airspeed drops and you reduce power, re-trim to normal tab settings because you no longer have an unbalanced power condition.

9. From then on it is a normal landing. Keep on enough power to control your rate of descent. Power reduction on final approach will vary depending upon which engine is out. With a dead outboard, you would throttle back the active outboard (as flaps come down) to about 12″ manifold pressure to give a normal tab setting.

Keep sink to a minimum with the inboard engines. Once you have a high rate of sink, it is hard to stop because of inertia. With a dead inboard, reduce the active inboard first and land with the outboards. As you make contact, close the 3 throttles together. **Note:** If No. 3 engine is dead, have the engineer switch on the auxiliary hydraulic pump and open the star valve when you want to bring flaps and gear down. After they are down on final approach have the star valve closed, but leave the switch on so the auxiliary hydraulic pump will charge accumulators.

Landing With 2 Engines Dead

In general the procedure is identical with that of a 3-engine landing with these exceptions:

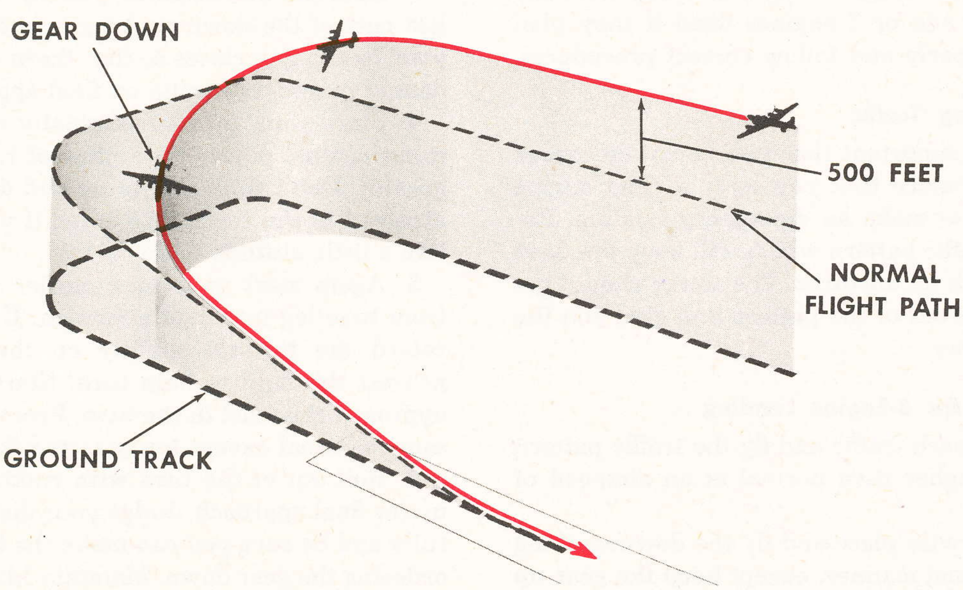
1. Approach and fly traffic 1000 feet higher than normal.

2. Maintain a slight descent throughout the pattern to maintain airspeed, and fly turns with the greatest care to lose minimum amount of altitude. Don't let the airspeed drop below 145 mph with 5° to 9° of flaps.

3. You should enter the turn on final approach about 500 feet higher than normal.

One engine dead on each side: Power can be easily balanced even though one is an outboard and the other an inboard.

Two engines dead on the same side: This is your most unbalanced power condition. Except more difficult turns in which it may be necessary to reduce power on the active outboard. On final approach gradually reduce power first on the active outboard and re-trim; control rate of descent with the inboard engine.



3-ENGINE GO-AROUND

This won't happen to you if you have been living a good clean life. You are on final approach with a dead engine, gear down, full flaps down and gliding at 125 mph when the tower orders you to go around. The sequence of operations is most important.

Procedure

1. Lead with balanced power. If an inboard is dead, lead with the outboard throttles. If an outboard is dead, lead with the inboards and follow gradually with the unbalancing throttle to avoid getting power on that you can't hold with rudders until your speed increases.
2. As always with a dead engine, the important things are a shallow climb and level wings to gain airspeed as rapidly as possible.
3. Get at least 125 mph before you call for flaps to 20°. As the flaps come up, slightly increase the angle of attack enough to avoid sink. Airspeed should immediately build up to 135 to 140 mph.
4. Important: Here's where sequence is important. Raise the flaps ahead of the gear, because it takes 30 seconds for the gear to come up and during that time you would have the drag of full flaps. When you have brought the flap handle to neutral, order the gear up.
5. With this procedure, you should have no trouble controlling enough power to gain adequate airspeed for climbing. As soon as you have 135 to 140 mph and a safe altitude raise flaps to 5° to 9° and keep this setting for maximum flying efficiency.

Note

If you are about to overshoot on final approach, don't dissipate altitude with a nose-high attitude. Reduce power and dive. This requires good technique, and you must start your flare-out slightly higher than normal.

AC POWER OR INVERTER FAILURE

If you feel that instruments are indicating with an uncanny steadiness, **don't reach for a feathering button.** There is probably inverter or AC power failure. Inverters change direct current from the batteries to alternating current to operate autosyn instruments and other units. There may be a fuse blown, inverter trouble, or an inverter fuse blown. You know there is nothing radically wrong with the airplane because there is no yaw, no vibration, and you are maintaining your airspeed, so don't feather. It is very unlikely that all 4 engines will fail at once. Cylinder-head and oil temperatures are still indicating normally.

Test for Inverter Failure: Turn the booster pumps on or off and observe the action of the fuel pressure gage. A variation in pressure indicates that the inverters are functioning. An alternative check is to watch the operation of the remote-indicating compass or the radio compass.

Effect of AC Power or Inverter Failure

1. Autosyn instruments (electrically operated) will tend to stay put or creep slowly down. On many airplanes this includes the tachometers, manifold pressure gages, fuel pressure gages and oil pressure gages. However, instruments controlled by AC power may vary on later models.
2. Other instruments will continue to register normally.
3. Radio compass will fail to function since it is on AC power:
4. At night:
   a. Magnetic compass lights will go out.
   b. Tube-type fluorescents will go out.
5. A-5 automatic pilot will cease to function.
6. Electronic supercharger, if so equipped, will lock waste gates in the position they are in when inverter fails. This gives no cause for immediate alarm but must be considered in changes of altitude and power settings.

Remedy:

Switch to the other inverter; if this fails, check all fuses concerned. These measures will usually restore your AC power. That's why you have extra fuses and 2 inverters but normally use only one—so that you'll have a spare inverter if needed.

Warning: If you have had inverter failure with an electronic supercharger control, keep your hand on the throttles when you switch inverters and control any manifold pressure fluctuations for at least 2 minutes to allow the amplifier to warm up. If circumstances permit, reduce power during this period.

Automatic Change-over

On some late series aircraft an automatic change-over relay switches to the spare inverter if the main one fails. A red light on the instrument panel flashes on to warn you that the main inverter is dead. The relay will not switch from spare to main, so always operate on the main inverter.

Flight Procedures in Case of Complete Failure

The most important thing is to keep your head:

1. Don't feather. Don't change power. Keep the airplane flying straight and level!
2. Fly the airplane by means of the altimeter, flight indicator, rate-of-climb indicator and your airspeed indicator.
3. You know the power setting you were using. Mark the throttle quadrant so you won't be tempted to shove on excessive power. Remember your airspeed indicator (in level flight) is a direct guide to the power you are getting.
4. If necessary to descend from high altitude, reduce power, and establish a nominal rate of descent. When you level off, judge increase in power by airspeed and re-establish power to give you the same indicated airspeed as higher up.
5. In case of a descent when equipped with electronic supercharger, your power reduction will have to be made entirely with throttles.
6. It is a good idea to land at the nearest suitable airfield.

Landing

You can make a normal landing without difficulty if AC power fails. Judge power settings by eye, ear, and flight instruments.

RUNAWAY PROPELLERS

The most important fact to keep in mind about a runaway propeller is **not to feather it** until you have tried out the 2 procedures which should give you control of it. Drill these procedures into your copilot so he will understand his part in controlling a runaway propeller.

It is seldom that a propeller runs away in a B-24. When it does happen, it is usually on takeoff, and it is imperative to know what is happening and how to regain control. A first step in knowing what to do is understanding normal operation of the propeller. You have two controls over its performance: "INCREASE"-"DECREASE" toggle switches on the pedestal, and fast-feathering buttons above the compass at the top of the windshield. Prop governor lights operate when the governors reach their limit of travel in either direction. For normal operation, you select the most desirable rpm by holding the toggle switch toward "INCREASE" or "DECREASE." A governor unit maintains the selected engine speed during all subsequent flight conditions, limited only by the angle of blade rotation possible, which is determined by pre-set governor limits. Automatic control of engine speed is obtained through the propeller by varying the blade angle to maintain a constant load on the engine: e.g., reducing the blade angle when the load increases, as in a climb.

What Causes a Propeller to Run Away

When a propeller runs away, it simply means that the propeller governors fail to hold the propeller at its constant rpm setting. Thus, before takeoff when engines are idling, propeller is in low pitch (small bite), high rpm. Sudden and fast application of power may cause a propeller to exceed the governor limit speed before the governor has a chance to take hold and increase the pitch. Governor cannot regain control until you throttle back and give it a chance. This is usually the case with a runaway propeller. However, if you have complete governor failure, you may not be able to regain control with throttle alone and will have to use the feathering button intermittently as described in the procedures that are given.

Preventive Action

The best way to cope with a runaway propeller is not to get one. Carefully observe tachometer reactions during run-up. Don't jam power on during takeoff. Apply it smoothly. If rpm starts to get out of bounds on an engine during first part of run, don't take off if you have room left in which to stop.

How to Regain Control

Always try this first, during takeoff and in flight. It may give you immediate control of the propeller so you can obtain a normal rpm setting.

First Procedure:

1. Reduce the throttle. This is the first thing necessary to slow the propeller down.
2. Work the toggle switch to decrease rpm. This should slow the propeller down.
3. If this works, reset your throttle, keeping close track of rpm. If it fails, then resort to the second procedure given here.

Second Procedure:

This procedure is recommended for heavily loaded airplanes because it gets more power from the engine.

1. Be sure throttle is reduced.
2. Copilot (at pilot's direction) pushes the feathering button in, holds onto it and watches rpm. **Be sure to get the right one** or you'll be short 2 engines. Take your time!
3. As the propeller decreases the rpm, increase the throttle to obtain climbing manifold pressure and rpm of 2500.
4. When you reach 2500 rpm, forcibly pull the feathering button out. This will keep rpm from going lower. If governor doesn't take control of rpm, it will immediately start back up.
5. When propeller reaches 2700 rpm, push feathering button in again and repeat the procedure to keep rpm between 2500 and 2700 and to maintain desired manifold pressure. Continue this until you have reached an altitude where you can safely feather the propeller.

Caution

Don't be in a hurry to feather. If either of these procedures is keeping the propeller below 2700 rpm, you are getting some power from the engine — possibly as much as 15% with the throttle reduced and up to 65 or 70% if the second procedure is working.

EMERGENCY FEATHERING

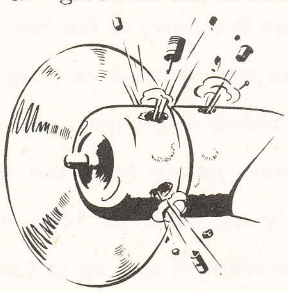
Feathering has a fatal fascination for some pilots. Say "Boo" and their fingers fly to the feathering buttons.

No emergency is urgent enough to justify feathering the wrong engine. Then you are short 2 engines. Remember, it is easier to throw power away than to get it back.

If there are indications of engine failure you are faced with 3 questions:

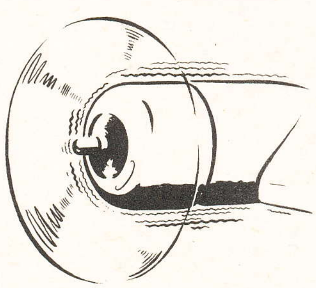
1. Which engine is failing?
2. What's wrong with it?
3. Does the failure call for feathering?

The answers to these questions are nearly always with you in the airplane. You can find them if you have learned how to read the signs: Yaw, vibration, increasing or decreasing temperatures and pressures, excessive rpm, manifold pressure, etc. Some of the questions and answers are given in this section.

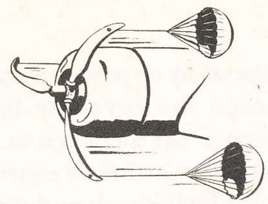


Feathering has several important advantages:

1. Minimizes damage to engine if failure is caused by an engine part.



2. Eliminates vibration.



3. Improves flight performance of airplane (if engine is dead) by eliminating the drag of the windmilling propeller.

Feathering has equally important disadvantages:

1. Danger of feathering wrong propeller, caused by featheritis. Pilots have been known to feather 4 propellers. If you are that confused, you might better use your time for bailing out.
2. Unnecessary loss of power from feathering when a reduction of power and proper procedures might have solved the problem or given at least partial power.

Knowing When to Feather Is Fully as Important as Knowing How to Feather.

Emergency Feathering Checklist

1. Throttle back
2. Feather
3. Mixture and fuel booster pump off
4. Apply power on live engines
5. Gear up
6. Trim ship
7. Cowl flaps closed
8. Ignition off
9. Generator off
10. Fuel valve off

In Case No. 1 or No. 2 Engine Fails or Both:

Check vacuum

Radio compass on (for direction aid by homing)

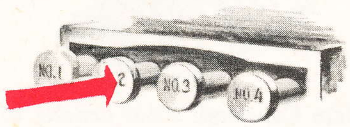
Autopilot tell-tale lights

Unfeathering

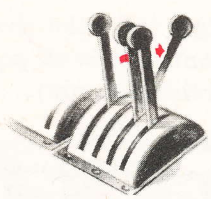
1. Fuel valve on
2. Ignition on
3. Prop low rpm
4. Throttle cracked
5. Supercharger off (oil regulated supercharger only)
6. Unfeather
7. Mixture "AUTO-RICH," booster pump off
8. Warm up engine
9. Generator on

AMPLIFIED EMERGENCY FEATHERING CHECKLIST

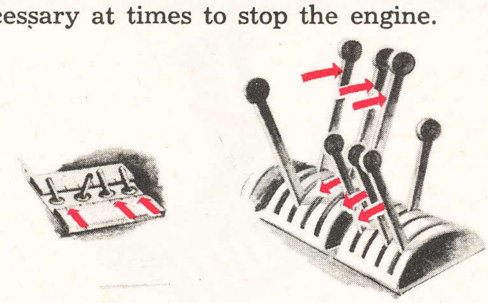
1. **Throttle back.** This procedure helps eliminate the possibility of feathering the wrong propeller. If you throttle back the wrong engine, you will increase yaw on the dead engine side.



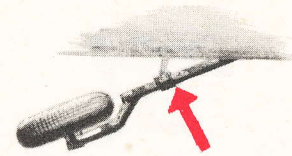
2. **Feather.** Upon determining which engine is defective, pilot presses feathering button in and removes hand. Button should kick out when propeller feathers. If not, propeller will unfeather. In this case, press button again and pull it out when the propeller stops in the feathered position.



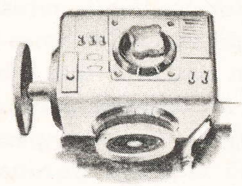
3. **Mixture and Fuel Booster Pump.** Copilot moves mixture control to "IDLE CUT-OFF" and switches fuel booster pump off. This is necessary at times to stop the engine.



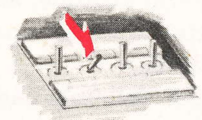
4. **Application of Power.** Copilot adjusts mixture controls on other engines and increases rpm. Pilot increases manifold pressure. Actions of pilot and copilot are approximately simultaneous, but the increase of mixtures and rpm should always precede the increase in manifold pressure.



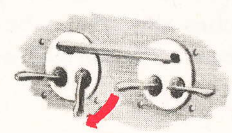
5. **Gear Up.** If the landing gear is extended, copilot retracts it.



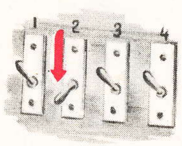
6. **Trim Ship.** Accomplished by pilot.



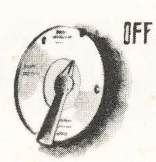
7. **Cowl Flaps Closed.** Copilot closes the cowl flaps on the dead engine to decrease the drag and opens the cowl flaps on the live engines to the trail position if cylinder-head temperatures are high.



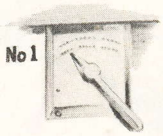
8. **Ignition Off.** Copilot cuts ignition switch for dead engine.



9. **Generator Off.** Engineer switches off generator on dead engine.



10. **Fuel Valve Off.** Engineer turns off main fuel valve of dead engine.



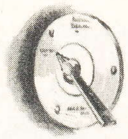
In Case No. 1 or No. 2 Engine Fails, or Both:

Vacuum: Pilot checks vacuum if No. 1 or No. 2 engines are stopped. Engineer changes vacuum selector position if necessary.

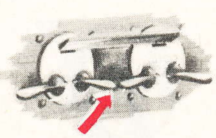
Radio Compass: Copilot tunes in radio compass to nearest station so that if both No. 1 and No. 2 engines are stopped, pilot may fly instruments by using the radio compass as a turn indicator and to maintain direction by homing from one station to another. Level flight may be maintained by reference to the ball-bank indicator for lateral attitude, and by reference to airspeed, rate of climb and altimeter for longitudinal attitude.

Automatic Pilot Tell-Tale Lights: If both No. 1 and No. 2 engines are stopped, there will be no suction for operation of the gyro instruments. Since the autopilot is equipped with electric gyros, the pilot can turn it on, trim ship and refer to the tell-tale lights to maintain level-flight attitude. Using this procedure, the autopilot clutches should not be engaged. This can only be done with the C-1 automatic pilot.

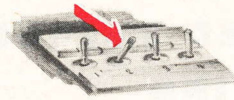
UNFEATHERING



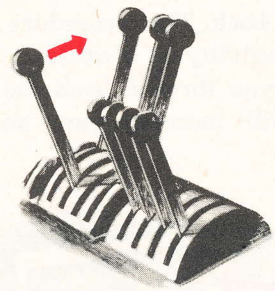
1. **Fuel Valve On.** Engineer turns on main fuel valve.



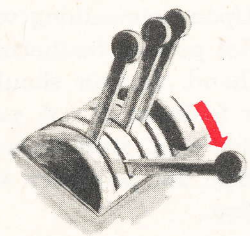
2. **Ignition On.** Copilot turns on ignition switch.



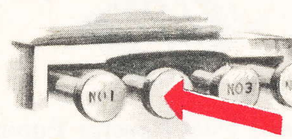
3. **Prop Low rpm.** Copilot checks to see that propeller is in full low rpm position.



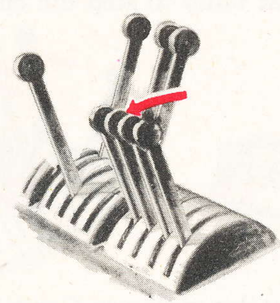
4. **Throttle Cracked.** Pilot cracks throttle.



5. **Supercharger Off.** Pilot checks to see that supercharger control is in off position (with oil regulated supercharger only).

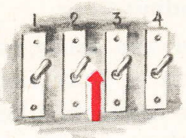


6. **Unfeather.** Pilot holds feathering button in until 800 rpm is indicated and then releases it.



7. **Mixture Auto-rich.** Copilot puts mixture control in "AUTO-RICH," booster pump off.

8. **Warm Up Engine.** Warm up engine at 20″ manifold pressure in "AUTO-LEAN." Increase power gradually as cylinder-head temperature rises.



9. **Generator On.** When power is increased as engine warms up generator is turned on.

After Feathering

Once an engine is feathered there is always danger of the failure of the remaining 3 engines. Reports of B-24 accidents prove this point. Reason: Subsequent failures are caused by pouring on the coal to the remaining engines without regard for proper power settings, bringing on detonation and a complete loss of power.

Be careful with that boost. Pilots who are perfectly aware of the danger of a heavy hand on the throttles make this mistake. If you have it to spare, sacrifice some altitude to get the airplane flying. Steady flying is imperative for 2 and 3-engine operation. If necessary, throw some things overboard. Don't burn up the engines with excessive power.

Feathering Trouble

1. **If You Feather the Wrong Prop:** You can stop the propeller from feathering if rpm is not below 1000 by pulling out the feathering button. But at less than 1000 rpm, feathering must be complete before unfeathering starts.

2. **If Propeller Feathering Buttons Do Not Work:** Hold the circuit breaker button down (not more than 90 seconds) while operating the feathering button. Circuit breaker buttons are red buttons on top of pedestal.

3. **If Propellers Feather and Unfeather Without Stopping:** Wait until propeller is in feathered position and pull out the feathering button.

4. **If You Have Lost All the Oil and Can't Feather:** Put propeller control in low rpm to reduce windmilling drag as much as possible.

Engine oil systems provide oil for operation of the propeller feathering system. On early airplanes, the feathering pump draws its oil supply from the "oil-in" line to the engine. On later planes, the feathering pump draws its oil supply from the sump at bottom of the oil tank.

QUESTIONS AND ANSWERS ON FEATHERING

1. Q. What is the general rule regarding feathering?

A. An engine losing power should not be feathered as long as yaw is less than that of a windmilling propeller, if there is not excessive vibration and as long as instrument readings are within reasonable limits. Reason: because the power you are getting from the engine more than offsets the reduction in drag obtained from feathering. Remember that engine failure causes a loss of manifold pressure only if turbo-superchargers are engaged.

2. Q. Would you feather the prop of an engine that was violently vibrating?

A. Yes, if it continued to vibrate after reducing throttle, because violent vibration can cause the engine to go to pieces or cause wing structural failure.

3. Q. How can you tell you have a useless windmilling propeller and which engine is causing the trouble?

A. First by yaw. The airplane will yaw in the direction of the dead engine, so you know which side it is on. Then a close scrutiny of instrument readings will tell you by excessively high or low readings which engine is at fault, particularly by low cylinder-head temperature.

4. Q. Would you feather the prop of an engine that showed decreasing oil pressure?

A. Yes, if oil pressure falls below 30 lb. There may be a broken oil line and you want to get the propeller feathered before all the oil runs out. At least one gallon of oil is required in the feathering operation.

5. Q. If there is violent vibration, how can you tell which engine is at fault?

A. First by visually checking to see which engine is vibrating. Then by checking cylinder-head temperature, which would probably be excessively high, and by checking rpm for fluctuation.