ILYUSHIN IL-18

Passenger and Cargo Aircraft

for Microsoft Flight Simulator 2024

TECHNICAL DESCRIPTION

PART 1 – SYSTEMS INFORMATION

by Nemeth Designs Aviation Bureau

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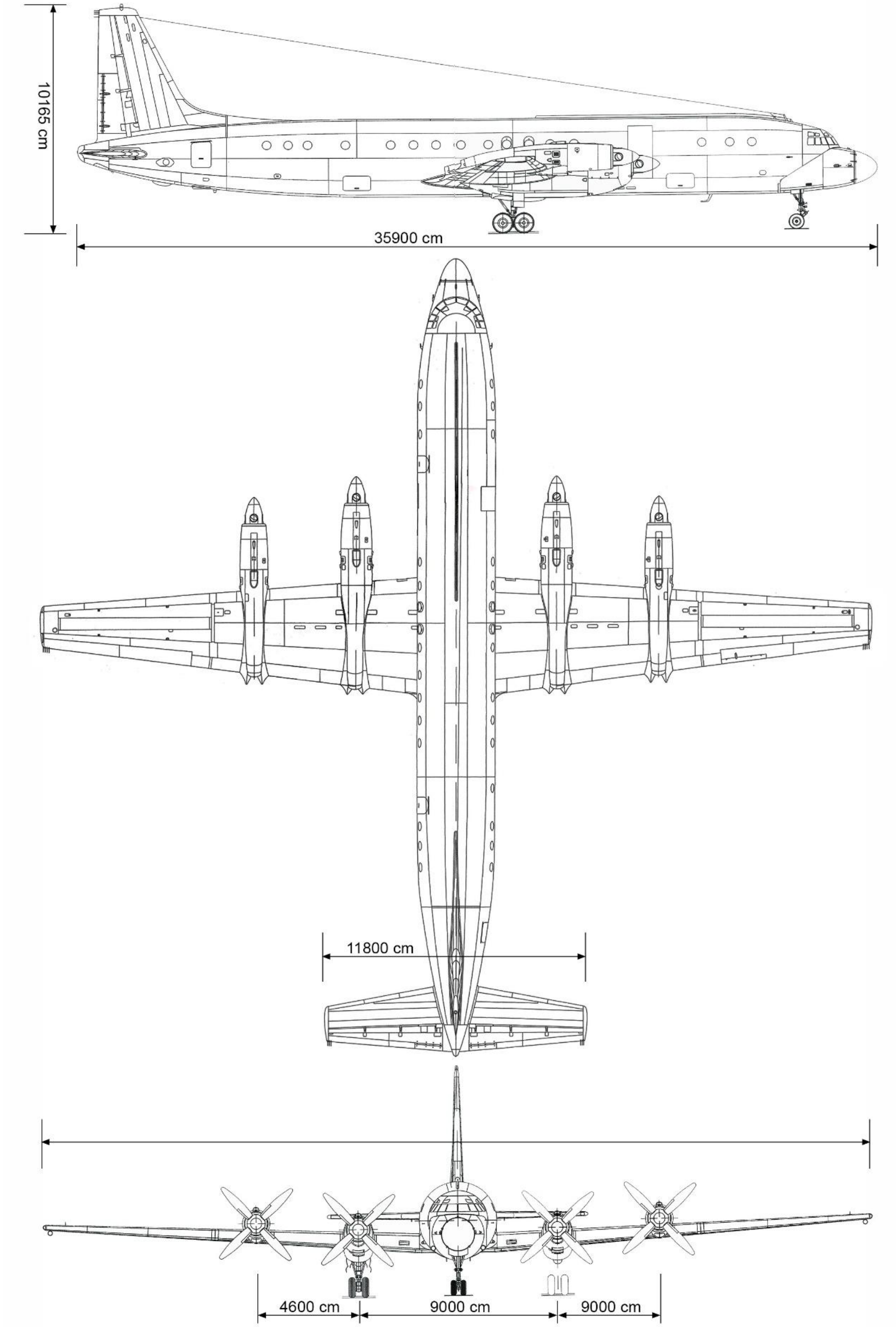
CHAPTER I

GENERAL INFORMATION ABOUT THE AIRCRAFT

The Il-18 is an all-metal cantilever monoplane with a straight, low-mounted trapezoidal wing, a cantilever horizontal tail, and a single-fin vertical tail. It is powered by four AI-20 turboprops of 4000 equivalent hp each and is intended to carry passengers, baggage, cargo, and mail on medium- and long-haul routes. Crew and passengers occupy a pressurized cabin that maintains adequate pressure and normal temperature at all altitudes.

The modifications are the Il-18A, B, V, D, and E. The first-series Il-18A seated 80; structural reinforcement raised the take-off weight and payload, producing the Il-18B with 89 seats. Later versions reworked the fuselage layout to add seats — initially up to 110 on the Il-18V and 122 on the Il-18E, later capped at 100 — and introduced improvements first to the fuel system, the cabin air-conditioning, and the water and sewage system, along with more advanced equipment. The Il-18D is distinguished by enlarged fuel tanks for long non-stop flights.

This add-on is based on a late, much-upgraded Il-18D. The descriptions below are drawn mainly from original service and flight manuals; many were later superseded in practice, and many describe systems or procedures that cannot be reproduced within Microsoft Flight Simulator 2024. Following every instruction here is not required to operate the aircraft in the sim, but it explains how the real systems worked and how far each is modelled in this add-on. This applies to all four parts of the documentation.


10165 cm
35900 cm
11800 cm
4600 cm
9000 cm
9000 cm

DIMENSIONS

Aircraft height	**10.165 m**
Aircraft length	**35.9 m**
Wingspan	**37.4 m**
Wing area	**140.0 m^2**
Mean aerodynamic chord of the wing	**4.052 m**
Wing aspect ratio	**10.0**
Wing taper ratio	**3.0**
Wing dihedral angle (leading edge)	**3°**
Installation angle — center section / outer root / outer tip	**+3° / +2° / −1°**
Installation angle, stabilizer	**9°**
Landing gear track	**12.755 m**
Landing gear base	**3.5 m**
Maximum fuselage diameter	**2 m**
Passenger cabin height	**3.23 m**
Baggage/cargo compartment No. 1 (L × W × H)	**9.24 × 1.4 × 1.035 m**
Baggage/cargo compartment No. 2 (L × W × H)	**9.655 × 1.37 × 1.035 m**
Entrance door (W × H)	**0.76 × 1.40 m**
Baggage/cargo compartment door No. 3	**0.9 × 1.28 m**
Emergency exit	**0.45 × 0.75 m**
Baggage/cargo compartment hatches No. 1 and 2	**0.75 × 1.25 m**
Ground to bottom edge — entrance door	**3.1 m**
Ground to bottom edge — cargo door No. 3	**2.87 m**
Ground to bottom edge — cargo hatches No. 1 and 2	**1.915 m**

WEIGHT DATA

Maximum take-off weight is 61,200 kg for the Il-18B and Il-18V, 61,400 kg for the Il-18E, and 64,000 kg for the Il-18D. It may be exceeded by no more than 500 kg, since that much fuel is burned during engine run-up and taxi from the terminal to the start point. Take-off weight comprises the equipped aircraft (empty weight plus service equipment), payload, fuel, and crew including cabin attendants. Service equipment — engine oil, removable galley equipment, toilet and galley water, removable household and oxygen equipment, and auxiliary items such as the onboard ladder and signal cartridges — weighs about 900–910 kg.

Maximum landing weight is 52,000 kg for the Il-18B, V, and E and 52,600 kg for the Il-18D. Landing above this, including at maximum take-off weight, is permitted only in exceptional cases and demands extra care from the pilot; afterward the landing gear and the adjacent center-section elements are inspected for deformation or damage. Empty weight, taken from the loaded-aircraft form, depends on the modification and the number of passenger seats.

Maximum payload is 13,500 kg — passengers, baggage, cargo, and galley supplies. At full payload the aircraft can fly about half its maximum range; for longer flights, payload is reduced by the weight of the additional fuel required. Maximum fuel reserve (at a density of 0.785 g/cm^3) is 23,550 kg for the Il-18D and 18,600 kg for other versions, and the maximum fuel remaining at landing is 10,000 kg — a limit imposed because fuel carried in the wing produces large inertial loads during landing.

Alignment (centering) is the position of the center of gravity relative to the wing, expressed as a percentage of the mean aerodynamic chord (MAC); for the Il-18's trapezoidal wing the MAC equals the geometric mean chord. Correct alignment is decisive for longitudinal stability and controllability: a CG too far forward or aft can make flight impossible, so in-flight alignment must stay within fixed limits. These limits are the same for all modifications except the aft limit of the Il-18D — maximum forward 16% MAC (gear up) and 18% (gear down); maximum aft 23% (gear up) and 25% (gear down), and for the Il-18D 24% and 26% respectively. The aircraft must therefore be loaded per the Il-18 centering and loading instructions. The CG shifts during flight as fuel burns (moving it forward), as the gear retracts (also forward), and as passengers move.

FLIGHT AND TAKEOFF/LANDING DATA

Flight and take-off/landing data are nearly identical across modifications except for the Il-18D's maximum range, and are given for standard atmosphere (15 °C at sea level, air density 0.00125 g/cm^3, pressure 760 mm Hg). Maximum speed at 8000 m is 650 km/h at a take-off weight of 56,000 kg. Near the ground at 61,200 kg, the maximum rate of climb is 7.0 m/s and the practical ceiling (where climb falls to 0.5 m/s) is 9200 m. Maximum range at 8000 m is 4800 km with 18,600 kg of fuel at 61,200 kg, rising to 6500 km for the Il-18D with 23,400 kg of fuel at 64,000 kg; range calculations always retain a navigational reserve against unforeseen delays. Take-off at 61,200 kg with flaps at 15° requires a 1250 m run and gives a lift-off speed of 250 km/h, while landing at 52,000 kg with flaps at 30° gives a speed of 230–235 km/h and a 1000 m roll.

MAIN FLIGHT RESTRICTIONS

Maximum permissible IAS in level flight	**510 km/h**
Maximum permissible IAS during emergency descent	**610 km/h**
Maximum permissible Mach number	**0.65 M**
Maximum permissible IAS, flaps 15°	**320 km/h**
Maximum permissible IAS, flaps 30°	**300 km/h**
Flaps 45°	**not permitted**
Maximum permissible IAS, gear retraction/extension	**350 km/h**

MAIN STRUCTURAL MATERIALS OF THE AIRFRAME

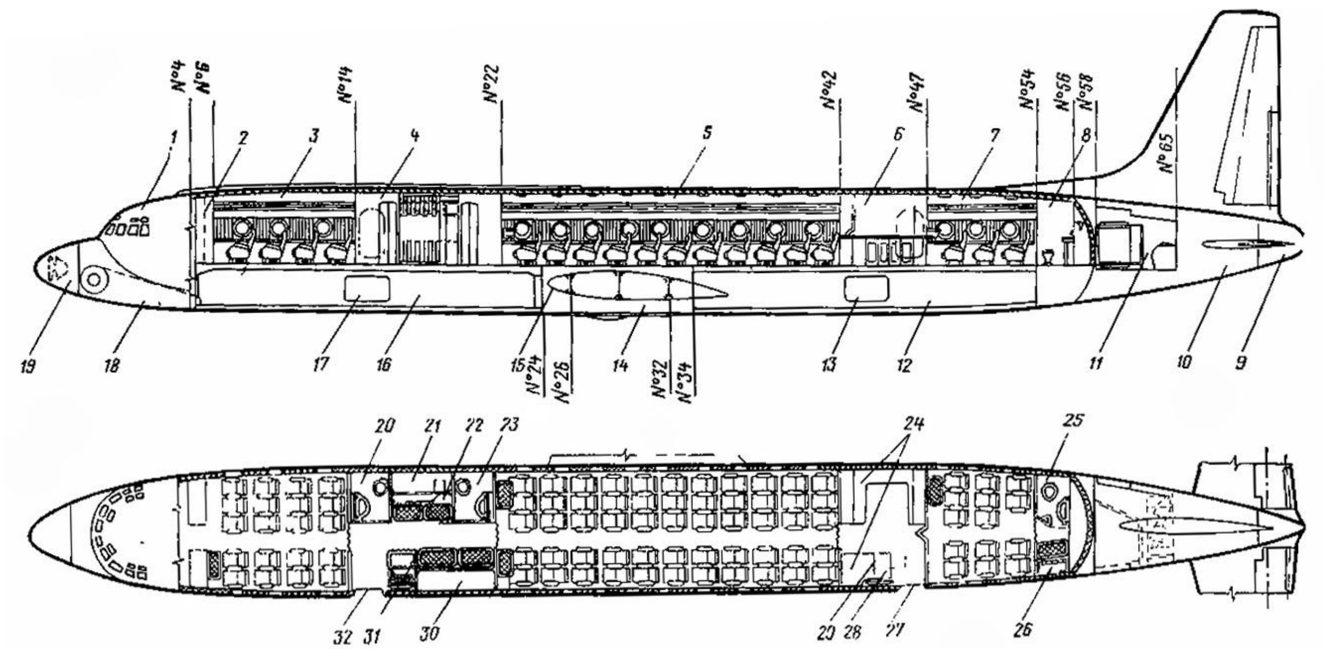
The airframe is divided into components by a number of joints, and its load-bearing elements are made of aluminum alloys, magnesium alloy, steels, titanium alloy, and other materials.

Duralumin carries the vast majority of structural loads. Heat-treated for the Il-18 to a tensile strength of 40–43.5 kg/mm^2 at a density of 2.8 g/cm^3, it is ductile and performs well under variable loads; the grade used is hardened with reduced harmful impurities. Extruded duralumin profiles form fuselage, wing, and tail stringers, frames, spar webs, ribs, and cold-stamped sheet parts, with various grades used for the plating, while hot-stamped alloy is used for butt-joint parts. Magnesium alloy serves medium- and low-loaded cast parts; lighter (1.85 g/cm^3) but weaker (21–22 kg/mm^2) than aluminum alloys, its drawback is poor atmospheric corrosion resistance. Steels and nickel are used for highly loaded butt-joint bolts, with tensile strengths of 100–125 and 145–165 kgf/mm^2; nickel is sensitive to impacts, scratches, nicks, and abrupt section changes, all of which concentrate stress dangerously under variable loads. Titanium alloy, a heat-resistant cladding and screen material, combines low density (4.5 g/cm^3) with a tensile strength of 60 kg/mm^2. Rivets are aluminum alloy — duralumin for lightly loaded joints up to 3.5 mm diameter, alloy for the main part, and steel rivets in steel and mixed assemblies.

FUSELAGE

The fuselage houses crew, passengers, cargo, and equipment and serves as the attachment base for the wing, empennage, and nose gear leg. It is a semi-monocoque stringer structure with many stringers and frames and relatively thick skin. A non-pressurized, radio-transparent fiberglass nose radome — outer and inner skins over a honeycomb core — is hinged to the fuselage on the right and held by tension locks on the left.

The floor divides the pressurized cabin into an upper part (passenger cabins or cargo hold, cockpit, and service areas) and a lower part (mainly baggage and cargo compartments). The cockpit occupies the nose up to frame No. 4 and seats two pilots, a navigator, and a flight engineer. The first pilot sits on the left, the second on the right, and the navigator behind the first pilot facing the left side. The engineer's seat originally stood between the pilots, but in the simulated aircraft it is removed and the engineer sits behind the right pilot at the former radio-operator station — the engineer's function having become obsolete after the radio equipment was modernized. A central panel between the pilots carries the powerplant and some system controls, flanked by left and right side panels, and a rear panel adds powerplant, flight, and navigation instruments, separated from the passenger cabins by decorative panels.



Cockpit and cabin layout

1) Cockpit - **2)** Radio equipment compartment - **3)** Front passenger cabin - **4)** Front vestibule, wardrobes, and toilets - **5)** Main passenger cabin - **6)** Rear vestibule and pantry-kitchen - **7)** Rear passenger cabin - **8)** Rear toilet and wardrobe - **9)** Tail fairing - **10)** Tail compartment - **11)** Cargo compartment No. 3 - **12)** Cargo compartment No. 2 – **13), 17)** Loading hatches for cargo compartments No. 1 and 2 - **14)** Wing center section compartment - **15)** Electrical equipment compartment - **16)** Cargo compartment No. 1 - **18)** Nose gear bay - **19)** Radar antenna fairing – **20), 23), 25)** Toilets – **21), 26), 30)** Wardrobes - **22)** Hydraulic equipment compartment - **24)** Pantry-kitchen – **27), 32)** Entrance doors - **28)** Inflatable slide TN-3 - **29)** Hand fire extinguishers - **31)** Service compartment

The pressurized cabin is bounded by a sealed zone whose elements and connections are all airtight. It runs along the skin from the nose to frame No. 56, the inclined and lower floor panels, the lower parts of frames 42, 24, and 32, the horizontal panel between frame 24 and the center section, the upper center-section skin and rear-spar wall, the spherical bottom at frame 56, the crew canopy, the passenger glazing, the entrance doors, and the hatch covers. Every passage of control runs, pipelines, and wiring through this zone is sealed.

In flight the fuselage carries loads from the wing, tail, and nose gear, plus cabin overpressure and inertial forces from cargo and equipment. Horizontal-tail aerodynamic force produces bending and shear in the vertical plane along the tail section; vertical-tail force, directed opposite to rudder deflection, produces bending and shear in the horizontal plane plus a twisting moment. Bending forces are absorbed by the skin and stringers in tension or compression and transferred to the wing, shear by the side skin, and torsion by the skin, all transferred to the wing.

The fuselage frame combines transverse and longitudinal members. The transverse set has 78 frames that shape the fuselage, stiffen its cross-section, and support the stringers and skin. Frames are either typical (normal) or power: power frames additionally absorb forces from other parts or, where they form sealed walls, carry cabin-pressure loads, and are reinforced fully or partly according to their loads.

Cargo configuration

Passenger transport configuration

MATERIAL AND DESIGN

Stringers are extruded angle — sometimes T-section — profiles whose cross-sections vary around the frames and along the fuselage with the local loads. Machined, variable-section reinforced stringers frame the window, door, and hatch cutouts to compensate for the weakened skin. Stringers are spliced with patches or, in some cases, lap joints; at structural frames they are cut and bolted through the frame walls via fittings, and they connect to the frames only through the skin, never directly.

The skin is the fuselage's main structural element: with the stringers it absorbs bending, and alone it takes shear, torsion, and cabin overpressure while transferring air loads to the stringers and frames. Its thickness varies from 1.0 to 2.0 mm — thin at the nose and tail, thick in the heavily loaded center-section zone. It is flush-riveted to frames and stringers, with lap joints made by flat-convex-head rivets for tightness and fatigue strength; transverse joints fall mainly on frames and longitudinal joints on stringers. Cutouts are framed and patched, and in the propeller plane duralumin sheets on rubber gaskets protect the skin from ice and stones during ground running. In the pressurized zone, sealing is achieved by hermetic riveting.

The crew canopy gives the pilots a forward view. Its frame of hot-stamped, bolted sub-frames attaches to the fuselage frames by ribs and gussets. The canopy has upper and lower glass rows; the lower glasses are flat to avoid distortion — the front four of heated silicate glass and the rest of 6–10 mm oriented organic glass. The organic panes are double, a main outer pane and a duplicating inner one, bonded with butyral film over an organic-glass spacer, the inter-pane space vented to the cabin through a silica-gel cartridge so that cabin pressure equalizes and the outer pane carries the overpressure; if it fails, the inner pane can withstand cabin overpressure alone. Glasses are fitted from inside and pressed by a duralumin frame with screws over rubber gaskets and tape, and cabin overpressure presses them to the frame and improves the seal.

One side of the canopy has a sliding vent running in upper and lower guides on two rollers, locked closed by a handled pin lock (handle down for locked, with the pins into the frame; horizontal to open). A front screw clamp tightens the vent during parking to keep out water, and a rubber profile seals the small window. Water collecting under the vent during parking drains overboard through a box and tube at the rear of the lower guide; in flight the tube's upper end is plugged to prevent cabin-air leakage.

PASSENGER CABIN WINDOWS

Round windows light the cabins and give a view, the round shape minimizing skin stress concentrations; the four windows above the wing are set into the emergency-exit covers. Each window is double — inner pane 5–10 mm, outer 11–6 mm — with the inter-pane space vented to atmosphere through a drainage system, so the spherical inner pane (best under internal pressure) carries the cabin overpressure and the outer pane backs it up. The opening is reinforced by a stamped alloy frame that forms the outer pane's seat, with a duralumin cup seating the inner pane; the outer pane is pressed by a duralumin ring and the inner by clamps and bolts on the cup, with a decorative ring between and rubber gaskets sealing both.

Moisture removal uses four systems covering all windows except the emergency exits: in each, the inter-pane spaces are linked in series by tubes and vented through a desiccant cartridge. Each fuselage side has two systems — one for the windows ahead of the emergency exits, one for those behind — with two cartridges per side mounted on the horizontal panel and reached through hatches in the main-cabin floor. Each emergency-exit window has its own cartridge in the exit cover, and their fuselage cups drain by tubes under the horizontal panel (under the lower skin on late series). Each cartridge holds coarse-grained silica gel plus an indicator and is inspected periodically as the gel saturates.

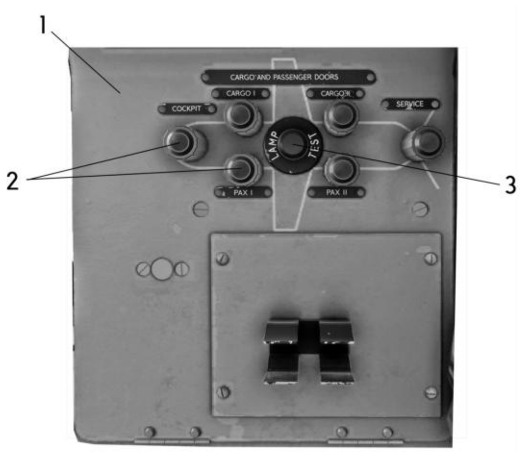
The pressurized fuselage has two entrance doors, two hatches for cargo compartments No. 1 and 2, four emergency exits, six access hatches for the water- and sewage-system filling and drain panels, and a ground-air-conditioner connection hatch. Doors and pressurized hatch covers open inward, so cabin overpressure presses them shut and improves sealing; all are locked when closed, and an open-position signal prevents take-off with any unlocked.

The entrance doors are on the left side and slide inward, moved along a fuselage rail by a roller carriage; the rail sits under the door sill, with a profile forming a gutter that drains water overboard through a tube plugged before take-off to stop cabin-air loss. The carriage attaches to the door through a panel via upper and lower hinge assemblies, letting the door move across the rail in the opening; when open, the door rests on a guide tube and roller, and the gap is closed by a casing. A two-pin lock with outer and inner handles secures it — turning a handle down to vertical withdraws the pins to open, horizontal drives them into the fuselage sockets to lock — and the recessed outer handle is held by a latch. Inner and outer rubber profiles seal the door, the larger outer one acting when locked and the inner under cabin overpressure

Emergency exits are in the main cabin on both sides, their covers removed inward. Each cover has a two-pin lock with the inner handle under a hinged trim lid, and is held by two lock pins and a lower rigid pin into fuselage sockets, with moisture from the lower socket draining overboard; outer and inner sealing profiles act on locking and under overpressure respectively. An evacuation rope is stowed in the fuselage above each exit.

Cargo-compartment hatches No. 1 and 2 are on the right side; the cover hinges at the top and opens upward and inward, locked like the entrance door but without an inner handle, and held open by lock pins resting on frame brackets. Sealing matches the doors, and folding thresholds with rollers protect the lower hatch edge and ease loading.

Water- and sewage-system hatches sit in the lower fuselage — three under the front toilets and three under the rear. Two per group have airtight covers with a single sealing profile, pressed from inside by lever two-cam locks; the third has a hermetic lid because the sewage-drain panel above it sits in a hermetic pocket. Non-hermetic lids hinge outward, fixed by locks when closed and held by a sprung strut when open. The ground-air-conditioner hatch on the right side has a non-hermetic hinged cover (its fitting casing being hermetic), similar to the water-system covers.



Hatches open indicators

1) right side panel – **2)** hatches open indicators – **3)** lamps test button

Open-door and -hatch signaling is in the cockpit: a “Doors and hatches open” panel on each pilot's instrument panel and six lamps on the right side — two for the entrance doors, two for the cargo hatches, and two for the front and rear hermetic water/sewage hatch groups. Limit switches on the fuselage, opposite the lock pins, close the circuits so that an open door or hatch lights both panels and the matching lamp. For an emergency landing where doors and exits cannot be used, two cut-through zones are marked in paint on the left fuselage skin, by the forward and rear cabin windows.

FLOORS OF CABINS AND BAGGAGE-CARGO COMPARTMENTS

The cabin floor consists of a frame — transverse beams and longitudinal beams (rails) — and flooring. The passenger-cabin rails support the covering and carry the seats: seat legs with locks fit into sockets spaced 30 mm apart, so seat pitch adjusts in 30 mm steps. Passenger- and crew-cabin floor panels are two plywood sheets with glued foam-plastic cores and pine edge slats; panels under the seats are bolted to the frame, while aisle panels use rotary locks for easy removal. Floor panels in cargo compartments No. 1 and 2 are duralumin and screwed down so they can be removed to inspect the skin beneath; compartment No. 3 has only transverse floor beams, with duralumin-and-foam-plastic panels.

THE WINGS

The wing generates lift, provides lateral stability, and stores fuel; it also carries the flaps, ailerons, main gear legs, and engine nacelles. It is a cantilever, trapezoidal monoblock in three parts — the center section and two outer panels. Unlike a spar wing, a monoblock wing has no heavy spar caps to take the bending moment, which is instead absorbed mainly by a powerful stringer set and thick skin. On the Il-18 the bending moment is taken by the inter-spar caisson;

the non-load-bearing nose and tail only form the profile and pass air loads to the caisson, so they are absent where the fuselage and nacelles cover the wing. The wing has 1° of geometric twist (incidence falling from +3° at the center-section joint to +2° at the tip) and a dihedral of 0° under the fuselage and +3° elsewhere for lateral stability.

LOADS ACTING ON THE WING

In flight, aerodynamic and inertial forces act on the wing, the inertial forces opposing lift and so unloading it. Aerodynamic pressure and suction on the skin pass through the rivets, in tension, to the stringers and ribs, which bend; the stringers feed the load to the ribs and on to the spar walls. Each section carries a bending moment, shear, and torsion. Torsion arises because the center of pressure (where aerodynamic force acts) does not coincide with the center of rigidity (the point at which a force causes no twist). Bending is taken by the skin, stringers, and spar caps in tension and compression, shear by the spar walls in shear, and torsion by the closed loops of inter-spar skin and spar walls, also in shear, which loads the skin-to-rib rivets. Bending balances within the wing, equal and opposite on each half, while shear and torsion pass through the joints to the fuselage and are balanced by fuselage and tail loads.

The center section has a caisson, nose, and tail. Its caisson uses three spars — front, middle, and rear — with stringers. The spars share a design: upper and lower caps of extruded angle plus a post-reinforced web, with the front and rear caps joined at the fuselage sides and the middle along the aircraft axis. Most stringers are channel section, forming an efficient closed contour with the skin under compression, while T-section stringers on the lower surface carry the removable fuel-access panels. Stringer count and area fall toward the ends to save weight, and the upper stringers are riveted to the ribs through extruded angles that double as alignment compensators; the upper surface gets the stronger stringer set because it works in compression and can buckle.

Ribs shape the profile, stiffen the wing, pass air loads from skin and stringers to the spars, and stabilize stringers and skin in compression; they are numbered outward from the zero rib on the axis and end in detachable ribs. They fall into three groups. Under-fuselage ribs are beam structures — a posted web with lightening flanged holes and chords — whose upper chords take cabin overpressure from the upper skin. Tank ribs, in the fuel-tank area, have sheet upper and lower beams reinforced with extruded profiles, the lower beams strengthened for fuel weight. Power ribs are solid-web beam structures with reinforced chords, also loaded by fuel weight. The detachable rib takes the outer-panel joint, redistributing shear from the two outer-panel spars to the three center-section spars, and also carries the flap rail.

The center-section skin is 3–6 mm duralumin, thickest at the fuselage where loads peak and thinning toward the ends; it is reinforced by patches at small cutouts and edgings at maintenance hatches, made airtight over the sub-fuselage part as part of the pressurized zone, and riveted to stringers, spar caps, and ribs. Removable lower panels and covers give access to the fuel tanks, bolted to stringers and ribs with anchor nuts; some bolts are longer, their heads color-coded to match the panel sections that need them.

The nose of the center section comprises rib noses, a stringer, skin, and hatch covers. The rib noses are sheet arches riveted to the front-spar web, their lower parts removable to allow pipe replacement, and the T-section stringer supports the nose skin and hatch covers. The nose skin is double, housing a thermoelectric anti-icing element between its sheets, and forms removable panels bolted to the front-spar upper cap, rib noses, and stringer. Full-length lower-surface hatches give access to pipes and wiring, their covers hinged to the front-spar lower cap and screw-locked when closed. The tail of the center section is rib tails and skin; the upper skin under the exhaust pipes is titanium alloy with steel rivets, the skin is stiffened by stamped profiles parallel to the ribs, and lower hatches give access to the aileron and flap control runs.

WING ATTACHMENT/FUEL COMPARTMENT

On the Il-18D the inter-spar bay between the front and rear spars is used as a fuel tank. Sealing uses sealants in three stages: putty-consistency sealant over all rivet and bolt joints; a sealant "bead" along corners and edges; then five brushed layers over the bead, rivet heads, and bolts, plus a continuous interior coating for sealing and corrosion protection. Externally the bay is further sealed along the top panel and the center-wing rear-spar web, and all riveting uses sealant-coated rivets.

At the center-wing/fuselage junction, the fuselage frames attach to the center-wing spars, the frame crossbeams to the upper panel, and the skin and some fuselage stringers to the skin and spars. The frames connect by six assemblies to the front, middle, and rear spars through fittings and bolts; outer and inner alloy fittings bolt to the frame rim, the outer to the front spar and the inner to the matching center-wing spar fitting. Above the wing, duralumin fillets (fairings) reinforced with profiles smooth the wing-to-fuselage transition to cut interference drag; they screw to the upper skin and to diaphragms over the spars and are not fixed to the fuselage skin — their edge is pressed by a screwed-down tape, rubber-faced over a stainless-steel patch to avoid chafing. Sealing film lies along all rivet seams, spatula-consistency sealant along element joints, and liquid sealant coats the tank interior and the rivet shanks before riveting.

ATTACHMENT OF THE OUTER WING

The outer panel joins the center section along the whole profile, but the load-bearing joint follows the caisson contour, with a detachable rib at the joint. Along the upper surface, joint profiles with slotted, counterbored wells are bolted (with rivets) to spar caps, stringers, and skin; in flight these surfaces work in compression, transferred panel-to-center-section by the abutting joint profiles so the bolts are unloaded, while on the ground and at landing the bolts take the panel's weight in tension. Along the lower surface, outer and inner duralumin tapes are bolted, the bolts threading into floating anchor nuts on the detachable rib and inner tape: under compression the tapes work in compression and the bolts in double shear; under tension the tapes work in tension. The front- and rear-spar webs of panel and center section are bolted through extruded duralumin angles, the transferred shear loading the bolts, and all outer-panel-to-center-section joint bolts are steel.

FLAPS

Extendable double-slotted flaps improve take-off and landing. Deflecting them increases profile curvature, raising both the lift and drag coefficients; because added drag slows take-off acceleration, small flap angles are used for take-off. Being extendable, they move aft as well as down, enlarging the wing area, so lift rises from both the higher coefficient and the larger area. The slots — formed between flap nose and wing tail, the second by a deflector on the flap nose — duct air from the lower to the upper surface, speeding the flow and delaying the vortex formation and separation that would otherwise cut lift, raise drag, and cause vibration; the double slot keeps the flow attached to large deflection angles.

The flap comprises spars, ribs, skin, a deflector, and a magnesium-alloy trailing-edge profile. The main spar is a web with extruded chords and uprights, and an additional spar reinforces the rib tails, its web cut where the ribs cross. All but the end ribs are split into stamped duralumin nose and tail with lightening holes, the carriage-bearing noses hot-stamped from alloy. The skin is duralumin except over the engine nacelles, where it is titanium alloy. Retracted, the rails and screw jacks sit in upper-surface nests closed below by drained fairings. The deflector — duralumin skin on ribs — attaches via bolted diaphragms and is cut at the rails. Along the outer-panel/center-section joint the flap is split and rejoined by bolts, rivets, and a contour joint strip, and alloy assemblies in the nose carry pins to which the lifter nuts attach.

Each flap half hangs on five rails on rolling carriages. The rail front ends fix to the center-section rear spar, restrained vertically by an upper strut and horizontally by a side strut, with the innermost rail's rear end tied to the fuselage by a four-bar linkage. Rails are hot-stamped steel, chromed for hardness and corrosion resistance. Each carriage is two alloy cheeks bolted to the reinforced rib noses, carrying needle-bearing rollers covered by magnesium-alloy guards with felt wipers. Every carriage has front and rear roller groups, each with upper and lower rollers gripping the rail's lower flange, and the reaction couple balances the aerodynamic moment on the flap. Carriages share the rails' numbers but differ in cheek size and roller layout — carriage No. 1 has six front rollers (four upper on a pivoted rocker, two lower) and three rear, plus two side rollers against lateral movement, while another has two-plus-two front and two-plus-one rear with no side rollers, as do the rest.

FLAP RETRACTION

With the flap handle at “Retracted,” current passes through the retracted-position limit switches to the contactor and relay windings. The contactors switch in the mechanisms' shunt windings and feed their series windings, so the mechanisms run and retract the flaps; the limit switches then break from NC to NO and de-energize the mechanisms.

FLAP EXTENSION

With the handle at “Extended,” the same buses and fuses feed, through the handle's limit switches closed in that position, the contactor windings and the relays' second windings. Once these act, voltage reaches the mechanisms' series windings and the electromagnetic brake/clutch couplings, extending the flaps until the limit switches go to NO and de-energize the mechanisms. Flap position is shown on the UZP-47 indicator on the pilots' panel.

AILERONS

Ailerons give roll control about the longitudinal axis, with axial aerodynamic compensation and weight balancing; a trimmer is fitted to the right aileron. Axial compensation reduces wheel forces by shifting the rotation axis aft of the leading edge, shortening the aerodynamic-force arm and so the hinge moment. The Il-18's ailerons have 29% axial compensation, meaning the area ahead of the axis is 29% of the total. Weight balancing prevents bending-aileron flutter: nose weights move the CG forward of the axis, and the ailerons are over-balanced, with the CG ahead of the axis by 20 mm inboard and 12.5 mm outboard, because wing deformation in flight can make exactly 100% balance insufficient; an aileron must be re-balanced if repair changes its weight.

AILERON TRIMMER

The trimmer reduces or removes wheel forces when the ailerons are deflected, deflecting opposite to the aileron so that its aerodynamic load creates a moment opposing that of the aileron.

The ailerons are split into two equal, unconnected inner and outer sections so that wing bending — which curves the rotation axis — cannot jam them in their suspension. Each section has a spar, split ribs, a front wall, an end stringer, and skin. The spar is stamped duralumin, and all but the end ribs are stamped duralumin nose-and-tail. The front wall mounts the cast-iron balance weight (running the full span, bolted on) and stiffens the nose skin, whose nose portion is removable for access. The alloy end stringer forms the trailing edge. The trim tab on the inner section has its own axial compensation and balancing: a duralumin spar, ribs, and skin with a riveted steel balance plate in the nose, attached to the additional aileron spar at four points through links that absorb installation tolerances. Each aileron section hangs from the outer wing at three points — two through tolerance-absorbing links and the middle one, where the control rod connects, bolted directly as the rotation axis — on alloy brackets with pressed-in ball bearings.

TAIL ASSEMBLY

The cantilever, single-fin tail has a horizontal assembly (stabilizer and elevator) and a vertical assembly (fin and rudder).

The stabilizer provides longitudinal stability, balancing the pitching moment from the offset between the wing's aerodynamic force and the CG; since the wing usually pitches nose-down, the tail must produce downward (negative) lift, so the stabilizer is set at −1° incidence. It is two identical halves riveted along the axis, each a box section (front, middle, and rear spars with stringers, ribs, and skin) plus a leading edge, trailing edge, and tip fairing. The structure mirrors the wing's but is lighter, since the loads are smaller; reinforced ribs sit at the elevator attachments and fuselage sides, the side ribs taking the attachment forces. The duralumin skin is mostly countersunk-riveted, with brazier-head rivets on the upper ribs. The three-section leading edge is double-skinned with anti-icing heating elements between the sheets, and the elevator suspension units are reached through skin and tip-fairing hatches.

The fin gives directional stability and is built like a stabilizer half, except its tip-fairing skin is radio-transparent glass-fiber laminate over an internal antenna. Its front, middle, and rear spars sit over the fuselage frames, the spar chords joined by angle butt profiles — bolted and riveted to the chords above, bolted to the frame rims below — while the webs pass through the skin cutouts and bolt to the frames and the over-frame stringers attach likewise. The fin skin joins the fuselage skin through two contour angles, the lower junction reinforced by a duralumin tape. Bending loads pass to the fuselage mainly through the chord and stringer butt profiles (partly through the contour angles), shear through the web-to-frame bolts, and torsion through the contour angles and web bolts. A dorsal fin ahead of the fin smooths the fuselage-to-fin transition — skin with diaphragms and stringers, bolted to the fin and tail fuselage and hermetically riveted to the pressure cabin, its fin junction covered by a duralumin tape.

The rudder gives directional control, with axial aerodynamic compensation and weight balancing, the balance weights setting the rudder CG 31 ± 1 mm ahead of the rotation axis. It carries a trim tab and a servo tab; the servo tab, built like the trim tab but connected to the rudder control system rather than its own, deflects opposite the rudder to help hold it deflected and so, like the axial compensation, lightens the pedal forces. Otherwise the rudder matches the elevator. It hangs from the fin at four points — three brackets, like the elevator's, and an end support — the lower bracket taking the rudder's weight and control-linkage forces. The end support differs from the elevator's only in that its support screw threads into a shoe on the fin, locked by a locknut and bolt

CHAPTER II

AIRCRAFT CONTROL

BASIC DATA OF CONTROL SYSTEMS

Elevator deflection	**up 24.5° / 355.5 mm; down 15.5° / 218.6 mm**
Rudder	**left/right 25° / 550.8 mm**
Ailerons	**up 20°+1 / 133.5+6 mm; down 20°+1 / 118.5+6 mm**
Elevator trim tab	**up 7.5°+1 / 26+3.5 mm; down 13.5°+1 / 45+3.5 mm**
Rudder trim tab	**left/right 9°+1 / 131.5+3.5 mm**
Aileron trim tab	**up/down 4° / 9.5 mm**
Rudder servo tab	**left/right 15°+1 / 59.1+3.5 mm**
Flaps	**take-off 15°; landing 30°**
Neutral position of ailerons (up)	**1.1°+10′ / 7.5+10′ mm**
Flap full travel — two motors / one motor	**≤15 s / ≤30 s**
Cable diameters — ailerons / autopilot / elevator trim	**5.0 / 3.0 / 2.5 mm**
Cable tension — ailerons / autopilot / elevator trim (+20 °C)	**60±5 / 65±3 / 40±3 kg**

The control system covers the elevator, rudder, ailerons, trim tabs, and flaps, plus a rudder-and-aileron locking system. Elevator, rudder, aileron, and elevator-trim controls are dual, with a set of levers for each pilot, while the rudder- and aileron-trim and flap controls sit on the central console within reach of both. The rudder linkage is all rods; the aileron linkage is mostly rods with a short cable run near the columns. AP-6E autopilot steering machines are cabled into the rudder and aileron systems, and a servo-compensator mechanism into the rudder system. Elevator-trim control is mechanical (cable), while the rudder- and aileron-trim, flap, and locking controls are electrical. Hermetic seals limit air leakage where the linkages leave the pressurized cabin.

ELEVATOR CONTROL

Pulling the columns back deflects the elevator up and pitches the nose up; pushing forward deflects it down and pitches the nose down. The system has two columns, a rigid linkage to the elevator, a loading spring, and a balance weight. As the most critical control, its rods and their connections carry duplicate backup elements for reliability.

Each column has a wheel, an upper link, a vertical pipe, and a lower link, the left and right joined by a horizontal pipe carrying the elevator lever; a transparent-covered hatch in the upper link allows inspection and removal of the aileron chains and cables. The columns mount on three supports — two on the lower links via trunnions in fuselage brackets, one on the horizontal pipe — with the center and right supports floating and ball bearings for easy rotation.

Each rod is two concentric pipes, either able to carry the full design load alone. Rod ends use adjustable or non-adjustable tips: the main joint is a riveted sleeve with a fork-and-eye ball-bearing bolt, duplicated by a splined coupling whose nut is set with limit screws, leaving a 3 ± 0.5 mm gap so the backup carries no load and its splines do not wear.

If the hinge bolt breaks, the gap closes and the backup engages — signalled by increased column free play and knocking. The rod-to-bellcrank joint is similar, its backup using two bolted steel plates whose lugs engage the bellcrank with a take-up gap.

Rods are either guided or suspended, placed alternately; suspended rods have adjustable ends, guided rods are fixed. In the cabin they run under the floor just left of the axis, rise to the hermetic outlet at the bulkhead, then pass above the stabilizer to the elevator halves behind the stabilizer rear spar. Guides are a magnesium-alloy bracket with three rollers at 120°; in the propeller plane the upper roller sits on an adjustable bellcrank to cope with vibration. Bellcranks redirect the linkage and scale forces through different arm lengths, on ball bearings. The hermetic outlet — a one-side-open alloy box on the rear of a frame — carries two bellcranks (one belonging to the rudder system), each a splined shaft with an inner and an outer adjustable lever.

AILERON CONTROL

Turning the wheels banks the aircraft — the left wheel raises the left aileron and lowers the right. The system has two wheels and mixed wiring of cables, rods, guides, cranks, and two hermetic outlets. Each wheel drives an axis on ball bearings carrying two sprockets, each with a roller chain ending in a 7×19-5 cable; the cables route over rollers down the vertical pipe and out along the column rotation axis, so they do not bind during column deflection, then to the sector crank, with turnbuckles for tension. Red and blue marks on the sprockets, chains, cables, and sector crank prevent mis-rigging — red on the elements that act when the wheels turn right.

Suspension rods are length-adjustable with locking pins. From the sector crank the rods run under the cockpit floor beside the elevator rods, then along the rear spars of the center section and outer panels. They are marked with two black rings, and the symmetrical left/right rods share numbers and are interchangeable. Guides match the elevator's, with adjustable guides in the propeller plane. The sector crank (on a frame, with a hard stop) and the central crank (on the center-section rear spar, splitting the wiring left and right and also linking the propeller control rods) feed inner and outer end cranks, which have neutral-locating pin holes for rigging. The two hermetic outlets behind the center-section rear spar use a bronze insert seating spherically against the housing to avoid jamming as the fuselage deforms, with a chrome-plated steel rod. The deflection limiter is a sector on the wheel axis and a bolt on the column, giving 138° of wheel travel each way, increased by filing the sector.

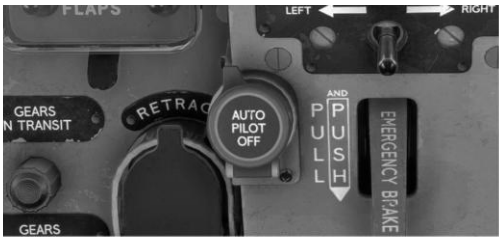
RUDDER CONTROL

Pushing a pedal forward deflects the rudder and yaws the aircraft that way. The system is two pedal pairs and a rigid linkage that includes a servo-tab mechanism. The swinging, lower-pivot pedals each have a magnesium-alloy lever, a corrugated footrest, and a three-position height adjuster (handle, rod, sprung rack, and a crank that normally locks lever and crank together), and the wheel-brake valve mechanisms also mount on them. Links are non-duplicated, length-adjustable with locking pins, marked with three rings, and routed beside the elevator links. The foot-control shaft — a duralumin tube with five levers — ties the two pilots' pedals together. The cabin bellcranks and the sector bellcrank match the elevator's, the end bellcrank is on the fin, and the hermetic-outlet bellcrank shares the elevator's bracket.

The deflection limiter is two spring cylinders on the fin rear spar and a stopper on the rudder. Beyond 12° the stopper compresses the outer spring; beyond 18° the inner spring adds further pedal force, full compression needing 110–115 kg — this added force compensating for the loss of pedal feel from aerodynamic over-compensation at the large rudder angles needed in high-sideslip flight. The spring servo-compensator automatically lightens pedal forces above 15 kg by deflecting opposite the rudder so airflow helps hold it; unlike a conventional servo tab, its deflection depends on pedal force, not rudder angle. Below the threshold the rocker passes force straight through the spring cylinder and the compensator moves with the rudder; above it the rocker rotates, compressing the cylinder and deflecting the compensator opposite the rudder.

CONNECTION OF AUTOPILOT STEERING GEARS WITH CONTROL SYSTEMS

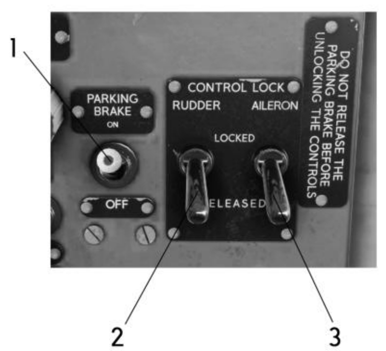
The autopilot's steering gears are electric motors driving an output drum, cabled through intermediate sectors to the aileron and rudder sector cranks and geared so that 10° of drum rotation gives about 1° of surface deflection. The paired sectors share a shaft — the small one bolted on, the large one joined through an emergency-disconnect mechanism. That mechanism has a cylinder and piston whose rod locks the large sector to the shaft with a cotter pin; firing a pyrotechnic cartridge shears the pin and pushes the rod out, freeing the sector, with a leaf spring locking the piston out. The guarded cutoff button on the central panel fires the squibs of all three intermediate sectors; once fired, the autopilot cannot be re-engaged in flight. The elevator and rudder gears and sectors sit on the upper stabilizer, the aileron set low in the fuselage by the center-section rear spar.



Autopilot cutoff button

RUDDER AND AILERON LOCKING SYSTEM

Parking locks protect the surfaces from wind and from other aircraft's jet and propeller wash — ailerons and rudder locked neutral, elevator 10° down. The electrical system has four locking mechanisms (two for the elevator halves, one rudder, one aileron) and lock-position signaling. Each elevator or rudder mechanism, in the surface nose, is an electro-mechanism, lock, rocker, and limit switch on a bracket; the rockers form a parallelogram giving the spring-loaded steel lock a straight in-and-out motion. If the lock misses the limiter-sector slot, a nose roller lets the body slide over it and compress the spring until the surface reaches neutral and the lock drops in. The aileron mechanism is similar, on the center-section rear spar, locking the central aileron crank through a slotted sector.



Control locking panel

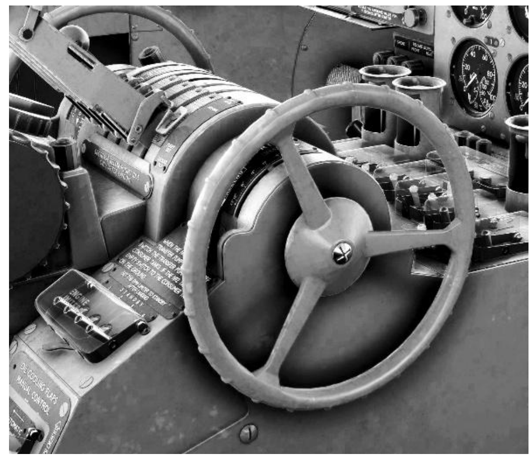
1) parking brake control – **2)** rudder lock – **3)** aileron lock

The locks are worked by “Aileron” and “Rudder” push-button switches on the left console (up to unlock, down to lock), protected by a “Rudder lock” breaker on the navigator's panel with an adjacent red “Rudder locking system on” lamp; in flight the breaker is switched off to prevent accidental locking, the lamp reminding the crew. Locking takes a 15–20 s press, the current driving two elevator and one each rudder and aileron electro-mechanisms until their limit switches break the circuit, and the reverse press retracts the rods to unlock. Red “Rudders locked” signs light if any lock is engaged, green lamps only when all four are clear, through limit switches at the locks chained in sequence.

ELEVATOR TRIM CONTROL

Dual elevator-trim control uses handwheels on each side of the central console. The system comprises the handwheel mechanism (with position indicators and a deflection limiter), cable wiring, two screw mechanisms, and a neutral-position signal; aircraft with the landing-approach system also have an automatic trimming unit. Because the engine levers sit between them, the two handwheels are linked by gears and a three-part universal-jointed connecting shaft to a common drum driving the cables. Freely-mounted indicators geared to the connecting shaft move along a 2°-division console scale. The limiter on the left wheel's axis is a screw and nut whose nut meets stop cams at the trim extremes, blocking further travel.

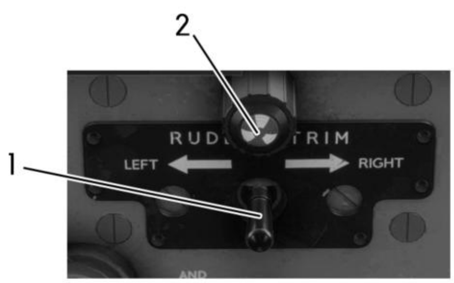
Cables run down the console and under the floor to the tail, branching before the stabilizer to the left and right trim screw mechanisms and entering each elevator half along its rotation axis. Rollers on sealed bearings and magnesium-alloy brackets redirect the cables, guides steady the straight runs, and a hermetic outlet — a slit rubber ball between bolted textolite blocks — seals the cabin exit. Each screw mechanism turns drum rotation into nut travel that swings a rocker and rod to deflect the trim tab, the rod tip adjustable. A neutral-position signal (a green console lamp closed by a limit switch through a collet clamped on a trim cable) confirms the tabs are centered before departure.



The trimming machine automatically works the elevator trim to relieve control loads with the autopilot engaged; without it, the autopilot's steering gear holds the hinge moment and the surface springs back to neutral on disengagement, causing uncommanded maneuvers. A force sensor in the rod between the sector crank and elevator signals compressive or tensile loads to control the tabs through an electro-mechanism whose drum carries the trim cables; three microswitches handle the trim extremes and the neutral signal, with a mechanical limiter as backup. The sensor's AC signal is amplified and rectified in the trim unit, which drives the electro-mechanism (and an indicator) to null the rod force, a 5 s time-relay delay preventing response to brief random load spikes.

RUDDER TRIM CONTROL

The rudder trim control is electric. It is operated by deflecting the "Rudder Trim" switch on the central console to the left or right. Pressing the switch to the left deflects the trim tab to the right, and vice versa, pressing the switch to the right causes the trim tab to deflect to the left.

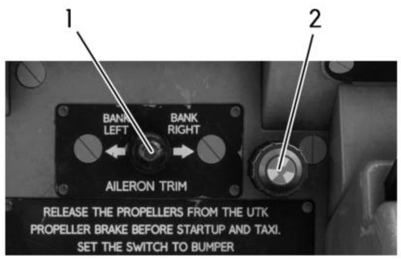


Rudder trim control

1) Rudder trim control switch – **2)** Neutral position indicator lamp

AILERON TRIMMER CONTROL

Aileron trim is likewise electric, set by the “Aileron Trimmer” switch (right deflects the tab down, left up). The system mirrors the rudder-trim system, with an electro-mechanism in the right aileron nose, a neutral lamp by the switch, and a “Trimmers. Aileron” breaker on the navigator's panel.



Aileron trim control

1) aileron control switch – **2)** neutral position indicator lamp

FLAP CONTROL

Flap control is electromechanical, via the console “Flaps” handle with three detented positions — up to retract, down to extend, and neutral to switch off — each pressing a limit switch; a cam-coupling lock prevents accidental movement and sets only when the flaps are up. The system has an electric actuator, a transmission, four gearboxes, four screw mechanisms, a limit-switch block, and position signaling. The actuator is two electric motors on a common gearbox: with both running the output shaft turns at 900 rpm, with one running at 450 rpm, doubling the travel time, so a single-motor failure still gives full travel at unchanged torque. A removable hand crank can drive the gearbox, motors de-energized, through a splined sleeve.

The transmission is duralumin pipes joined by cardan joints — some splined to lengthen or shorten — that absorb wing deformation, supported by ball-bearing hangers on the center-section rear spar and sealed where it passes through the fuselage sides with twin self-aligning bearings, rubber cuffs, and an oil fill. The four gearboxes, inside the inner and outer nacelles, scale shaft speed so flap-end travel matches the local wing chord, using bevel-geared input, intermediate, and output shafts, the output shaft's thrust bearings carrying axial loads into the center section.

Each screw mechanism converts gearbox rotation into flap motion: a cardan-driven screw and a fork-ended nut fixed to the flap pin, with recirculating balls in a semicircular thread, the balls grouped at the nut ends and returned by deflector teeth through bypass channels. Front and rear stops limit nut travel — the front sprung-damped, the rear with a rubber absorber — though a properly set limit-switch block stops the motor before the nut reaches them. The block, with the electro-mechanism on the center-section rear spar, also drives the position sensor; the right-panel indicator reads 0/15/30/45°, with two orange lamps showing each motor's operation during extension (both lit is normal, and they warn of motor failure or spontaneous running). The breaker is the engineer's “Flaps.”

Flaps extend to 15° for take-off and 30° for landing, the latter in two stages (15° then full) so pilots can react to stability changes or a malfunction. Extension beyond 30° is prohibited after serious incidents caused by a “nose-dive” effect. Before extending, the two “Flaps” motor breakers on the navigator's panel are switched on; the handle is unlocked and moved down, then returned to neutral and locked, with the limit-switch block cutting off the mechanism at the extremes.

Flaps control lever on the center console

CHAPTER III - AIRCRAFT LANDING GEAR

GENERAL INFORMATION

The landing gear moves the aircraft on the ground and absorbs landing and taxi loads. It is a tricycle arrangement — a twin-wheel nose leg and two main legs with four-wheel bogies — retracting forward: the main legs into the inner-engine nacelles, the nose leg into a fuselage bay. Forward retraction lets the legs extend reliably under their own weight and airflow if the hydraulic system fails, though it shifts the center of gravity noticeably. Retraction and extension are hydraulic, with an emergency extension method on failure, and the legs lock in both the up and down positions. All struts use nitrogen-hydraulic shock absorbers that, with the tires, absorb landing and taxi shocks. The nose leg has hydraulic steering for maneuvering during taxi, take-off, and landing roll when the rudder is ineffective, and the main wheels have hydraulically-controlled disc brakes. The bays are closed by doors with the gear both up and down, cutting drag substantially, and the main structural elements are steel.

FRONT LANDING GEAR STRUT

The nose strut is a beam-strut design with semi-lever wheel suspension, on the aircraft axis, attached to the bay's longitudinal beams at frames No. 2 and 4. The semi-lever suspension reduces bending on the shock-absorber rod, easing its seals. The shock absorber is a sealed vessel holding a metered charge of fluid and nitrogen of variable volume; its main parts are the cylinder with diffuser and the rod with plunger. The three-part welded cylinder has a stamped middle section with lugs for the struts, steering-cylinder rods, and turn stops; a sealed, nut-retained cover; a nitrogen charging valve; and a plugged fluid-fill opening. A diffuser pipe screwed into the cover carries fluid-passage holes and longitudinal grooves, with a freely floating return-damping valve (a washer with two small annular-linked holes) above it for smooth expansion.

On compression, wheel loads drive the rod into the cylinder: fluid is forced from the lower cavity into the middle and upper cavities through the diffuser and rod-diffuser gap (and, initially, the grooves for a soft start), raising the fluid level and compressing the nitrogen. The impact energy goes mainly into compressing nitrogen, with the rest lost to hydraulic resistance and rod friction as heat. On the return stroke the compressed nitrogen pushes the rod out, the fluid now metered back through the valve's two small holes for damping, part of the energy lifting the aircraft.

Centering cams set the nose wheels neutral at full extension so the leg enters the bay and locks cleanly: an upper cam on the rod meets a lower cam in the cylinder, their protrusions preventing rotation. When compressed, the rod is free to turn; on the next extension the upper cam slides down the lower cam's protrusions and rotates any turned wheels back to neutral. The cams also limit rod extension. The bronze steering yoke, on sliding bearings on the cylinder, transmits force between the steering cylinders and the wheel lever in control mode and damps shimmy in the reverse; a movable ring with a stop limits yoke and wheel rotation to ±43°. Unscrewing a bolt lets the swivel clamp turn a full 360° for towing — a flagged wrench left on the bolt warns that the clamp is disconnected from the steering cylinders and must be re-secured before departure. The steering cylinders, attached between the shock absorber and the clamp ring, both steer the leg and damp its self-oscillation.

The hot-stamped wheel lever transmits axle loads to the rod and swivel clamp, ending in a pipe for the wheel axle and carrying an adjustable bracket and roller for emergency flap-lock opening. The variable-section axle takes mostly vertical and lateral loads; the right and left wheel nuts have right- and left-hand threads respectively. Each wheel is an arched-type tube-and-cover pneumatic tire on a drum, the arched tire giving a large footprint and low ground pressure for soft surfaces. The traverse (two halves on the cylinder head, with trunnioned pins in the bay's plain bearings) secures the strut to the fuselage, and a guide rod supports the rear strut's upper end during retraction and extension.

The extended-position lock holds the leg down: at the end of extension the rear-strut shackle enters the spring-held hook, whose latch then snaps over the hook shank to lock it. Hydraulic pressure from the retraction line extends a cylinder rod that withdraws the latch, freeing the hook. Two limit switches signal the closing of the bay doors and the green down-and-locked light, and a parking safety pin must be removed before take-off or the leg cannot retract. The retracted-position lock is similar but smaller and adds an emergency-opening rocker, spring, and cable tied to the cockpit emergency handle; it carries one limit switch for door closing. The lift cylinder, between the shock-absorber lever and a fuselage bracket, develops the retraction and extension force — rod in when down, out when up.

NOSE GEAR BAY DOORS

The bay is closed by front and rear door pairs. The front doors close it with the gear both up and down, opening only during the cycle, suspended on three brackets each and worked by two cylinders (open by upper-cavity pressure, close by lower-cavity, held open hydraulically and locked closed by locks). The rear doors close only with the gear up; with it down they stay open, forming the opening the leg passes through, and are rod-driven from the guide rod so they track the leg's motion. Each front door has front and rear locks: the front engages an eyelet, the rear traps the door cylinder's roller-pins so the rod cannot extend; both close automatically as bevels turn the spring-held hooks over the catches.

The flap locks open three ways. The main method, during normal cycling, uses a hydraulic cylinder whose rod turns a rocker that tensions cables to all four locks. The emergency method, for emergency extension only, uses a cockpit handle whose cable bypasses the main rocker to the hooks directly. The manual method, for maintenance with the leg down, turns a handle that rotates the rocker through a cable; safety clamps must then be fitted to the door-cylinder rods to prevent accidental closing under residual pressure.

To retract from the down-and-locked state (front doors closed, rear open, jack rod in), the “Gear Retract” button energizes the door valves: fluid opens the flap-lock cylinder and the doors, and when fully open their limit switches admit fluid to the gear valve. This opens the down-lock (freeing the rear strut) and feeds the jack, which swings the leg forward and up about the traverse axis while the guide rod gradually closes the rear doors. The up-lock then engages, its switch driving the doors closed and locked, and the bay limit switches de-energize the valves.

MAIN LANDING GEAR GEARS

The main legs are symmetric about the axis just behind the CG, attached to the wing between center-section ribs, and — being near the CG — carry almost 95% of the gear loads; retracted, they lie in the inner-nacelle bays behind doors. On retraction the bogie rotates so the front wheels move toward the strut and the rear wheels extend it, reducing the bay height needed in the nacelle. The shock absorber works on the same nitrogen-hydraulic principle as the nose unit, with a three-part welded cylinder (sealed cover, bronze lower guide, multi-ring gland with fluoroplastic anti-extrusion rings) and a two-part welded rod with a sealed bottom, an upper gland guide, an extension-limiting ring, and a three-hole reverse damping valve. It has upper, lower,

and annular cavities; the upper holds fluid and nitrogen, the lower and annular hold fluid. Compression forces fluid from the lower cavity to the upper (through the diffuser, the rod gap, and initially the grooves for a soft start) and on into the annular cavity, raising nitrogen pressure; expansion meters fluid from the annular cavity back through the valve's three holes for damping.

The hot-stamped traverse secures the strut to the wing on trunnions in center-section bearings. The extended-position lock secures the rear-strut lug when down; the retracted-position lock under the front spar secures a clamp lug when up and carries a second limit switch for the red up-position light.

The jack runs between a trunnion on the cylinder and a center-section assembly by the rear spar. The bogie comprises a rocker arm, two axles, four braked wheels, and two brake-torque mechanisms; the three-part hot-stamped rocker arm transfers axle loads to the rod and has stops limiting bogie rotation when retracted. The wheels use a round high-pressure tire (versus the nose unit's arched type) on a cast magnesium drum with one removable split flange, on tapered roller bearings.

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WHEEL BRAKES

The wheels use disc brakes — compact and effective, but prone to overheating with frequent use, which reduces effectiveness and can cause failure. Each brake has a housing, four stationary discs, five movable discs, a pressure plate, and a cylinder block. Stationary discs are steel rings carrying bimetallic (steel-and-cast-iron) friction sectors that key into the housing grooves and slide axially without rotating; movable discs are steel rings with riveted cermet friction segments that key into the drum grooves and rotate with the wheel. The pressure plate, a one-sided stationary disc, transmits piston force to compress the pack; its protruding pin shows disc wear, sitting 2 mm proud of the block at maximum permissible wear. The cylinder block holds ten sleeves and eight return springs, a fluid fitting, and a bleed/gauge plug; spherical-headed pistons avoid skewing, and a relocatable spacer ring takes up disc wear to keep piston travel short. Inertial anti-skid sensors driven by drum gears sit on the rear bogie wheels. A brake-torque mechanism on each wheel pair — front and rear levers riding freely on the axles, with brake rods — routes braking torque to the shock-absorber rod rather than the axles, preventing load redistribution between wheel pairs.

MAIN GEAR COMPARTMENT DOORS

The bay has front, middle, and rear door pairs, all closed with the gear both up and down to cut take-off drag. The front doors are worked by two cylinders per side (open by upper-cavity pressure, held open hydraulically, locked closed). Each is locked by hooks that trap the door cylinder's roller-pins and close automatically as bevels turn the spring-held hooks. The locks open by cables from a rocker on the bay's left side, with three ways: main (a hydraulic cylinder turning the rocker), emergency (an emergency rocker on the same axis, tripped by a pin on the rear-wheel axle as the leg drops under its own weight), and manual (a cable handle behind a “Flap locks” hatch, after which the doors are opened by hand with safety clamps fitted to the cylinder rods).

Retraction and extension of the main leg follow the nose-leg sequence, except the bogie rotates at the start of retraction: fluid flows freely into the bogie-turning damper cylinder, while a hydraulic damper ahead of the lift cylinder slows fluid into it and so slows the leg's retraction.

EMERGENCY LANDING GEAR RELEASE

On hydraulic failure, emergency release opens the up-position locks of all legs and switches the hydraulic rotary valves to connect the retraction lines to the reservoir, preventing hydraulic locks. The legs then drop under their own weight, aided by airflow, until they latch on the down-locks. The system is a sealed floor handle by the cockpit's right side (held down by a sealed spring clip) connected by cables to the locks; the cables run on textolite rollers and guides with turnbuckles for tension and sealed rubber-ball glands where they leave the cabin. Lifting the handle locks it up (a hook-and-latch released by a button), and an adjusting screw presses a limit switch that de-energizes the hydraulic valves, joining the retraction, extension, and door lines to the reservoir.

Emergency gear extension lever

With the handle up, the spring-tensioned cables turn the emergency rockers on the up-locks, opening them and, through spring linkages, switching the rotary valves. The legs extend under gravity, the main legs' doors pushed open by pins on the rear-wheel axles (the left pin also releasing the door locks); the doors, protected by pads, are not held open without hydraulic pressure and do not re-close after release.

LANDING GEAR LEG POSITION INDICATION

There are four indications — light (the main one), sound, electromechanical, and mechanical. The light system has three red and three green lamps on the gear panel (right instrument board), one pair per leg. Red lights when a leg is up, via limit switches on the up-locks (main legs) and a fuselage switch driven from the nose-leg crossbar; green lights when a leg is down and locked, via switches on the down-locks. As a leg extends the red switch opens and the lamp goes out, and at full extension the down-lock closes the green circuit.

An audible siren in the right console warns of landing with the gear up or not fully down. Its circuit closes through the green-lamp limit switches (when not pressed) and a throttle-quadrant switch, so it sounds only when a leg is not fully down and the throttles are at “flight idle,” lighting the red “Extend landing gear” warning at the same time. A console switch can silence the siren, but it still sounds with flaps beyond 16–18°, and the warning light cannot be switched off; a relay shares the siren with the radar collision warning, disconnecting it from the gear system during that function. Electromechanical indicators (main legs only) show “Retracted”/“Extended” via crossbar-driven sensors; a mechanical pin ahead of the second pilot's window rises above the skin as the nose leg extends. A panel test button lights all lamps and the warning and sounds the siren.

LANDING GEAR AND CONTROL

Retraction and extension are hydraulic, controlled by electro-valves, with emergency extension available when the main electrical circuit is fully disconnected. Electro-hydraulic valves serve gear extension/retraction and door opening/closing, worked by the central-console “Extension” and “Retraction” buttons; power comes from the navigator's panel through a breaker. Each leg has three valves for the leg and three for its doors, plus an electro-valve (on the left console) for parking brake-on/off.

Control instruments of the landing gears on the central console

Pressing "Extension" opens the door valves through the down-position switches; as each leg extends, its switch flips to close the doors, and once they close, a 0.45–1.12 s time relay releases the button to end the cycle. Pressing "Retraction" feeds current through the breaker, the emergency-release switch, and the right main-leg "ground-air" compressed-strut switch to the relay; the door valves open the doors, the button latches in until the cycle completes, and the time relay (which keeps the doors pressed shut after the legs move) releases it once the doors close at the end of retraction.

CHAPTER IV - AIRCRAFT HYDROGEN-NITROGEN SYSTEM

GENERAL INFORMATION

The system combines a main hydraulic system and an emergency nitrogen system. The hydraulic system retracts and extends the gear, steers the nose wheel, provides main and parking braking of the main wheels, and drives the windshield wipers. The nitrogen system handles emergency wheel braking, emergency propeller feathering, and charging the hydraulic accumulators. Hydraulic drive is preferred for its incompressible fluid — giving high efficiency, smooth shock-free operation, low lag, the ability to hold mechanisms in intermediate positions, and self-lubrication. The working fluid is petroleum-based mineral oil with a low pour point (−75 °C) and high flash point (+95 °C open cup). Nitrogen is chosen for emergencies because gas can briefly develop great power and does not support combustion, improving fire safety, though its units operate with shocks, cannot be held in intermediate positions, and are hard to seal.

MAIN DATA OF THE HYDRAULIC-NITROGEN SYSTEM

Hydraulic system capacity / tank fill	**75 / 40 L**
Operating pressure	**210 ± 15 kg/cm²**
Brake pressure — normal / constant / emergency	**65±5 / 50+10/−8 / 75+10 kg/cm²**
Wiper system pressure	**150 ± 10 kg/cm²**
Nitrogen system operating pressure	**150 kg/cm²**
Initial nitrogen pressure in hydraulic accumulators	**65 +4/−5 kg/cm²**
Initial nitrogen pressure — emergency braking / feathering cylinders	**130–150 / 65±5 kg/cm²**

The units and controls are grouped mainly in the gear bays and cockpit. Breakers sit on the navigator's panel; gauges, warning lights, and switches on the left instrument panel and the left and central consoles, with some units inside those consoles. Each main-leg bay carries three hydraulic panels — pressure-source and main-braking units on the left side, emergency-braking units on the lower center-section skin — and the front vestibule holds the hydraulic tank and its drain units.

Figure 35.
Arrangement of hydraulic system units

1) EM-80 pressure gauge (emergency feathering) – **2) 7)** pressure gauges (main braking) – **3)** pressure gauge (brake hydraulic accumulators) – **4)** pressure gauge (general network) – **5)** hydraulic pump operation signal lights – **6)** pressure gauge (emergency cylinders)– **7)** pressure gauge (general network) – **8)** pressure gauge (parking brake)

PRESSURE SOURCE HYDRAULIC SYSTEM

The pressure-source system (common network) generates working pressure and supplies it to the consumer valves. It includes the hydraulic tank, a drain tank with check and relief valves, four check valves, two engine-driven pumps with filters, pump-operation indicators and unloading automatons, two hydraulic accumulators, two shock absorbers, two electric gauges, a fine filter, airfield power panels, and pipelines. The aluminum-alloy tank has a mesh-filtered filler neck, a return fitting whose flared bellmouth reduces foaming, and a suction fitting set above the bottom to keep contaminants and water out of the suction line.

The tank drainage system connects the tank to the sealed cabin, holding it above atmospheric pressure in flight to pressurize the pump inlet, improve altitude capability, and reduce cavitation. A throttled non-return valve admits cabin air when tank pressure falls (opening at 8–15 mm Hg) while keeping fluid vapors out of the cabin, and a relief valve guards the tank and drain tank against over-pressure from over-filling. The plunger pumps, driven by the inner engines at constant speed, deliver a constant 17–20 L/min. A safety valve prevents over-pressure if an unloader fails: a ball valve then vents the spool's inner cavity to drain, and the pressure differential across a throttle shifts the spool to route the pumps to drain; the ball reseats and the spool recloses once pressure drops to normal (235 kg/cm^2).

LANDING GEAR HYDRAULIC SYSTEM

This system retracts and extends the legs, opens and closes the bay doors, unlocks the door and up/down position locks, and rotates the main bogies during retraction. It is three independent systems — the two main legs identical, the nose leg slightly different — each split into door control and leg control. The elements must operate in a fixed sequence (doors open, leg moves, doors close), enforced by the sequential switching of the door and gear electro-valves through limit switches on the doors and on all three legs' up/down locks. The door limit switches form four blocks: two duplicating blocks in the nose bay and one on the front wall of each main bay.

WIPER HYDRAULIC SYSTEM

The wipers clear the front canopy windows. The system has a pressure-reducing valve, two throttle valves, two hydraulic drives, a non-return valve, and pipelines. The reducing valve drops pressure from 210 to the 150 kg/cm^2 the drives are rated for, and doubles as a safety valve above that. It has “Pump,” “System,” and “Tank” fittings and high-, reduced-, and drain-pressure cavities; rising line pressure feeds fluid through the inlet valve to the wiper line while moving the piston against the reducing spring, the inlet valve metering to hold 150 kg/cm^2 and the outlet valve dumping any excess to tank.

HYDRAULIC SYSTEM FOR NOSE LANDING GEAR STEERING

This system steers the nose wheels and damps their self-oscillation during taxi, take-off, and landing to hold a straight track. It comprises an electro-valve, an electro-hydraulic pressure relay, a distribution-and-damping mechanism, two steering cylinders, a non-return valve, and pipelines, fed from the common network through a fine filter. A switch above the nose-gear traverse enables control mode only when the leg is fully extended and automatically reverts to damping mode at the start of retraction, so the wheels cannot turn while retracting.

The electro-hydraulic pressure relay lights the “Nose gear steering on” lamp when upstream pressure exceeds 65 kg/cm^2 and opens it below 45 kg/cm^2. The distribution-and-damping mechanism routes fluid to the steering cylinders, hydraulically locks the wheels in the turned position, and damps self-oscillation; above 10 kg/cm^2 inlet pressure its valve closes the bypass and links the cylinder cavities through a throttle for the damping mode.

MAIN LANDING GEAR WHEEL BRAKING HYDRAULIC SYSTEM

This system brakes the left and right wheels independently or together, from either pilot, with an automatic anti-skid system. It comprises two accumulators, an electric gauge, a water-hammer damper, four brake valves, ten shuttle valves, two electro-hydraulic switches, two gauges, four electro-valves, eight separable valves, five check valves, and pipelines, fed through the network and a fine filter. The brake accumulators (like the network ones, initial nitrogen 65 kg/cm², marked with yellow/green stripes and "Brakes," in the nose bay left side) store energy to brake without network pressure, isolated by a check valve so they do not discharge if network pressure drops. A water-hammer damper smooths the parking-brake valve switching.

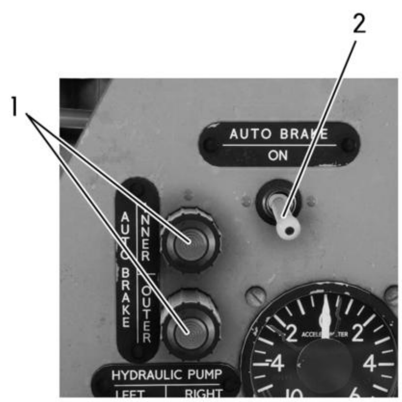
Each pilot has two brake valves — one for the left wheels, one for the right — that reduce supplied pressure in proportion to how far they are pressed, through a control spool, piston, reducing spring, and main spool. Brake pressure holds while the pedal is pressed; releasing it lets the pressure-plate springs return the fluid through the valve to drain.

AUTOBRAKE (ANTI-SKID)

The autobrake automatically releases a main wheel that skids. Skidding occurs when the braking moment (set by brake pressure) exceeds the tire-to-runway adhesion moment, which varies with surface, tread, and wheel load; since a pilot cannot keep these balanced, unmanaged braking either under-brakes or over-brakes and skids, lengthening the rollout (sliding friction is 15–20% below rolling friction) and wearing the tires. The system keeps the braking moment near the adhesion moment using four inertial sensors, four electro-valves, two electro-hydraulic switches, two relays, the autobrake switch, the emergency-release switch, limit switches, and two signal lamps. Each inertial sensor, on a rear bogie wheel, releases two symmetric wheel pairs (inner or outer of both bogies together) to avoid yaw.

The inertial sensor has a body, a gear-driven shaft turning much faster than the wheel, a loosely-fitted sleeve with helical-and-straight grooves, a pusher linking shaft and sleeve, a friction-clutched flywheel, a lever, and a microswitch. Rolling normally, all parts turn together and the switch is open. When a wheel skids, the shaft decelerates sharply while the flywheel's inertia drives the pusher along the helical grooves toward the lever, closing the switch; the flywheel's brake pads slip to limit inertial loads. The closed switch energizes the electro-valves, draining the brakes to tank, and lights the matching lamp (one for outer, one for inner wheels).

The emergency wheel-disarm switch (left console), used if the brake valves fail, energizes all four electro-valves to drain all brakes; it is rated for no more than 3 minutes of continuous use. Limit switches on the main-leg splined hinges disarm all wheels when the shock absorbers fully extend — i.e. if the aircraft becomes airborne during the run — so it cannot land with locked wheels; either switch alone disarms both legs through a relay. The system is checked by spinning and abruptly stopping each removed sensor with the left pilot's pedals fully pressed: brake pressure should drop to zero then rise again to 65 +5 kg/cm² with the lamp lit.



Autobrake control panel

1) Operation indicator lamps – **2)** Autobrake system control switch

PARKING BRAKING HYDRAULIC SYSTEM

Parking braking holds the aircraft stationary while parked. It uses a parking-brake electro-valve (like the steering valve but with manual buttons, inside the left console with its release button protruding), a pressure-reducing valve set to 50 kg/cm^2, an electro-hydraulic switch, and three electric gauges, sharing units with the main braking system. The "Parking Brakes" switch on the left console selects "Braked" (accumulators to the parking system, main system to reservoir) or "Released" (accumulators to the main system, parking system to reservoir).

Set to "Braked," the valve feeds accumulator fluid through the reducing valve (to 50 kg/cm^2) and the shuttle and separable valves into the brakes, and the electro-hydraulic switch extinguishes the "Parking brakes off" light; the "Parking brakes" gauge should read 42–60 kg/cm^2. "Released" drains the brakes to tank and re-lights the lamp; with the aircraft de-energized, the valve button releases the brakes manually. Internal leakage gradually bleeds the accumulators, so the brakes eventually release on their own — the accumulators hold the parking brake for about 24 hours if leakage is within limits.

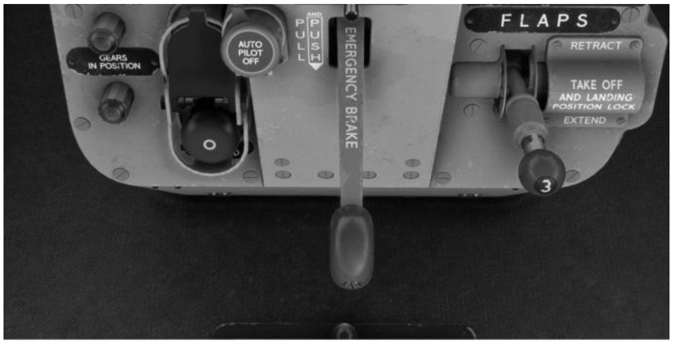
AIRCRAFT LANDING GEAR EMERGENCY BRAKING SYSTEM

The nitrogen emergency braking system is used if the main system fails or is weak; it brakes the left and right wheels together or separately but has no autobrake. It includes a 12 L nitrogen cylinder (pressure 130–150 kgf/cm^2), an electric gauge, a reducer, an emergency brake valve, a brake differential, two reduction accelerators, two dampers, two brake reservoirs, four metering devices, and pipelines, plus shared shuttle and separable valves. Three lines run through it: a high-pressure line (cylinder nitrogen to the accelerators and, via the reducer at 50 kg/cm^2, to the valve), a control line (from the valve through the differential to the accelerators, vented to atmosphere at rest and pressurized up to 15 kgf/cm^2 by handle force), and a working line (from the accelerators through dampers, brake reservoirs, metering and shuttle valves to the brakes, the last section fluid-filled).

The reducer drops cylinder pressure to a steady 50 kg/cm^2 via a spring-loaded diaphragm and valve, with a relief valve venting to the cockpit above 75 kg/cm^2. The emergency brake valve meters control-line pressure by tappet stroke — pressing the tappet isolates the control line from the cockpit, admits nitrogen, and builds pressure until the intake valve closes at a value set by handle force, up to 15 kg/cm^2 at full stroke; releasing it returns the piston and vents the control line. The brake differential, under the cabin floor on the center wing with its spring rod clamped to the rudder linkage, gives differential braking: deflecting a pedal raises one piston to vent that side's brakes, the pressure difference between sides being proportional to pedal travel (with about 1 kg/cm^2 residual in the released side at full travel).

OPERATION OF THE EMERGENCY LANDING GEAR WHEEL BRAKING SYSTEM

Pressing and holding the central-console handle drives the valve tappet; standby nitrogen enters the control line at a pressure set by stroke, passes the differential to the accelerators' control cavities, and opens them so cylinder nitrogen displaces fluid from the brake reservoirs into the brakes through the metering, shuttle, and separable valves. With pedals neutral both sides brake equally; deflecting a pedal releases that side's wheels and turns the aircraft that way (left pedal releases the right wheels), the released-side pressure reaching 5–8 kg/cm^2. Releasing the handle vents the accelerators' control cavities so the return springs push the fluid back to the reservoirs.



Position of the emergency braking lever on the central console

To check the system, power the aircraft and switch on the "Hydraulic system pressure gauges" and "Parking brake" breakers — cylinder pressure should be 130–150 kg/cm^2. With the parking brake off and reservoirs filled, moving the handle 20–35 mm should not raise brake pressure; pressure should then rise quickly to 5 kg/cm^2 and smoothly to 75 ± 10 kg/cm^2. Releasing smoothly should fall to 0–8 kg/cm^2; a sharp press should brake in ≤1.5 s and release to 4–6 kg/cm^2 in ≤3 s. Pedal travel from 0 to 57 mm should not change brake pressure, and beyond 65 mm the braked side holds 75 ± 10 kg/cm^2 while the released bogie falls to 8 kg/cm^2; the system is then reset.

CHAPTER V – POWERPLANT

GENERAL INFORMATION

The powerplant is the engines plus every system, unit, and structure needed for their efficient, reliable operation. On the Il-18D it comprises four AI-20M engines with AV-68I propellers, the nacelles, the engine mounts, and the exhaust, control, fuel, and oil systems. Each nacelle has a front part (cowling) and a rear part: the cowling smooths the airflow, protects the engine, and ducts air to the compressor, while the rear part transfers engine loads to the center section and fairs the exhaust pipe. The inner-engine nacelles also house the main gear legs, and the outer ones fair the oil coolers. The cowling is attached to the engine and the rear nacelle to the center section, the two left unconnected so engine vibration reaching the cowling is not passed to the rear nacelle.

The inner-engine cowling has a nose section, a gearbox-housing fairing, an upper beam, two side covers, and a lower cover. The nose section and gearbox fairing form the air intake; the nose carries a hot-air anti-icing device fed from the compressor, and an oil cooler sits in its lower part with a tunnel ducting outside air to it. The gearbox fairing is profile-stiffened duralumin, studded to the gearbox front flange and resting at the rear on eight rubber cushion stops — worn to a 3 mm protrusion (1 mm wear allowed), checked at engine changes. The upper beam, which carries the side covers, attaches to the cowling nose and, through rubber-bushed brackets and a three-rod steel truss with adjustable tips, to the engine.

The side covers open for engine access, located by front pins and held open by a latched strut; the left cover has an oil-filler hatch. They hinge to the upper beam at the top and use tension locks on the lower cover at the bottom — the locks must be evenly tensioned, since over-tensioned locks may break and under-tensioned ones may vibrate open in flight, freeing the covers. The lower cover smooths the transition to the gear bay, carries the oil-cooler outlet tunnel and flap, and attaches by four rubber-bushed assemblies (two to the cowling nose, two by adjustable struts to the engine). Cowling sealing reduces drag, keeps out precipitation and dust, and damps panel vibration. Symmetric cowling parts are interchangeable, but disassembly is normally prohibited; the outer-engine nose section has no oil-cooler tunnel since those coolers sit in the rear nacelle.

The rear nacelle is bulkheads, stringers, a horizontal panel, and skin. Titanium-lined lower bulkhead sections and an alloy-lined upper section form fireproof partitions separating the engine, exhaust-pipe, and gear compartments; the horizontal panel between bulkhead No. 1 and the center-section front spar is likewise fireproof and stiffens the nacelle, with four asbestos-sealed access hatches. The stringers bordering the gear-bay cutout are reinforced for the door brackets. The duralumin skin has a removable upper tail section and an alloy removable tail to allow exhaust-pipe removal. The outer-engine rear nacelle replaces the gear bay with an oil-cooler compartment (frames 1–3, under the horizontal panel), the cooler on a steel-rod truss with a tension-locked lower cover and tunnel. Inner nacelles attach to the center section at frames 6 and 9 with fittings and contour angles.

Nacelle ventilation cools the engines and exhaust pipes and prevents accumulation of flammable vapors. Atmospheric air ventilates the engine compartment (through side-cover and upper-beam intakes, exiting via side gills), the exhaust-pipe compartment (side intakes, the air passing both sides of a screen and out an annular gap that draws off heated air), the gear compartment or, on outer nacelles, the oil-cooler compartment, and blows the generators, turbine casing, oil-gauge sensor, brake reservoir, emergency-braking reduction accelerator, and thermo-cartridge.

EXHAUST (OUTPUT DEVICE)

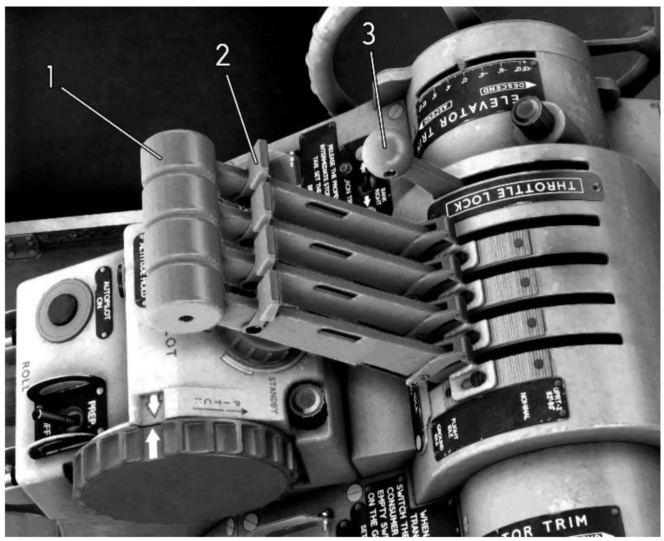
Each engine has its own stainless-steel output device of a transition flange, cone spacer, and exhaust pipe, removing gases behind the wing trailing edge. The transition flange bolts to the engine and carries a welded internal gas reflector. The cone spacer between flange and pipe eases connection, compensates pipe-to-engine misalignment, and blocks vibration transfer. The exhaust pipe is welded from sections with external reinforcing bands and two rollers for rolling it into the nacelle on rails; the inner-engine pipe is 1.5 m longer than the outer. Horizontal and side screens (the horizontal one removable, bolted to a wing profile) protect the wing skin and nacelle from heat, with air gaps for cooling; the rear mounting allows thermal expansion via a spring-loaded rail-and-clamp roller. The pipe interior is coated with heat-resistant enamel and is removed every 10–15 flights to inspect and clear deposits, with fastening, the gas reflector, and the absence of cracks, dents, tears, and burnouts checked per the maintenance regulations

ENGINE AND NACELLE DRAINAGE

Drainage removes fuel left in the combustion chamber after a failed start and fuel seeping through the telescopic cone-spacer joints. A valve on the chamber housing drains it through a pipeline routed to the end of the nacelle, kept clear of the landing gear wheels (inner nacelles) and the central distribution unit (outer nacelles).

ENGINE MANAGEMENT

Engine management covers ground and in-flight starting, normal and emergency shutdown with feathering, and operating-mode control. Mode control sets the throttle valves in the command-fuel units, with a separate throttle system per engine made of a control lever and linkage.



Engine control system

1) engine control levers – **2)** control lever locking pins– **3)** control lever friction

The linkage is mixed — cable from the lever to a roller at nacelle frame No. 1, rigid thereafter. The control levers form a removable mechanism on the central console, with an adjustable flight-idle stop that holds rearward travel at the 16° mark (the latch must be lifted to reach ground idle) and a cam-washer lock preventing spontaneous movement. Lever-roller cams press the gear-position limit switch at flight idle. Cables run down the console and under the floor to the center-section front spar, then along it and the left sides of the nacelles, with turnbuckles for tension, magnesium-alloy roller brackets, textolite guides, and split-ball sealed glands at the cabin exit. The end roller at frame No. 1 converts cable to rigid linkage and has a serrated, oval-holed lever whose adjustable length sets how fast power changes; duralumin rods with adjustable tips run on to the throttle-valve driver in the command-fuel unit.

Pushing a lever forward rotates the end roller, which through the rods and an engine rocker turns the throttle-valve driver to raise fuel flow; pulling back reduces it. Lever position is read on the fuel-lever position indicators (UPRT) on the central panel — four sensors and two dual-needle indicators (engines 1–2 and 3–4). Equal lever positions should read equal: ground idle reads 0°, flight idle 16°, and full forward 98–105° (take-off power), with the levers stopping 7–8 mm short of the forward stop.

CHAPTER VI - FUEL SYSTEM

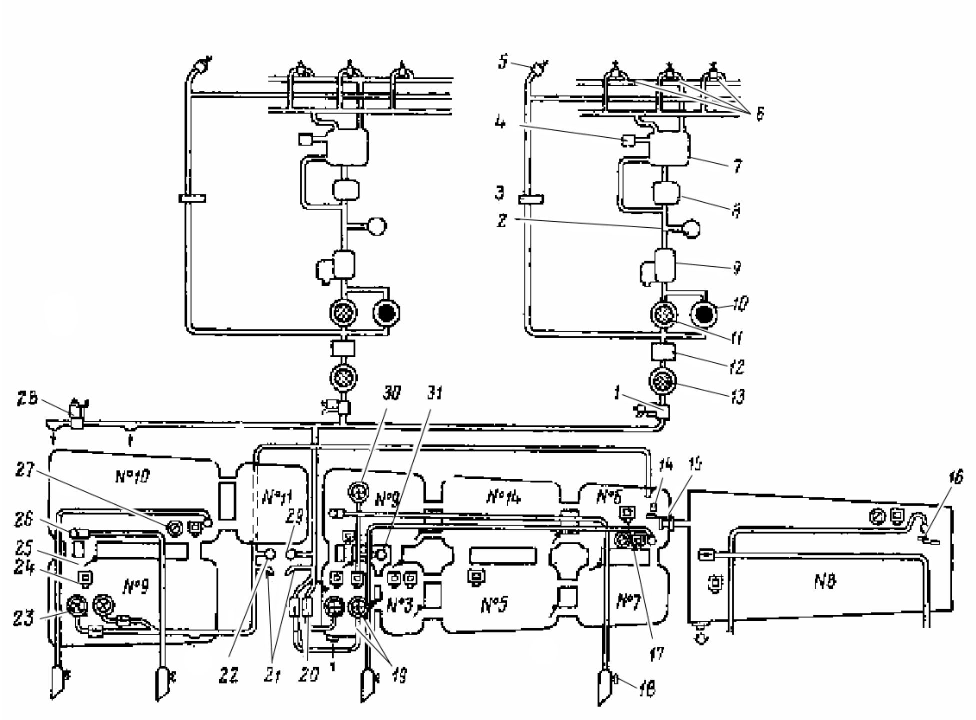
GENERAL INFORMATION

The fuel system stores the flight fuel reserve and supplies it uninterrupted to the running engines. It divides into an external (aircraft) system and an internal (engine) system, and into two identical, independent left- and right-engine systems joined by a cross-feed pipeline with a cross-feed valve. Each half-wing's tanks form a main group (between the inner and outer nacelles, plus the outer-panel tank-compartment) and an auxiliary group (between fuselage and inner nacelle). The split improves fire safety: on short flights the fuselage-side auxiliary tanks are left empty, and when filled their fuel is used first. Besides over-wing filling through the necks, pressure (bottom) refueling lets the tanks be filled from the ground. The system runs automatically, with manual control as backup.

MAIN DATA OF THE FUEL SYSTEM

Tank capacity per half-wing — main group (incl. compartment 3300)	**8200 L**
Tank capacity per half-wing — additional group	**3650 L**
Total aircraft tank capacity	**23,700 L**
Pressure from boost pumps	**0.8–1.3 kg/cm²**
Applicable fuels	**T-1, TS-1, T-2 and mixtures**

Each half-wing has eleven tanks (No. 1–8 main, No. 9–11 additional) plus five pumps, filters, valves, sensors, a flowmeter, a capacitive fuel gauge, drainage, and pressure refueling; each engine adds a boost pump, a high-pressure pump, a command-fuel unit, and main and starting nozzles. All tanks except the compartment tank (No. 8) are soft and unprotected — kerosene-resistant rubber bonded to an outer fabric, with vulcanized metal fittings and a bolted lower mounting hatch. Tanks connect to their neighbors top (drainage) and bottom (fuel transfer) through bolted alloy sleeves; some bottom connections have check valves to stop fuel running toward the tip during maneuvers. The tanks sit in canvas-lined metal containers (spar and rib walls with riveted duralumin sheets, foam-plastic packed under the lower sheet) and are held by snap locks in conical sockets plus bolts.



Fuel system in the wings

1) shut-off valve - **2)** pressure switch - **3)** electromagnetic valve for starting fuel - **4)** pressure receiver - **5)** starting nozzle - **6)** working nozzles - **7)** command-fuel unit - **8)** main fuel pump - **9)** flow meter sensors - **10)** indicator - **11)** fine filter - **12)** booster pump - **13)** preliminary filter - **14)** float valve for fuel transfer - **15)** float valve for unloading - **16)** float valve for drainage - **17)** level indicator - **18)** vacuum valve for drainage - **19)** fuel booster pumps - **20)** check valves - **21)** fuel drain cocks – **22), 31)** pressure indicators - **23)** pumps for transferring fuel from the additional group of tanks - **24)** fuel gauge sensor - **25)** tank check valve - **26)** double drain valve - **27)** filler neck for top fuel filling - **28)** looping valve - **29)** pressure indicator - **30)** pump for transferring residual fuel

PUMPS

Fuel pumps maintain the head needed for uninterrupted supply at any altitude, improving safety. Two boost pumps per half-wing in tank No. 8 supply the engines; the first carries full consumption and the second (standby) cuts in only on failure or when tank No. 8 falls below minimum. Each pump is an electric motor and pump in one body with an impeller, a rough-cleaning net, a flow-regulating valve, and a non-return flap valve that closes when the pump stops to prevent backflow. Pumps mount on hatch covers so most of the unit sits inside the tank for cooling; with the tank empty a pump must not run over 10 minutes. Tank No. 1 and 2 pumps are manual, tank No. 9 pumps manual or automatic, with breakers on the navigator's panel and "Boost," "Transfer residues to the main tank," and "Transfer from additional tanks" switches on the console.

The tank No. 9 transfer pumps switch on automatically from the tank No. 6 level sensor once 150–250 L have been used from tanks No. 1–7, and off from both the tank No. 9 sensor and a pressure switch when the additional group empties and pressure falls below 0.18 kg/cm^2 — the duplicate cutoff ensuring complete, reliable consumption. Pressure switches drive the warning lights: below 0.18 kg/cm^2 behind the tank No. 1 boost pumps lights "Failure of boost"; pump operation lights the green "Transfer from additional tanks" panel; and below 0.35 kg/cm^2 behind a booster pump lights the red "Minimum fuel pressure" panel. Each warning light is an electro-hydraulic relay whose diaphragm capsule works a microswitch.

VALVES, FILTERS, AND INSTRUMENTS

Check valves behind the tank No. 1 and No. 9 pumps prevent backflow if a pump fails and close when the engines feed from the opposite wing. Shut-off (fire) valves stop fuel to the engines in emergencies and during parking, driven by an electro-mechanism turning a rubber-faced valve — the outer-engine valves in the wing nose between nacelles, the inner-engine valves in the main bays, worked by capped “Fuel valves” switches on the central panel. Pre-filters clean fuel before the boost pumps, with clogging signals paralleling the fine filters. Flowmeters (four sets, twin-impeller sensors, amplifier, and indicator) measure hourly consumption and remaining fuel per engine, the counter showing the difference between fueled and consumed fuel. Electric pressure gauges read the engine manifold pressure (sensors on the right engine mounts, indicator on the central panel). The cross-feed valve, like a shut-off valve, on the center-section front spar in the electrical compartment, feeds left tanks to right engines and vice versa, worked by a capped “Cross-feed valve” switch.

The float relief (unloading) valve in tank No. 6 delays consumption from tank No. 8 until 3500 L remain in tanks No. 1–7, so the compartment fuel unloads the wing longer with a bending moment opposing lift; above 3500 L the float holds the valve shut (up to 0.15 kg/cm^2 compartment pressure), and below it the float drops and admits tank No. 8 fuel, holding a constant level in tanks No. 1–7. The float transfer valve, similar, prevents the main tanks overflowing while being pumped from the auxiliary group: it stays shut when the main tanks are full (up to 2.5 kg/cm^2) and opens after 500–600 L are used from tanks No. 1–7.

CAPACITIVE FUEL GAUGE

The capacitive gauge measures tank quantity, automatically controls the tank No. 9 pumps and the bottom-refueling valves, and lights the low-fuel warning. It comprises sensors (in tanks No. 1–10, doubled in tanks 1, 3, and 8), level alarms, indicators, selector switches, a “Fuel Gauge” switch, and measuring and automation units. Sensor alarms perform the logic: tank No. 2 closes the “Fuel

remaining 1000 kg” display, tank No. 6 starts the tank No. 9 pumps, tank No. 9 stops them, and tanks No. 8 and 10 close the bottom-refueling valves. Level alarms in tank No. 6 close the bottom-refueling valves for tanks No. 1–7; each alarm is a float with an iron core moving in an AC inductance coil, the changing inductance signalling the action.

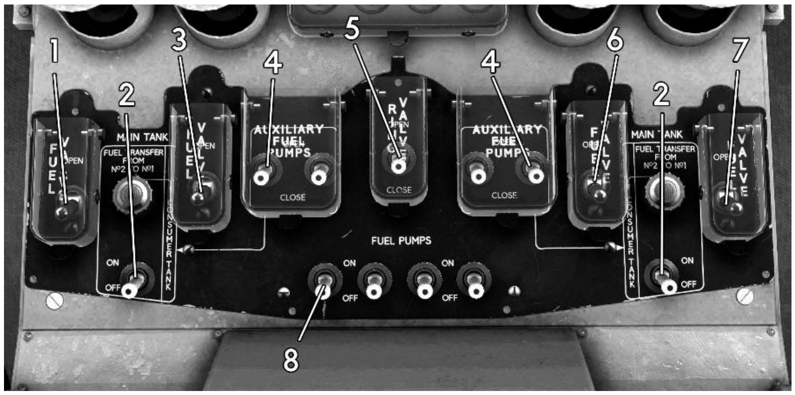
Two gauges sit on the central panel and two on the refueling panels in the main bays. The central gauges have inner and outer scales — inner for the main tanks (No. 1 and 3), outer for total, group, and tank No. 8 reserves — while the refueling-panel gauges have one scale for group and tank No. 8 reserves. Selector switches route the gauges to individual tanks or groups; the central switch positions are “Total,” “1st group,” “2nd group,” “Tank 8,” and “Main tanks” (the last reading the inner scale, the rest the outer). The “Fuel Gauge” switch on the

left console selects “Onboard fuel” or “Refuel” — but pressure refueling is not implemented in this add-on, so the switch functions only in “Onboard fuel,” and Microsoft Flight Simulator's EFB is used for refueling. To power the gauge, switch on airfield power, the “PO-1500 On” and “Fuel Gauges Right/Left” breakers, the “PO-1500” switch to “ESTS,” and the “Fuel Gauge” switch.

FUEL SYSTEM OPERATION

To run the system, switch on the fuel-pump and related breakers on the navigator's panel and use the central-panel switches to open the fuel valves and start the boost pumps; if the auxiliary tanks are empty, also start the tank No. 2 pumps (green lights confirm). The main-tank boost pumps feed each engine pair at 0.8–1.3 kg/cm^2; after the check valves, shut-off cocks, and filters the fuel reaches the engine boost pumps, then at 2.0–3.0 kg/cm^2 through fine filters and flowmeter sensors to the high-pressure pumps, which deliver up to 83 kg/cm^2 to the command-fuel unit and working nozzles. Part of the flow feeds the starting nozzles through the starting fuel valve only during start.

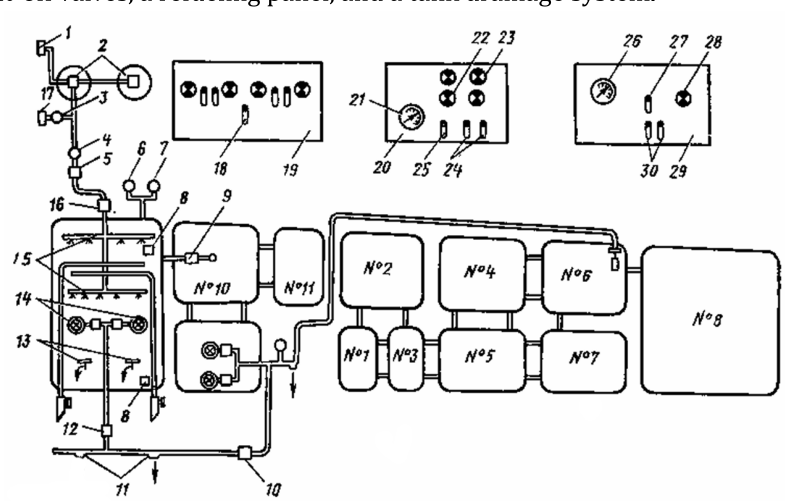
After 150–250 L are used from the main group, the tank No. 9 transfer pumps start automatically (green "Transfer from auxiliary tanks" light), though fuel reaches tank No. 6 only once the float transfer valve opens after 500–600 L. When the additional group empties, those pumps stop automatically and the tank No. 2 pumps are switched on; if the auxiliary pumps fail to start within 15 minutes, they are run manually and turned off when the light flashes. At 3500 L remaining in tanks No. 1–7 the unloading valve admits tank No. 8 fuel, holding a constant level until tank No. 8 falls to 200 L, after which residual fuel is consumed and the green "Residual fuel consumption" light comes on at 1000–1100 kg remaining. An unusable, non-drainable reserve always remains; if needed, opening the ring valve and stopping a wing's boost pumps allows all four of that wing's tanks to be consumed.



1) – tank group 1 valve **- 2)** consumption tank valve **- 3)** tank group 2 valve **- 4)** auxiliary tank valves
5) ring (cross-feed) valve – **6)** tank group 3 valve – **7)** tank group 4 valve

DIFFERENCES IN THE ILYUSHIN IL-18D

The Il-18D raises capacity to 30,000 L with an extra under-fuselage tank-compartment No. 12 (6300 L), whose fuel is used first — pumped equally into both main groups — and which has a neutral-gas system for fire safety. The system adds tank No. 12, its transfer pumps, two level sensors, a transfer shut-off valve, four check valves, a transfer control panel, two refueling shut-off valves, a refueling panel, and a tank drainage system.



Fuel system of the Il-18D aircraft with a neutral gas system

1) Signal eye of cylinder self-discharge – **2)** fire extinguishers – **3)** Bleed valve – **4)** Shut-off valve – **5)** Jet with a diameter of 1.8 mm – **6)** Pressure switch – **7)** Pressure switch – **8)** Fuel gauge sensors – **9)** Electric refueling valve – **10),16)** Check valves – **11),13)** Sediment drain valves – **12)** Electric transfer shut-off valve – **14)** Pumps – **15)** Spray manifolds in the tank – **17)** Bleed fitting – **18)** Neutral gas system control switch – **19)** Aircraft fire protection system control panel – **20)** Tank No. 12 refueling panel – **21), 26)**

Fuel gauge indicators – **22)** Red lamps "Valve closed" – **23), 28)** Green lamps "Valve open" – **24)** Refueling electric valve control switches – **25)** Main refueling switch – **27)** Transfer shut-off valve control switch – **29)** Control panel – **30)** Transfer pump switches.

The transfer pumps (4000 L/h, at least 0.6 kg/cm^2 up to 10,000 m) move fuel from tank No. 12 to tanks No. 6 of both wings, controlled manually by "Transfer Pumps" switches or automatically off the level sensor, with check valves preventing backflow into tank No. 12 and from the second group. The transfer shut-off valve (like the ring valve) closes the line once tank No. 12 empties, worked by a "Transfer valve" switch with a green open-light. The double drainage runs cross-tank pipes venting through oblique-cut pipes and vacuum valves under the skin.

In operation, the tank No. 12 transfer pumps and shut-off valve are turned on before start. After 150–250 L are used from the main group, the tank No. 6 sensor signals the auxiliary pumps but they stay off (the open transfer valve's limit switch breaks their circuit); after 500–600 L the tank No. 6 float valve opens and tank No. 12 fuel flows in. At about 770 L remaining in tank No. 12, the level and pressure signals stop the pumps and the transfer valve is closed, its limit switch then starting the tank No. 9 pumps, after which consumption follows the standard sequence. Tank No. 12 is refueled by gravity from tanks No. 10 of both wings through electric valves on the tank No. 10 hatches, worked by "Left/Right valve" switches on the right main-bay panel with red closed and green open lights, plus a main refueling switch and a tank No. 12 gauge.

THE FUEL SYSTEM OF THE TG-16

The TG-16 turbogenerator (APU) has its own autonomous fuel system; only the aircraft part is covered here — a fuel tank, filter, electric gauge, drain, filler neck, and a float bottom-refueling valve. The fuel is kerosene. The welded alloy tank (100 L, two shells and two bottoms, internally profile-stiffened) carries welded nozzles and flanges for the filler neck with mesh filter, the gauge sensor, the float refueling valve, the supply to the TG-16, and the drain, and sits on the left of the rear cargo compartment. The filter cleans fuel before the unit. The gauge reads quantity remotely and signals a full tank, its indicator on the TG-16 control panel, switched from the navigator's panel. The tank fills through its neck to 93.4 L or by pressure (bottom) refueling through a neck, pipeline, and float valve.

Location of the TG-16 fuel gauge on the TG-16 control panel

CHAPTER VII - OIL SYSTEM

The oil system stores the oil for engine operation and propeller feathering, supplies it to the engine under pressure, and scavenges and cools it. Each engine has an identical, independent system, divided into an external (aircraft) part and an internal (engine) part; only the aircraft part is covered here. It comprises an oil tank, oil cooler, drain tank, pipelines, and control, monitoring, and signaling elements, while the engine part adds the boost, main, scavenge, torque-meter, and governor pumps, the filters, and the air separator.

Working pressure, discharge line	**5.0–5.5 kg/cm²**
Oil tank capacity	**56.5 L**
Non-consumable reserve for feathering	**14 L**
Sediment remaining in tank	**1.5 L**
Minimum oil pressure (warning)	**3.9 kg/cm²**

With the engine running, the boost pump feeds the main pump, whose discharge stage supplies the engine at 5.0–5.5 kg/cm². Spent oil collects at the engine's low points, is scavenged by the main and scavenge pumps, passed through the air separator, cooled in the oil cooler, and returned to the main pump — a closed engine–cooler–engine loop in which the oil stays under pressure, replenished from the tank. This "short-circuited" system suits turboprops: the constantly-pressurized oil prevents vapor locks (improving altitude capability), the foamed oil never returns to the tank (so the tank is only a small reserve), and the oil warms quickly at start. Its drawback is that the tank is not used for cooling, so a larger, heavier cooler is needed.

OIL TANK

The welded aluminum-manganese tank stores the flight oil reserve, with an internal baffle for rigidity that also keeps oil over the intake pipe during maneuvers. The intake sits above the lowest point, leaving an unused 15.5 L below it — sediment plus feathering oil. A top flange carries the mesh-filtered filler neck, the float-type level sensor (with its own scale and pointer for the usable oil), and a dipstick, and there are fittings to the drain tank, for engine intake, and for the air-separator return hose.

OIL COOLER

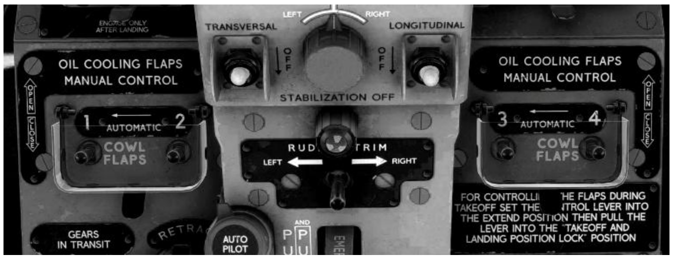
The all-brass cooler rejects oil heat to atmospheric air: hexagon-flared tubes soldered together form oil channels between them, with air blown through the tubes. Internal baffles add rigidity and lengthen the oil path, their windows set high or low (some both) to route the flow. Inner-engine coolers mount in the cowling nose; outer-engine coolers mount on frames on the horizontal panel between nacelle ribs No. 1 and 3, both strapped down with rubber-gasketed steel bands.

DRAIN TANK AND PIPELINES

The drain tank on the oil-tank vent line traps escaping oil vapor; welded from alloy with a conical baffle, it has bottom nozzles for incoming vapor and returned oil and a top drain whose pipe vents under the cowling (inner engines) or behind the cooler compartment (outer engines) clear of the central distribution device. It hangs from the cowling upper beam. The lines use asbestos-insulated, pressure-tested hoses (no other type permitted, the outer-engine cooler hoses longer than the inner) and short alloy pipes joined by durite couplings.

OIL SYSTEM CONTROL

Control reduces to working the cooler flap to regulate oil temperature at the engine inlet, manually or automatically via an electro-mechanism. The central-panel switch has “Auto,” “Open,” “Closed,” and neutral positions — toggled to “Auto,” pressed for the manual positions. “Open” drives the flap open, increasing cooling air and lowering oil temperature; “Closed” raises it. A non-return valve in the cooler outlet protects the cells from crushing when the safety valve is closed. The automatic regulator uses a bimetallic spiral: below 65 °C the flap stays fully closed, above 65 °C it opens in pulses every 2.5–3.0°, and at +82 °C it is fully open; the bridge stays balanced between about 58–74 °C so the flap and temperature hold steady, and below 55 °C the flap remains closed.



Cowl flaps control on the central console.

INSTRUMENTS AND SIGNALING

An electric oil meter reads tank quantity from rheostat float sensors (each with its own direct scale); twin-pointer indicators on the left console cover engines 1–2 and 3–4. Electric indicators read oil pressure (sensor on the right of the cowling nose rear wall, lower-left scale) and temperature (sensor in the cooler-to-pump line, lower-right scale) on the central panel, and a four-pointer indicator on the left console shows all four cooler-flap positions. Red “Oil residue 5 l” signs (closed by the oil-meter sensor) and “Minimum oil pressure” signs (closed by a pressure switch below 3.9 kg/cm^2 in the discharge line) sit on the central panel. Normal operation requires the “Motor indicators,” “Oil temperature regulation,” “Oil meters,” “Thrust pressure gauges,” and “Oil cooler flap indicator” breakers on the navigator's panel.

OPERATION

The boost pump first fills the engine lines and replenishes the cooler–engine circuit, the main pump's discharge stage supplying the engine at 5.0–5.5 kg/cm^2. Oil scavenged by the main and scavenge pumps passes the centrifugal air separator; clean oil flows to the cooler and back to the discharge stage, while air/emulsion returns to the tank. The boost pump holds 0.6–0.8 kg/cm^2 at the main pump inlet via its bypass valve — topping up from the tank if pressure falls and returning oil if it rises. Temperature, pressure, and quantity are watched continuously; below 3.9 kg/cm^2 lights “Minimum oil pressure,” and 5 L remaining lights “Oil residue 5 l.”

Filling is through the tank neck. From dry, the tank is filled to the brim, the propeller turned 20–30 revolutions (some oil entering the engine, at least 17 L remaining), then topped up to 28L, checked by dipstick and gauge.

CHAPTER VIII - AV-68I AIRCRAFT PROPELLER

GENERAL INFORMATION

The AV-68I converts engine torque into positive thrust for flight and negative thrust for braking during the landing roll. It is a variable-pitch propeller that, with its governor, automatically holds a set constant speed in all engine modes and flight phases, operating as a single "propeller–governor" system with the R-68DT constant-speed governor and the control equipment.

Type	**hydro-centrifugal, reverse-acting**
Blade angles at 1600 mm — start / intermediate stop / feathered	**0° / 12° / 83.5°**
Mechanical-lock trigger angle range	**45° to 0°**
Rotation speed (all modes)	**1075 rpm**
Centrifugal-lock trigger speed	**1115 +15 rpm**
Diameter / weight	**4.5 m / 385 kg**

Blade pitch is the angle between a blade-element chord and the plane of rotation; it varies along the blade, so it is checked at a control section 1600 mm from the axis. In the reverse scheme, oil pressure from the governor pump increases pitch (coarsens), while the transverse components of the blades' centrifugal forces plus engine-system oil pressure decrease it (fines). The scheme uses less oil than a double-acting propeller, and the centrifugal forces are stable thanks to the turboprop's constant speed. Its drawback is that a drop in propeller oil pressure lets the blades "lighten" and the propeller overspeed, which the rising centrifugal forces could destroy; to prevent this, three pitch locks are fitted — hydraulic (HPL), mechanical (MPL), and centrifugal (CPL).

When power is reduced in flight, the governor automatically fines the blades to hold speed; at fine pitch and high speed the angles of attack can go negative, producing dangerous negative thrust (which increases speed). A "propeller regulator" tied to the hydraulic lock limits the minimum in-flight pitch to prevent this, and negative thrust is not permitted except when reverse is intentionally used. For ground engine runs, the KFU-37 lock fits in place of the spinner and fixes the pitch at the 12° intermediate stop; for starting, the blades are set to 0° for the required auxiliary-unit power.

DESIGN OF THE AB-68I SERIES 03 PROPELLER

The propeller has a hub, four blades, a cylinder-piston group, oil-supply parts, and a hub fairing. The high-quality-steel body mounts everything and fits the gearbox shaft, with rear studs and splines (studs to the flange, splines to transmit torque) and a central bore carrying the oil line and drain holes. Its four blade sleeves each have three ball grooves for the socket assemblies, which fasten the blades with a cup, clamp, nut, locking ring, and balls plus a positioning pin.

The duralumin blades have a profiled airfoil tip (creating thrust) and a threaded root (securing the blade), the root using a left-hand round thread, a centering band and ring, a pin hole fixing the balance-set angle, and an end bore for the balance weight and washers; the tip is geometrically twisted. In icing, leading-edge ice alters the airfoil and unbalances the propeller, so electric heating pads are glued into milled leading-edge grooves to preserve the geometry.

Assembled blades are non-interchangeable by weight and geometry, so the body, cup, blade, and cup parts share matching numbers 1–4.

CYLINDER-PISTON GROUP

This hydraulic drive changes blade pitch, comprising a cylinder, a piston with crosshead and connecting rods, the oil-line assembly with diaphragm, the hydraulic and mechanical pitch locks, and the stop-removal spool. The duralumin cylinder, nutted to the hub, has an internal shoulder forming the 0° fine-pitch stop. The piston, moving on oil pressure, turns the blade sleeves via the crosshead and rods; it divides the cylinder into the coarse-pitch cavity A and a drain cavity (vented to the gearbox), with the fine-pitch cavity B inside it. Cavities A and B connect to the governor by the coarse-pitch (CP) and fine-pitch (FP) channels. The crosshead, splined to the oil line, prevents the piston rotating and fixes the rod and port positions, and steel two-headed connecting rods link it to the blade-cup pins through spherical liners.

The hydraulic pitch lock seals oil in cavity A when the lock-channel pressure drops — from governor-pump failure, oil leakage, setting the intermediate stop, or centrifugal-lock action — preventing spontaneous lightening, and reopens cavity A when pressure returns. In normal operation its valve is held open by a plunger fed at 38 kg/cm² from the lock channel; when pressure falls the plunger retracts and the valve closes, while coarse-pitch oil can still overcome the spring to increase pitch. The plunger's spool, retracting with it, rapidly drains oil from under the mechanical lock coupling. The mechanical pitch lock duplicates the hydraulic lock and acts with it.

PROPELLER HUB FAIRING

The fairing fixes to the hub disks by conical pins, locked at the front disk by a keyed, slotted steel ring whose tooth tailpiece protruding above the surface signals it is open. A glued-in front heating element connects through two pins to the cylinder centering bush, and the four rear blade cutouts are closed by two-piece rubber root fairings clamped on the blade and covered by visors. The assembled fairing is balanced on a machine and must not be disassembled; imbalance is corrected by filing protrusions on the mounting disks.

CONSTANT-SPEED GOVERNOR (R-68DT)

The governor supplies oil to remove the propeller from the intermediate stop, to feather, and to unfeather, acting on electrical signals from the control system and switching automatically to feather on negative-thrust, overspeed, or nitrogen-emergency signals. Its pump creates high pressure in normal operation and feathering; a check valve guards against a rapid pressure drop on pump failure; a filter cleans the oil; and a reduction valve holds pump pressure low at equilibrium speed (easing pump load) and higher when coarsening, backed up by coarse-pitch oil. Centrifugal regulators with a hydraulic booster hold constant speed and make up coarse-pitch leakage. Electromagnetic spools direct oil to remove the propeller from the stop and to unfeather; a selector valve connects the feathering pump during feather/unfeather and otherwise circulates hot oil to keep the feathering hoses, pump, and tank oil warm. Feathering and unfeathering valves feed the coarse- and fine-pitch channels, the stop-removal valve drains the fine-pitch channel when removing the stop, and the all-mode feathering unit switches the feathering valve, its limit switch commanding feather when negative thrust exceeds 1200 kg.

The “propeller–governor” channels connect these valves to the propeller cavities. The coarse-pitch channel feeds cavity A from the governor pump (coarsening) or the feathering pump (feathering) through the hydraulic-lock valve. The fine-pitch channel feeds cavity B constantly from the engine oil system at 5–5.5 kg/cm², and also the stop-removal spool — with governor-pump oil at 38 kg/cm² when leaving the intermediate stop and feathering-pump oil at 65 kg/cm² when unfeathering; an indicator lights a red lamp if its pressure exceeds 20 kg/cm² (requiring emergency feathering if seen in flight). The pitch-lock channel feeds the hydraulic and mechanical lock cavities through the centrifugal lock, with a red lamp if its pressure falls below 12.5 kg/cm². Both indicators sit on the right upper engine strut, their lamps on the central panel.

OPERATION

At equilibrium speed the governor spool blocks the coarse-pitch channel and the pump works "on itself" through the reducing valve, while oil holds the pitch locks open; cavity-B pressure and the blades' centrifugal forces would fine the pitch, but oil locked in cavity A forms a hydraulic stop. When power, speed, or altitude rises and the propeller tends to overspeed, the governor spool opens the coarse-pitch channel, oil enters cavity A and coarsens the pitch (forcing cavity-B oil back to the pump) until speed returns to equilibrium and the channel recloses at the larger blade angle.

REDUCTION OF PROPELLER PITCH

When power, speed, or altitude falls and the propeller slows, the governor spool drops and connects the coarse-pitch channel to drain. The centrifugal forces and cavity-A pressure then fine the pitch, oil draining from cavity A through the governor, until equilibrium speed is restored or the blades reach the intermediate stop.

INTERMEDIATE STOP

The intermediate stop keeps blade angles from falling below 12° on approach, preventing negative thrust and giving rapid thrust build-up for a go-around. As the lightening blades reach 12°, an adjusting-sleeve port aligns with the oil line so cavity A and the area under the hydraulic-lock plunger drain to cavity B; the plunger retracts, the lock valve closes and seals cavity A, and the retreating plunger spool drains the mechanical-lock cavity so its spring-loaded clutch engages the rotating sleeve's end splines. The two locks together hold the propeller firmly at the stop.

Intermediate stop (pitch lock) control on the central console.

REMOVING THE PROPELLER FROM THE INTERMEDIATE STOP

With a power increase, removal is automatic: the governor feeds the coarse-pitch channel, opening the hydraulic-lock valve so the piston moves back to coarsen, unimpeded by the fine-pitch parts. With a power decrease and fining, the unfeathering valve connects the governor pump to the fine-pitch channel; oil moves the stop-removal spool, opens the fine-pitch hydraulic lock, and admits oil to the fine-pitch mechanism, driving the piston forward while cavity-A oil drains to the governor — lighting the feathering-channel low-pressure and fine-pitch high-pressure lamps.

LOCKING BY THE CENTRIFUGAL PITCH LOCK

If the governor's centrifugal-mechanism spool sticks low, its channel drains and the propeller lightens and overspeeds. At 1115 rpm, centrifugal force shifts the spool: its lower land blocks the governor lock channel and its upper land drains the lock cavity, so the hydraulic and mechanical locks engage and stop further overspeed. If the governor fault clears and acts to coarsen, the centrifugal spool returns below 1100 rpm and the governor regains control.

FIXING BY THE HYDRAULIC AND MECHANICAL PITCH LOCKS

Besides the intermediate-stop and centrifugal-lock cases, the hydraulic and mechanical locks fix the blades on governor-pump failure, loss of engine oil, or rapid depressurization of cavity A with falling channel pressure, holding the blade angles to prevent further lightening and overspeed.

FEATHERING

The blades are feathered at the first sign of engine failure. The equipment is a feathering electric pump, its contactor, and a central-panel button (KFL-37) for manual feathering, whose red engine-failure lamp lights when the automatic system operates, prompting manual back-up. An engine-mounted sensor triggers automatic feathering on a torque-meter oil-pressure drop, and the system switches off once the blades start moving. A partial-feathering button (left panel) tests feathering without the engine-stop system, and an adjacent check switch tests the automatic sensor circuits. A nitrogen emergency system backs all of this up.

To feather manually, the KFL-37 button is pressed and released after 2–3 s (held by an electromagnet), switching on the time relay, contactor, feathering pump, and a green pump lamp. With the engine running, oil comes from both the governor and feathering pumps; stopped, from the feathering pump only, draining cavity B to the engine oil system. A simultaneous signal to the stop valve cuts the fuel. As the blades feather, cavity-A pressure rises until at 38 kg/cm^2 the reducing valve dumps excess oil; the time relay stops the pump after 20 s. Full feathering takes ≤10 s running, ≤20 s stopped. Automatic feathering (on a torque-meter pressure drop or excessive negative thrust) works identically, also lighting the KFL-37 engine-failure lamp, triggered by the engine sensor, the negative-thrust sensor with the all-mode unit, and the KV9-2T limit switch in the governor.

To keep cavity oil from thickening, the fine-pitch oil is continuously renewed with hot engine oil — cold oil drains from cavity B through a diaphragm nozzle and from the lock channel through the centrifugal-lock spool gap. Oil in the tank's feathering compartment, hoses, and pump can also thicken in cold, degrading the system, so a circulation hole and check valve in the governor selector valve route hot pump oil through the hoses and pump back to the tank at 2–4 L/min at normal temperature.

Propeller feathering signal lights and manual control levers on the central console

REMOVAL OF BLADES FROM THE FEATHERED POSITION

Unfeathering is manual only, by pulling and holding the KFL-37 button until the blades reach working angles. This switches on the contactor and the governor's unfeathering solenoid valve and de-energizes the stop valve; the feathering pump (with lamp) supplies the selector valve, whose spool passes oil to the filter and on to the unfeathering valve, feeding cavity B to bring the blades out while oil also opens the hydraulic lock. Unfeathering goes only to the intermediate stop unless the stop is also removed; on the ground the blades are usually brought to the start angle by setting the central-panel stop-removal switch to "Propeller removed from stop" as the button is pulled. The propeller then behaves as in pitch reduction, cavity-A oil draining to the crankcase; the button is released and the switch set to "Propeller on stop" on completion. Removal takes ≤20 s.

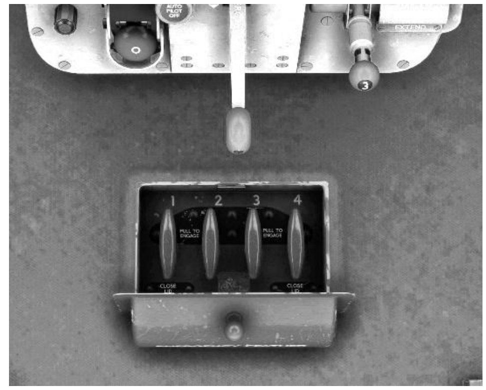
FEATHERING PUMP

The feathering pump creates up to 65 ± 10 kgf/cm^2 in the governor channels and propeller cavities for feathering and unfeathering, comprising an electric motor and a gear pump with a reducing valve and a heating valve. Off, the heating valve is spring-seated and hot circulating oil passes through its sleeve holes; on, the pumped oil's rising discharge pressure pushes the valve off its seat, closing the heating holes, and at 65 kg/cm^2 the reducing valve bypasses excess oil from discharge to suction. Leaked oil between the motor seals vents to atmosphere.

EMERGENCY NITROGEN FEATHERING AND ENGINE-STOP SYSTEM

This system feathers the propellers and stops the engines if the pump-driven systems fail, comprising a nitrogen cylinder, the EM-80 electric gauge, four emergency feathering valves, four sumps, and the governor and command-fuel-unit spools. The cylinder (max 65 kgf/cm^2, like the emergency-braking cylinder but without external wire wrapping) is protected by a charging-line check valve, its pressure read on the EM-80 (sensor by the cylinder, indicator on the left panel).

The feathering valves admit nitrogen to the R-68DT feathering-input valve and the KTA-5F engine-stop spool, worked by floor handles behind the central console (each with a rack and sprung latch) and cable rigging on rollers under the floor. The rigging carries 17.3 mm of deliberate slack — with a tensioning spring — so temperature-driven length changes cannot feather a propeller by accident. Pulling a handle fully opens its valve, sending nitrogen to the engine-stop spool (cutting fuel) and to the feathering-input valve, which connects the governor pump to the coarse-pitch channel; the propeller mechanism then behaves as in a normal move to coarse pitch.



Emergency feathering levels between the pilots' seats

CHAPTER IX - PRESSURIZATION, HEATING, AND VENTILATION SYSTEM

MAIN DATA

The high-altitude equipment keeps crew and passengers comfortable on high-altitude flights and comprises the pressurization, heating, and ventilation system plus the oxygen equipment, the latter sustaining life if the cabin depressurizes at altitude. The pressurization system holds raised pressure, normal temperature, and adequate air purity in the cabin. Air is bled from all four engine compressors at 2500–3900 kg/h; the amount rises as temperature falls (denser air) and falls as altitude rises (lower compressor pressure), altitude having the larger effect — so the supply nears 3900 kg/h low down and 2500 kg/h at the design altitude. The system still supplies enough air with two engines failed, and its main units are duplicated for safety. It divides into a hot line, a ventilation system, passenger- and crew-cabin heating systems, and a canopy-window blower line.

HOT LINE

Air enters the hot line from the engines' tenth compressor stages at up to 280 °C, through eight non-return valves, two shut-off valves, two absolute limiters, four metering tubes, and temperature-compensated pipelines into a common manifold. Most goes to the ventilation system; the rest, through metering tubes, blows the TG-16(M) turbogenerator and the water/sewage panels, mixes into the heating systems, and blows the canopy windows. Four non-return valves (in the main bays) stop air flowing from a running engine's compressor to a stopped one; two (in the electrical bay, frames 24–26) prevent leakage on upstream failure; one at frame 32 stops cabin leakage on outside-unit failure; and one at frame 4 stops hot-line leakage if the right duct loses pressure.

The shut-off valves switch the whole system on and off via electric mechanisms with no intermediate position, worked by “Air supply from engines”/“Off” switches on the right-console system panel, with limit switches and two red “Signal — supply off” lamps that light when the valves close. The absolute pressure limiters hold a constant absolute pressure in the supply line so the metering tubes, mixing flaps, and turbo-cooler work correctly, a command bellows maintaining the constant pressure that the heating mixing flaps and the uniform blowing of windows, panels, and turbogenerator depend on.

CABIN VENTILATION SYSTEM

The ventilation system supplies fresh air to every seat, crew station, restroom, and the buffet-kitchen for ventilation and pressurization. Air is cooled in an air-to-air radiator (outside air drawn by ejectors) and a turbo-cooler. The radiator's cooling depends on the purge-air temperature and — since cruise speed is a near-constant 600–650 km/h — mainly on ambient temperature, its outlet running about 40 °C above ambient, usually −16 to +85 °C; cabins are ventilated above 15 °C outside. In the turbo-cooler, air accelerates and cools through the guide vanes and gives up kinetic energy to the turbine, dropping up to 50 °C (25 °C at 10,000 m); its cooling stays constant to about 6000 m while inlet pressure holds, then falls as compressor pressure drops.

The URVK-18 flow indicator (right panel) reads cabin air supply in conventional units — normally 3.6–5.8 — each unit being 625 kg/h, sensed by a Venturi tube in the unpressurized fuselage between frames 28 and 29. An MPK-8 electro-mechanism positions the dampers to mix cold and hot air, shown on a “Cold/Warm/Hot” dial, controlled automatically by the RTA-16-6 regulator (a 0–55 °C setter, usually set to 15–20 °C) or manually by a four-position switch (neutral, “Automatic,” “Hot,” “Cold”).

BYPASS DAMPER UNIT (AUTOMATIC CONTROL)

When the air behind the turbo-cooler drops below the set value, the P-2 sensor signals the MPK-8 to open the bypass damper, routing air around the turbo-cooler so its outlet temperature rises, and in the limit shutting the turbo-cooler down. If the temperature still has not risen, a further damper mixes hot-line air into the radiator air, the blended flow bypassing the turbo-cooler into the cabin; above the set value the dampers reverse. Individual nozzles deliver air to crew stations, seats, the buffet-kitchen, and restrooms.

PASSENGER CABIN HEATING

The heating system holds +15 to +20 °C and, in warm weather, can serve as general ventilation with the hot-air mixing damper closed; supply air is normally 15–80 °C. The mixing damper is controlled manually (a switch like the MPK-8's) or automatically by a thermostat (dial 16–25 °C) and a bimetallic limiter — which signals to stop opening the damper at 80 °C inlet air and to close it at 110 °C, simultaneously lighting the red “Dangerous overheating” lamp.

WINDSHIELD HEATER

The canopy defrost line prevents fogging and inner-surface freezing, using a shut-off valve, metering tube, silencer, and pipelines. Most of its air comes from the right ventilation duct (no hotter than 20 °C), with hot-line air mixed in when the valve opens, giving 20–100 °C; a regulator or turbo-cooler failure can push it above 100 °C, so its temperature is checked periodically in flight.

Windshield heater and heater test control on the pilot’s overhead panel

AIR CIRCULATION IN THE PRESSURIZED CABIN

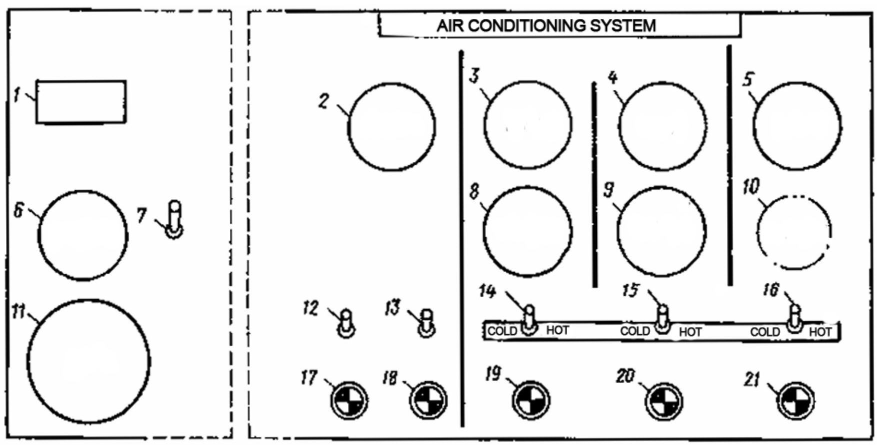
Air enters through the ventilation, heating, and canopy-defrost systems — cold air from above, warm from below — mixing for a uniform vertical temperature. Cabin air passes to the baggage and cargo holds through perforated tapes under the luggage shelves, warming the cabin walls behind the trim and insulation (eliminating cold radiation) before exhausting overboard through two automatic pressure regulators. A check valve at frame 4 lets crew-cabin air pass into the passenger cabin normally but closes on crew-cabin depressurization to protect the passenger cabin.

PRESSURE REGULATION

Two automatic regulators control cabin pressure to a set law. From the ground to 5000 m the differential rises from zero to 0.5 ± 0.02 kg/cm^2 and then stays constant at all higher altitudes; the cabin holds 760 mm Hg to 5000 m, after which the cabin “altitude” rises — reaching about 1500 ± 300 m at 8000 m and 2500 ± 300 m at 10,000 m. In each regulator, cabin air bleeds into a command cavity through a high-resistance nozzle so that cavity sits at 760 mm Hg; the pressure difference bends the actuating-valve diaphragm to expel exactly as much air as the engines supply, holding 760 mm Hg to 5000 m, above which the overpressure assembly takes over (holding the 0.5 kg/cm^2 difference) and the absolute assembly switches off. The three-way valve must be turned fully clockwise, locked, and sealed for normal operation.

Safety valves vent the cabin if the regulators fail, when landing at a low-pressure airfield, or admit air during rapid descent. Landing where atmospheric pressure is below 760 mm Hg requires dumping the cabin overpressure or the doors will not open: a solenoid (dump) valve vents the relief-valve cavity so cabin overpressure pushes the diaphragm off its seat and air escapes. Its switch on the right panel has “Closed” (in flight) and “Open” positions, with a “Depressurization” breaker on the engineer's panel. During rapid descent the same valve works as a vacuum valve, admitting atmospheric air — even a small negative differential is dangerous, since the cabin is not built for it and could be crushed. Two safety valves sit beside the automatic regulators on the cabin exhaust lines.

MONITORING AND CONTROL



Control devices and switches for controlling the boost, heating, and ventilation systems

1) warning panel – **2)** temperature gauge of air going to defog the cockpit canopy glass TUE-48 – **3)** air temperature gauge in the cockpit TV-19 – **4)** air temperature gauge in the passenger cabins TV-19 – **5)** ventilation gauge of cabins and TV-11 cabins – **6)** "height" and pressure difference gauge UVPD-20 – **7)** pressure relief switch (cabin depressurization) – **8)** air temperature gauge in the cockpit heating system TUE-48 – **9)** air temperature gauge in the passenger cabin heating system TUE-48 – **10)** temperature setter in the ventilation system ETA-7 – **11)** air flow gauge URVK – **12),13)** pressurization system switches – **14),15),16)** switches for switching from automatic to manual regulation of air temperature in the heating and ventilation systems – **17), 18)** lamps signaling the position of the shut-off valves – **19), 20)** lamps signaling air overheating in the heating systems – **21)** lamp signaling the set temperature behind the turbo-cooler.

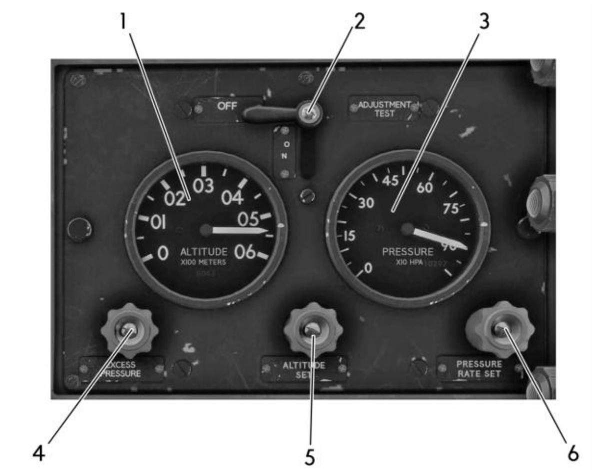
Control covers air temperatures (passenger and crew cabins, their heating systems, ventilation, and the canopy defrost line), cabin air supply, cabin “altitude,” the differential, and the rate of pressure change. Two electric gauges read cabin temperatures (P-9 sensors at frames 4 and 48, normally 20 °C, 15–20 °C under automation); two read heating-system temperatures (P-1 sensors at frames 4 and 34, 15–80 °C normal, 20–110 °C under automation); one reads ventilation temperature (behind the turbo-cooler, 15–20 °C); and one reads the canopy-blower temperature (≤100 °C). The UVPD-20 combined gauge shows cabin “altitude” (in meters) and the differential (in kg/cm^2, with a red danger sector for negative differentials), and the VR-10 variometer shows the rate of “altitude” change (normally 2–3 m/s).

A depressurization warning uses the BC-46 sensor (right console), which trips when cabin “altitude” rises to 3000 m, lighting two red “Dangerous Depressurization” panels, a flight-attendant lamp, and a buzzer (silenced by the “Depressurization Buzzer” switch). On the ground the cabin microclimate depends on ambient temperature, so ground conditioners supply 15–20 °C air before boarding, with the relief valves opened via the “Ventilation Valves” breaker and switch.

PRESSURIZATION, HEATING AND VENTILATION SYSTEM OF THE IL-18D AND IL-18E AIRCRAFT

Compared with earlier series, the Il-18D/E system adds a new cabin pressure-regulation system, an autonomous temperature-regulation system for the rear cabin, per-engine hot-line flow limiters, metering-tube and exhaust-grille critical sections enlarged 30% for the higher supply, purge air for the temperature regulators, a rearranged right console and pilots' panel, and new hot-line sealing rings. Regulation resembles the Il-18V's except that the cabin's initial pressure equals the departure airfield's atmospheric pressure, held constant until the cabin overpressure reaches its calculated value.

Before take-off, panel handles set the cabin altitude at which regulation begins, the excess pressure, and the rate of pressure change. For rapid ground depressurization, the overpressure selector is set to zero or the “Pressurization–Depressurization” switch to “Open”: the command-device bellows compresses and opens its valve, dropping the pressure in the command cavity and the exhaust-valve upper cavity, so the exhaust-valve diaphragm opens and the cabin depressurizes rapidly.



Cabin pressurization control panel

1) cabin altitude gauge – **2)** main Pressurization system switch – **3)** preset cabin pressure gauge– **4)** cabin altitude setting – **5)** cabin altitude setting – **6)** pressurization rate setting

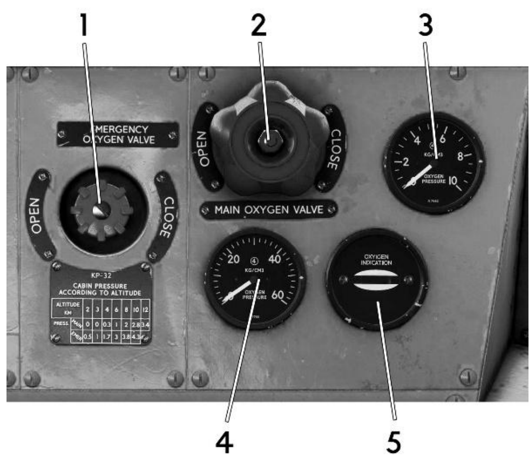
Cabin depressurization valve switch on the right-side pilot panel

CHAPTER X - OXYGEN EQUIPMENT

MAIN DATA

The oxygen equipment supplies the crew if the cabin depressurizes and the passengers under normal conditions if needed; for safety, one pilot must wear an oxygen mask continuously above 4000 m. It consists of a stationary system for the crew and ten portable KB-3 cylinders for passengers. The stationary system comprises two oxygen cylinders, three oxygen devices, six indicators, six masks, a valve, pressure gauges, and a charging system. Each cylinder holds 36 L at 30 kg/cm^2 and is installed in cargo compartment No. 1 on the starboard side.

The pulmonary-type oxygen devices meter oxygen to the pilots' masks, automatically adjusting the oxygen percentage in the gas mixture as altitude changes, with the supply watched on the indicators. A separate device feeds the navigator, radio operator, flight engineer, and flight attendant, supplying oxygen only when the flight altitude exceeds the cabin “altitude” — so under normal conditions (cabin “altitude” above flight altitude) no oxygen flows, though it can be turned on at the device tap if needed. Each crew member's device, mask, and indicator are at their station, with the shared device, gauges, and valve on the right panel; opening that valve feeds oxygen through the devices to the masks. The portable passenger cylinders, with their devices, masks, and gauges, are stored in the service compartment on the left of the front vestibule.



Installation Diagram of the Oxygen System

1) emergency oxygen valve – **2)** valve KV-5 – **3)** manometer MK-13M – **4)** manometer MT-60 – **5)** engineer's oxygen indicator IK-32

CHAPTER XI - AIRCRAFT FIRE PROTECTION

ENGINE NACELLE FIRE PROTECTION SYSTEM

Nacelle fires are suppressed by filling the engine and exhaust-pipe compartments with an inert gas that excludes atmospheric oxygen. The agent is Composition 3.5 — bromoethane and dehydrated carbon dioxide (the actual inert gas) plus chloroform, added to slow bromoethane's oxidation of aluminum-alloy parts — effective from +60 to −60 °C. The system is two identical halves (left and right nacelles) joined by a ring pipeline; each has three OS-8M extinguishers, a check valve, four electromagnetic distribution valves in a block, six spray manifolds, pipelines, and the SSP-2A signaling and control system.

Each OS-8M extinguisher stores Composition 3.5 plus nitrogen to expel it, at 85 ± 5 kg/cm^2 at 15 °C (air is prohibited as it corrodes the cylinder). The steel cylinder is wire-wrapped (to contain fragments if it bursts) and phosphated inside, with a GZSM arrester carrying a safety membrane, a pressure gauge, and the outlet. The spherical brass membrane ruptures at 200 ± 20 kg/cm^2, venting the agent through a signal eye on the nacelle's right side and knocking out its self-discharge disc — a missing disc indicating a self-discharge, identified by gauge. A pyrotechnic cartridge releases the valve latch to fire the extinguisher, and a 0.3 mm relief hole in the third-nacelle pipeline bleeds any leakage that could otherwise stop the electromagnetic valves opening. The extinguishers, clamped to nacelle frame No. 1 for easy removal, form two queues: the three left units are first queue for the left engines and second queue for the right, and vice versa — a second queue firing only if the first fails to extinguish.

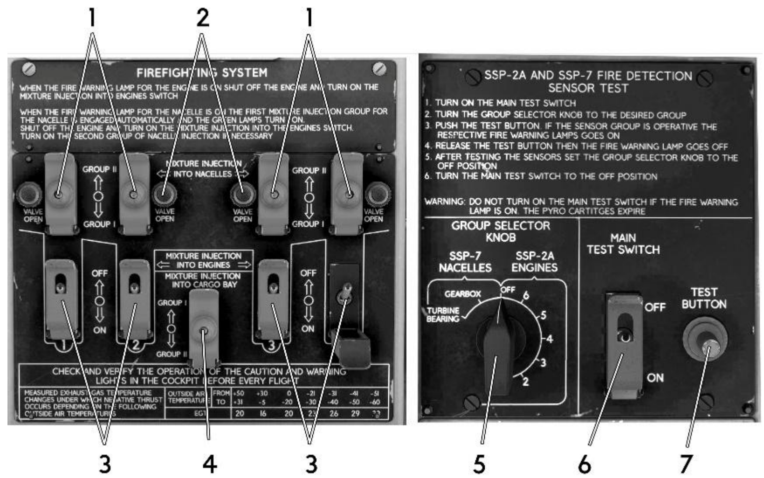
Poppet-type non-return valves prevent agent from the working second-queue extinguishers draining into empty first-queue ones. The electromagnetic distribution valves (two per nacelle, firing together for redundancy, in a common four-valve block) route agent to the inner or outer nacelle, opened by an electromagnet; their limit switches then arm the first-queue squibs and light a green valve-open lamp on the fire panel above the canopy windows. The squibs fire only after the valves open, since otherwise the agent pressure would hold the valves shut against the electromagnets. Steel ring spray manifolds (two in each engine compartment, one in each exhaust-pipe compartment) with wall holes disperse the agent; all system parts are painted red.

SSP-2A SIGNALING AND CONTROL

Fire signaling is light and sound: four red “Fire in nacelle 1–4” panels (two per instrument panel) and a right-console siren (silenced by a switch). The system is automatic and manual — only the first queue is automatic, both queues manual. Automatic control uses fire sensors in the engine and exhaust-pipe compartments, in six groups per nacelle (five engine, one exhaust), the system staying operable if a group fails. Each sensor has series chromel-copel thermocouples with low-inertia junctions above and high-inertia below, so a rapid temperature rise heats the low-inertia junctions faster and produces a fire-signal EMF. Manual control uses four panel switches (neutral, “1st stage,” “2nd stage”), the neutral position latched by a cover. Landing gear-up automatically fires agent into the inner nacelles, triggered by shear-bolt limit-switch mechanisms on the rear main struts — inner-engine fire being likelier than outer because the inner engines sit lower due to wing dihedral.

OPERATION

To arm, switch on the four “Fire Suppression” breakers (navigator's panel) and the “Fire Protection Signaling” breaker (engineer's panel). On a fire, the nacelle panel lights, the siren sounds, and the burning engine's two electromagnetic valves open — their limit switches lighting the green lamps and firing the first-queue squibs. The crew should simultaneously feather the propeller, shut down the engine, and close the fuel valve. Restarting the engine in flight after a fire is prohibited. Afterward the valves are closed — manual switches returned to neutral, or, after automatic first-queue use, closed automatically as the sensor de-energizes the solenoids.



Fire protection system control panel on the overhead panel

1) fire protection system switches for engine nacelles - **2)** lamps for signaling the opening of distribution valves - **3)** fire protection system switches for engines - **4)** fire protection switch for cargo bay - **5)** rotary system selector switch - **6)** main system health check switch - **7)** system health check button

ENGINE FIRE SUPPRESSION SYSTEMS

These extinguish fires in the oil cavities of the compressor and turbine bearings and in the front-casing cavities. Each engine has its own identical system of two extinguishers, a shut-off valve, two diaphragms, a nozzle, pipelines, and the SSP-7BIS signaling system. Each extinguisher is a 2 L spherical cylinder (lock like the OS-8M's) charged with Composition 3.5 or Freon and nitrogen at 85 ± 5 kgf/cm^2 at 15 °C, with a mesh filter at the outlet. The two units mount on nacelle frame No. 1 (one right-front, one left-rear) with insulating covers, the left also air-blown for cooling, and a self-discharge disc on the nacelle's left side.

The shut-off valve directs agent into the bearing cavities while blocking their scavenge line: in operation the agent pressure pushes the spool down, and at rest a spring raises it so the cavities vent to the centrifugal breather. Diaphragms at the engine inlet and before the valve keep oil vapor out of the system and rupture under agent pressure when it fires. Four red “Fire in engine 1–4” panels (beside the nacelle panels) signal an internal fire from two sensors per engine (front crankcase and the agent inlet line), the sensors like the nacelle ones. Manual control is an “Off”/“On” switch (latched off by a cover). The systems can fire on an internal-engine fire, a nacelle fire, spontaneous feathering and shutdown in flight, or before a gear-up landing (all four firing after shutdown); on an internal fire the pilot switches on the affected engine's system after the warning.

FIRE PROTECTION SYSTEM OF THE TG-16M TURBOGENERATOR UNIT

The TG-16M turbogenerator that starts the engines sits in cargo compartment No. 3, isolated by a titanium-alloy cowl. Its system is two OS-2GIL extinguishers, two spray manifolds, pipelines, and an SSP-2A system, the extinguishers along the fuselage sides with a self-discharge disc low on the left. A red “Fire TG-16” lamp (left panel) signals a fire; control is automatic (first stage only) and manual (both), from two sensor groups in the compartment.

The left-console switch has neutral (“Automatic”), “I stage,” and “II stage” positions, with an orange “Fire occurred” lamp that lights after a fire to warn against restarting the unit. On a fire the sensor lights “Fire TG-16” and fires the first stage, and simultaneously stops the unit and closes its air-intake damper, cutting the compartment air supply. The first stage is duplicated by setting the switch to “I stage”; if the lamp does not go out within 6 seconds, the second stage is fired.

CHECKING OF FIRE-FIGHTING SYSTEMS

The nacelle and engine systems are checked with the main test switch, the rotary test switch, and a button on the nacelle panel: with the four “Fire Suppression” breakers and the main switch on, the test switch is positioned and the button pressed — healthy SSP-2A sensors light all four nacelle lamps and the siren, healthy SSP-7BIS sensors light the engine lamps. Any lamp that fails to light, or stays lit after release, indicates a fault. The main switch is moved only with the test switch off, or the system could fire. The TG-16M system is checked with the “Check SSP-2A and lamps” switch set to “Group I” then “Group II,” both lighting the “TG-16 Fire” and “Fire Occurred” lamps if healthy.

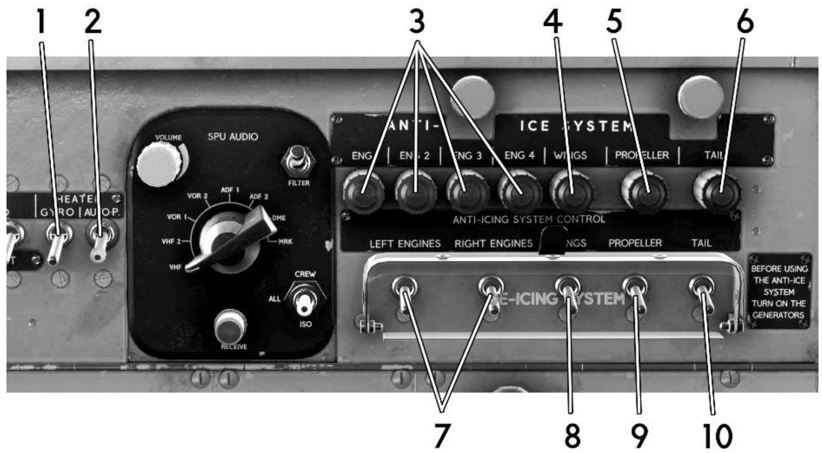
FIRE EXTINGUISHING SYSTEM OF THE Il-18D AIRCRAFT

The Il-18D adds a system for tank zone No. 12 — two electromagnetic valves, three spray manifolds, and nine sensors (four on the front spar, five in the high-altitude equipment compartment). Agent comes from the nacelle extinguishers, discharged in two stages (the first automatic or manual, the second manual only). The cockpit panel has a green valve-open lamp, a manual switch, and a red tank-compartment fire lamp.

CHAPTER XII - AIRCRAFT ANTI-ICING SYSTEMS

GENERAL INFORMATION

The aircraft protects the wing, tail, propeller blades and spinners, cockpit windows, engine air intakes, and compressor guide vanes. All devices are thermal — the surfaces are heated above freezing so ice cannot form and existing ice melts and blows away. The wing, tail, propellers, and windows are electrically heated, while the intakes and guide vanes use hot air bled from the compressors. Icing in the intake ducts is signaled by detectors that light two red “Icing” panels.



Aircraft de-icing control panel

1) gyro heater switch – **2)** autopilot heater switch – **3**) engine intake heater function indicator lamps – **4)** wing heater function indicator lamp – **5)** propeller heater function indicator lamp – **6)** tailfin heater function indicator lamp – **7)** engine intake heater switches – **8)** wing heater switch – **9)** propeller heater switch – **10)** Tail heater switch

The icing detector is a differential-pressure gauge with dynamic- and static-pressure chambers linked by a jet: the static chamber vents through side openings and the dynamic through axial openings, maintaining a pressure difference. When ice blocks the axial openings the pressures equalize through the jet, closing the “Icing” panel and detector-heater circuit; the heater melts the ice, the openings clear, and the restored difference breaks the circuit — so in icing the panel cycles on and off, confirming normal operation. A visual indicator — a profiled strut below the canopy on the right, marked with black stripes every 10 mm — lets the crew judge icing intensity by the ice thickness.

WING ANTI-ICING DEVICE

The wing device protects the leading edge, powered by 27 V DC. Heating is cyclic to save power: the wing sections' total calculated 140 kW falls to 35 kW (four times less) with cyclic supply, because the thin ice layer that periodically forms — without disturbing the aerodynamics — greatly reduces heat loss to the airflow, so far less energy is needed to shed it. Heating elements run the full span, separated by 20 mm unheated gaps; each is two brass busbars with soldered 0.15 mm constantan wire, laid more densely at the front and edges so ice melts and sheds there first. The element is insulated by two fiberglass layers from the outer skin and three from the inner. Each half-wing's elements form four sequential sections numbered from the fuselage outward, working 1–2–3–4–1..., each on for 38.5 s and off for 115.5 s.

TAIL ICE PROTECTION DEVICE

The tail device (27 V DC, same heating elements as the wing) adds a “thermal knife” in the stabilizer nose — constantan wires along the full span that are powered continuously, not cyclically, to improve ice shedding from the whole stabilizer nose. Stabilizer and fin elements form four sections numbered from the fuselage to the end fairings, powered in sequence, with a green lamp paralleling the first sections. Operation matches the wing device, with a “Tail” switch and lamp on the anti-icing panel and a “Tail” breaker on the engineer's panel.

ANTI-ICING DEVICES FOR AIRCRAFT PROPELLERS

The propeller devices use 115 V AC, minimizing the rotating magnetic field's effect on the instruments. The blade heating element — a 0.10–0.12 mm steel conductive tape between one outer and five inner fiberglass layers — is set in a leading-edge recess under a rubber gasket and a leaf-shaped steel overlay (the rubber resisting wear and bonding the overlay, the overlay

resisting damage, erosion, and vibration). It covers about 60% of the blade length and 17% of the chord, omitting the tip where friction heating and centrifugal force prevent and shed ice. The hub element is the same design in 0.2 mm constantan tape, its ends brought to a panel fed through contact bolts with a plug connector so the fairing can be removed; blade and hub elements are in parallel, and the conductive tape is more reliable than wire.

Current reaches the rotating propeller through an engine-mounted textolite current collector and contact rings on the hub, via carbon brushes spring-pressed against the rings. Symmetric engines' devices work together: current flows for 38 s to engines No. 1 and 4, then 38 s to No. 2 and 3, cycled

by an electro-mechanism and switched by the “Propellers” switch. A green lamp (in the No. 1/4 circuit) and the engineer's-panel ammeters confirm operation. With the “Propellers and Fairings” breaker and “Propellers” switch on, the program mechanism feeds the contactor, which energizes the blade and fairing elements; the heated tapes melt the ice to a water film that, with centrifugal force and airflow, sheds it.

CREW CABIN CANOPY GLASS ANTI-ICING DEVICES

The canopy glasses use 115 V AC stepped up by transformers to 190, 208, 230, or 250 V — the varied voltage reflecting the difficulty of getting a uniform conductive-film thickness and hence resistance. Each heated unit is inner (8 mm), middle (12 mm), and outer (4 mm) silicate glass bonded with film in a duralumin frame; the inner and middle glasses are structural (taking cabin overpressure) and the outer non-structural, carrying the conductive film on its inner face plus a working and a spare thermistor. Control is automatic: the thermistors feed heating automatons that hold +35 ± 5 °C, the bridge unbalancing at 40 °C to open the circuit. “Glass Heater Left/Right” switches sit on the overhead panel and the “Window heating control” breaker on the engineer's panel; there is no operation signal, so heating is checked by hand.

ENGINE AIR INTAKE ANTI-ICING DEVICES

The intake devices are air-thermal, using hot air from behind the tenth compressor stages. Each comprises a thermal chamber (formed by nacelle frame No. 1 and the cowling nose skin, with partitioned inlet and outlet nozzles), an ejector, an electrically-driven throttle valve, and piping. The ejector lowers the supply-air temperature before the chamber: hot air accelerating through its nozzle drops the static pressure and draws comparatively cold air from under the cowling, mixing the flows to cut the temperature from 210–260 °C to 140–180 °C while increasing mass flow, saving hot air, and preventing chamber overheating. The throttle valve switches the supply on and off (“Open”/“Closed,” watched visually), and the stainless-steel pipelines fiberglass lagged.

With the two “Engine Anti-icers” breakers and the “Engine Intakes” switch on, the electro-mechanisms open all four throttle valves, their limit switches lighting four green lamps, and air through the valves and ejectors heats the cowling-nose thermal chambers; switching off closes the valves and extinguishes the lamps.

ANTI-ICING DEVICES FOR ENGINE COMPRESSOR GUIDE VANES

The guide-vane device is an electrically-driven shut-off valve (“Open”/“Closed,” inside a nozzle) and stainless-steel pipelines, all on the engine's right side. The “Engine” switch on the anti-icing panel opens all four valves, admitting tenth-stage compressor air to heat the vanes; there is no operation signal, and two “Engine Anti-icers” breakers sit on the engineer's panel.

CHAPTER XIII - ELECTRICAL EQUIPMENT

GENERAL INFORMATION

Electrical equipment is among the most important systems on the Il-18, most control, regulation, and drive functions relying on electrical units. Over 2000 electrical products are fitted, including 12 generators and converters, more than 100 instruments, 95 mechanisms and motors, over 330 relays and contactors, about 450 lamps, and more than 400 connectors. All must be reliable, vibration- and shock-resistant, and able to work at altitude and from −60 to +60 °C.

The main system is single-wire 27 V ± 10% DC with a 96 kW installed capacity — the single-wire scheme halving wire weight — chosen because most consumers run on 27 V DC and because the aircraft has electric de-icers. Eight STG-12TMO starter-generators (two per engine) start the AI-20A engines and then power the network. Their capacity comfortably covers all loads even in icing, leaving a 36 kW margin: one generator failing needs no load shedding, and six of eight still run the de-icers and everything else, while losing two engines or four generators requires shedding only non-essential loads (galley, main lighting) — and not even that if the de-icers are off. Hot starting with 20 batteries gives autonomous on-board starting (the first engine from batteries, the rest from batteries buffered by the running engine's generators), and three 12-SAM-28 batteries start the TG-16.

The second system is single-phase 115 V +6/−3% AC at 400 Hz from four SGO-8U synchronous generators (8000 VA each, not paralleled) and a PO-1500 converter: generators No. 1 and 3 feed the propeller and spinner de-icers at full power, No. 2 feeds the heated glass, instruments, and radio, and No. 4 is a backup for any failed unit. The PO-1500 powers two ARK radio compasses in flight, the radio on the ground with engines off, and AC consumers on the No. 2 buses. Two PT-1000Ts converters (main and standby, 1000 VA each) supply three-phase 36 V ± 5% AC at 400 Hz ± 2% to the pilot-navigation instruments, autopilot, heading system, artificial horizons, RPSN-2N radar, and ILS indicator.

Current protection in 411 feeders disconnects consumers on short circuits and dangerous overloads, matched to the wire cross-sections by their ampere-second characteristics to prevent overheating. The network is a closed (ring) centralized primary distribution system fed from two independent sources (left and right generator-and-battery groups), so consumers stay powered until the last source fails. There are four central distribution units (CDUs) in the nacelles and four distribution units in the fuselage, the latter fed from the inner-nacelle CDUs; an external-generator start uses a ShRA-800-10VK connector, and ground power connects to the rear ShRAP-500 socket, the plugs under the center section.

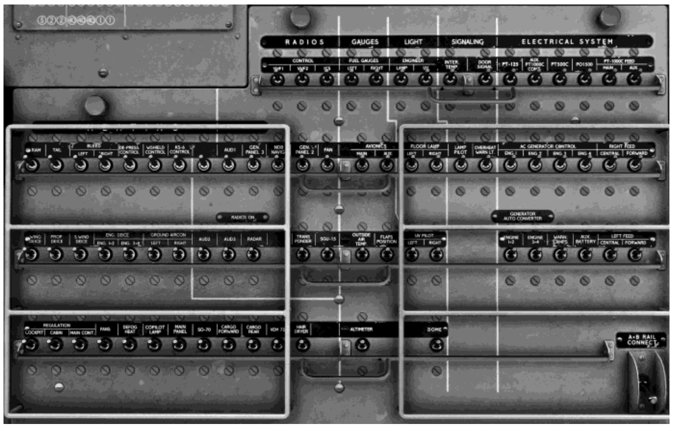
PLACEMENT AND FASTENING OF ELECTRICAL UNITS

The equipment is grouped by purpose — DC and AC power, engine and fuel, control, thermal, instruments, navigation, lighting, signaling, and household systems — much of it remote electro-mechanisms (engines, thermal systems, gear, flaps, trimmers). Most control, signaling, and monitoring units are in the cockpit on the instrument panel, pilots' electric panel, control wheels, consoles, and navigator's panel, with protection and supply units in the engineer's and navigator's central distribution boxes on the rear cabin wall and the flight attendant's box in the buffet.

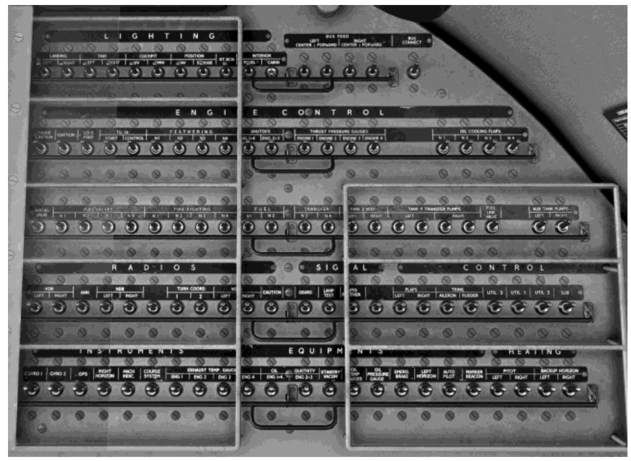
Network protection sits in the nacelle CDUs — inner ones on the starboard side in the main bays, outer ones low behind the oil cooler — with a tail distribution box (frames 65–68, starboard) for the tail units and an AC central distribution box on frame 24 in the electrical compartment. Where fitted instead of battery packs, the TG-16 turbogenerator sits in rear cargo compartment No. 3 on three rubber-damped mounts under a tension-locked titanium-steel casing, connected through a relay. The tail also houses the autopilot steering machines, tail light, the elevator-trim neutral limit switch, and the rudder and elevator locking mechanisms.

Flight Engineer's Central Distribution Panel

The engineer's central panel carries the power monitoring and control instruments in four panels: DC monitoring, DC protection, AC monitoring, and AC protection. The magnesium monitoring panels hang on rubber dampers and hinge open for wiring access; the protection panels below carry SP fuses and relays (AC) and circuit-breaker switches (DC). Breakers run in three horizontal rows, grouped by function with white dividing lines and stencils, each row with a common changeover bar to engage all its breakers at once. The panel also holds the breakers and instruments for the passenger and cargo compartments.



AC protection panel at the engineer's station



DC protection panel at the navigator's station

DC POWER SYSTEM

The DC sources are the eight STG-12TMO starter-generators and 10 or 20 12-SAM-28 batteries (or, on some aircraft, a TG-16 with three batteries for its start). Each starter-generator works with a DMR-400 differential relay, an RN-180 voltage regulator, a VS-25B remote resistor, and a BS-12000 ballast resistor, which together hold constant voltage, block reverse currents, and allow parallel operation. Generators of engines No. 2 and 3 feed the inner-nacelle buses, which link to the outer-nacelle distribution devices; the outer devices power their own engine's loads and pass the surplus to the inner buses, from which the fuselage distribution units are fed over two-channel lines protected at both ends.

Each distribution-unit bus is split into two parts joined by fuse or breaker protection, so consumers stay powered through any break or short of one of the four supply wires; a bus short disconnects only that bus, its loads distributed so the system keeps working from the other section. The inner-nacelle jumper and the dual-channel fuselage supply form a single energy ring powering all units until the last source fails — and if the jumper breaks, the remaining half-ring (left inner bus — fuselage buses — right inner bus) still feeds everything, its multi-channel nature surviving

one or two channel failures. Units that must work with the network dead — fire-fighting equipment, cockpit lighting, and the artificial horizon — are fed directly from the battery buses. The scheme also gives automatic 24-to-48 V transition at start (with the network protected from 48 V), automatic disconnection of generators in starter mode, a start interlock if only one ground socket is connected, failed-generator and socket signaling, and manual battery/socket disconnection.

CONTROL OF THE DC POWER SYSTEM OPERATION

The DC control panel carries eight A-2 ammeters (one per generator), an A-3 ammeter with switch for battery current, two B-1 voltmeters with switches, a battery voltmeter, and the failed-generator and socket lamps. The STG-12TMO is a six-pole brushless claw-pole machine that starts the engine in starter mode and powers the network in generator mode, switching automatically with engine speed; it can cold-crank on the ground from a socket at up to 400 A without oil pressure, with a cooling

fan for generator mode. The RN-180 regulator holds the set voltage, governs parallel operation and battery charging, and raises speed in starter mode, parallel operation using compensating windings, a saturation choke, and ballast resistors to produce a controlled voltage drop for stable load sharing; two differential relays sit in each nacelle CDU.

BATTERIES

The 10 or 20 batteries (24 V, 28 A·h each) are backup sources used to power the ground network at light load, check the radio and communicate before start, cold

-crank a hot engine (10 batteries), start autonomously (20 batteries), and connect automatically to the network. They recharge from ground power via the on-board source switch, with an ammeter for charge current and a voltmeter for voltage, each selectable to the left or right group; batteries connect only with the switches at “Batteries and socket” and the source selector at “On-board.” The ground-power switching panel is on the center-section front spar in the electrical compartment.

AC POWER CIRCUIT

AC is supplied as single-phase and three-phase. The single-phase side uses the four SGO-8U generators with regulating gear, the PO-1500 converter, and the ShRA-200LK ground connector. The generators are not paralleled — each on its own buses, one per engine — with
three carrying the load and the fourth in reserve; No. 1 and 3 feed the propeller de-icers and spinners, No. 2 the heated glass and radio. Each generator's gear is a KVP-1A switching box, a KRT-1 voltage-regulating box, a PMK-14 box, an RN-600 voltage regulator, and a remote resistor.

Switching a generator on triggers its KVP-1A, which energizes the excitation winding, connects the load, and clears the “Generator not working” lamp. On a generator or network fault the voltage drops sharply and the KVP-1A with the PMK-14 disconnect the generator after a programmed delay — long enough for the faulty consumer's fuse to blow, after which the generator keeps feeding the rest

and the boxes reset; if the voltage has not recovered by the end of the delay, the KVP-1A disconnects the generator and lights its lamp. The reserve generator can be switched in for any failed unit, lighting the “Standby generator working” lamp.

The PO-1500 converter — a DC motor and single-phase synchronous generator in one self-ventilated housing, with remote start, a radio filter, and automatic voltage/frequency regulation — powers the two ARK compasses in flight (two-wire), checks the radio on the ground, and backs up the 28G bus, fed from the No. 3 nacelle panel and switched on the engineer's AC protection panel. It connects automatically to feed either just the two ARK compasses (two-wire) or all 28G-bus consumers (single-wire) depending on the No. 2 AC generator; if it fails, the compasses revert to the AC generator on a single-wire circuit. Ground AC connects through the ShRA-200LK on the left fuselage, interlocked so a generator and ground power cannot be connected together.

Three-phase navigation power comes from the main and standby PT-1000Ts converters (front baggage compartment, frames 8–9, left and right), fed from DC buses 26A and 26B through breakers. Switching from main to standby — manual or automatic via the KPR-9 box — covers phase-to-phase and three-phase shorts, one-to-three-phase breaks, and a DC-supply fault, the box tripping with up to a 0.7 s delay so consumer protection clears its own line shorts first; the changeover lights the “Standby converter working” lamp.

CONTROL OVER THE OPERATION OF THE AC POWER SYSTEM

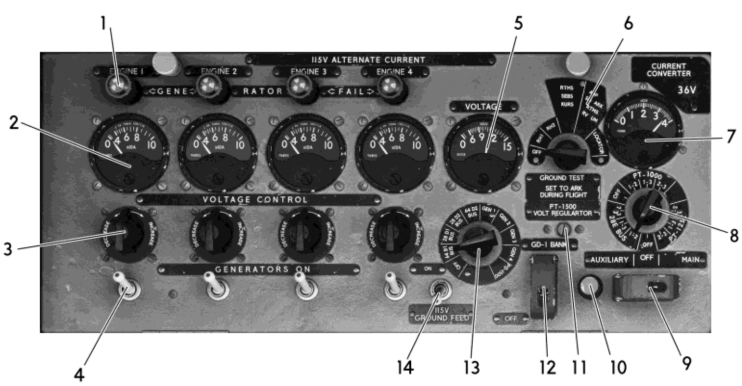
The AC control panel carries three AF-100 ferro-dynamic ammeters (via measuring current transformers) for the SGO-8U generators, a VF-150 voltmeter with switch for an SGO-8U or the PO-1500, a VP-46 voltmeter with switch for the working PT-1000Ts, and the generator-failure, standby-generator, and standby-converter lamps. The SGO-8U is a three-phase synchronous machine with independent DC excitation, its delta-connected AC winding on the rotor (slip-ring collection) and excitation on the stator, usable for single- or three-phase loads. Supporting boxes include the KVP-1A (switching and protection), the PMK-14 (automatic fault disconnection), the KRT-1 with the RN-600 carbon regulator (precise voltage control), and the KPR-9 (three-phase changeover); the ShRA-200LK ground connector is rated 115 V, 200 A with 100% overload.

NETWORK SUMMARY, RESTRICTIONS, AND REGULATION

The single-phase network runs in island operation, generators of engines 1–3 normally carrying the whole 115 V/400 Hz supply and No. 4 substituting for a failure, the automatic switch keeping full supply until two generators fail; the PO-1500 supplies the radio compasses and backs up the network, switchable between buses, the radar, or the HF station. Security comes from RN-600 voltage regulation, AZP-1SD overvoltage protection, KVP-1A undervoltage protection, and the automatic switch. The three-phase network runs from the main and standby PT-1000Ts (the KPR-9 switching to standby on a main failure, lighting its lamp), with a PT-125Ts as a manual emergency source.

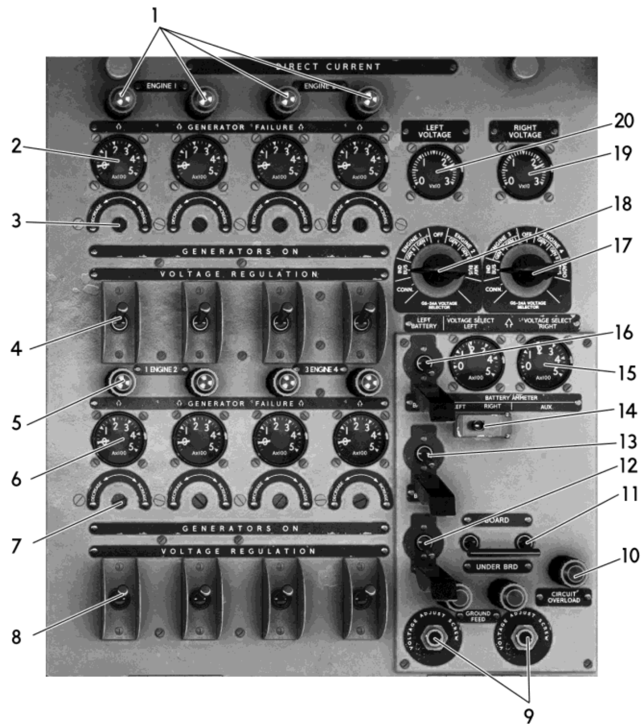
Key restrictions: a 27 V external source always uses the rear socket, the front being only for 2×24 V starting (permitted only if the auxiliary system is unrepairable, using a front 24 V/≥500 A·h set or a rear 27–30 V/≥34 kW generator). When the auxiliary system is running, the "On board/External" switch is moved through the middle without pausing, and the PT-125Ts must not run long on external power. The maximum permissible load difference between DC generators is 40 A. Before shutdown, battery voltage is checked (>24 V), non-essential loads are switched off, and the AC then the DC generators are switched off; the "On board/External" switch must not go to "External" with the batteries off before the engines stop. To regulate a DC generator, it is switched off (lamp on), its voltage set to 27.5–28 V on its rheostat, and after all are connected the mains is checked at 27–28.5 V — the more heavily loaded generator regulated down if loads differ by over 40 A, regulation done only after at least 30 minutes of running.

POWER CONTROL PANELS



Control panel of the AC electrical system

1) Fail lamp of the AC generators – **2)** Voltage gauges of the AC generators – **3)** Voltage regulators of the AC generators – **4)** main switches of the AC generators – **5)** Voltage indicator gauge for the AC voltage selector knob – **6)** Ground test voltage selector knob - **7)** Voltage indicator gauge for the current converter selector knob - **8)** Voltage gauge selector knob for the current converters – **9)** AC bus selector switch – **10)** **11)** voltage regulators – **12)** GD-1 bank switch – **13)** Voltage gauge selector knob for the AC voltage indicator – **15)** Ground AC feed switch



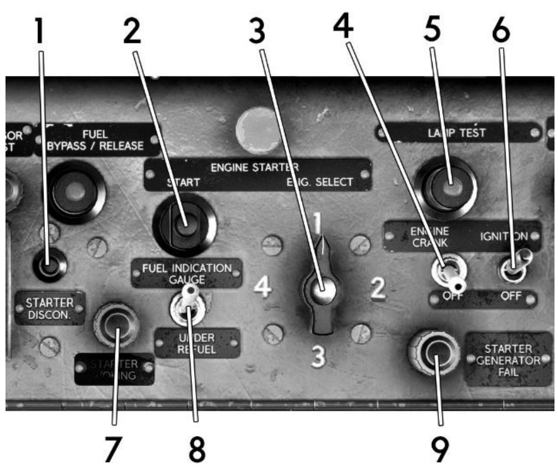
Control panel of the DC electrical system

1)Fail indicator lamps for DC generators 1, 2, 3, 4 – **2)** Ammeters for the DC generators – **3)** DC ampere regulator screws – **4)** Main switches for DC generators 1, 2, 3, 4 – **5)** Fail indicator lamps for DC generators 5, 6, 7, 8 – **6)** Ammeters for DC generators 5, 6, 7, 8 – **7)** Ampere regulator screws for generator 5, 6, 7, 8 – **8)** Main switches for DC generators 5, 6, 7, 8 – **9)** Voltage adjustments screws – **10)** Circuit overload indicator lamp – **11)** external power switch – **12)** Auxiliary DC battery main switch – **13)** Right DC battery main switch – **14)** DC battery ammeter gauge selector switch – **15)** Auxiliary DC battery ammeter indicator – **16)** Left DC battery main switch – **17)** Selector knob for the right voltage indicator – **18)** Selector knob for the left voltage indicator – **19)** Right voltage indicator gauge – **20)** Left voltage indicator gauge

ELECTRONIC COMPONENTS OF THE POWER PLANT

STARTING SYSTEM

The AI-20A turboprop has an electrical starting system for ground starting, cold cranking, in-flight starting, and starter cutoff. The engine is first spun up until the turbine produces enough power to drive the compressor, then accelerates on its own. The two STG-12TMO starter-generators, in starter mode, spin the rotor and accompany the engine to 4500–6400 rpm turbine speed, then revert to generator mode — the dual use giving large weight savings. Each engine carries the two starter-generators, two ignition coils and plugs, an electric-motor switch to disconnect the starters at 4500–6400 rpm, a starting fuel valve, and a propeller parking-lock mechanism.



1) engine starter disengage button – **2)** engine starter button – **3)** engine start selector knob – **4)** engine starter mode switch **5)** advisory lamp test button – **6)** ignition switch – **7)** engine starter function indicator – **8)** – fuel gauge source selector (INOP) – **9)** starter generator fail warning lamp

Layout of engine start controls on the pilots' left panel

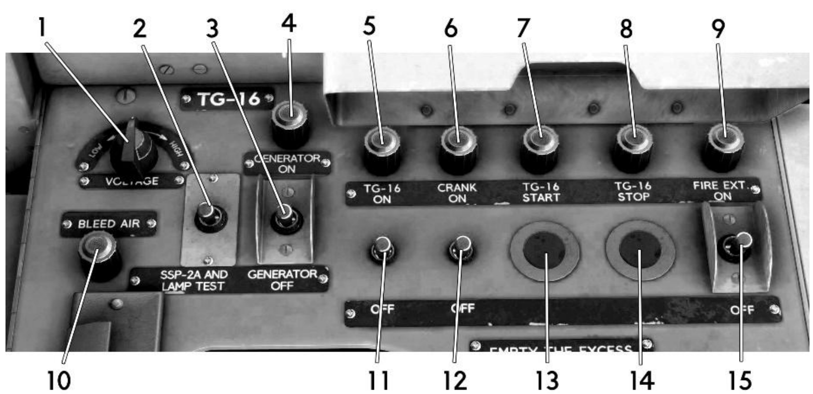
The left-panel start section has the main start switch, engine selector, cold-cranking switch, start button, fuel-bypass button, starter-disconnect button, the automatic-panel lamp, propeller-lock switches and lamps, and a lamp-test button; in-flight start buttons are on the central panel, and the automatic-start panel, starter-generator start panel, and start-relay box are in the electrical compartment (frames 24–26). Interlock relays prevent starting with only one ground socket connected or with the propellers feathered, and contactors switching starter power sit in the nacelle distribution devices.

STARTING FROM EXTERNAL POWER SOURCES

With ground power, the “On board/External” switch goes to “External” (isolating the batteries), relays then allowing a start only with two sockets connected and isolating the generator circuits. After switching on the pilots' panel and the main start switch, setting the cold-cranking switch to “Start,” unfeathering the No. 1 propeller, and selecting the start sequence, a brief start-button press energizes the start relays: the ignition fires the plugs, the starter-generators spin up smoothly, and at the 20th second a switch removes power from the stop valve so working fuel flows and ignites, the turbine taking up torque while the power regulator raises starter speed. At 4500–6400 rpm the electric-motor switch breaks the command-relay circuit and the program mechanism quickly disconnects the starter-generators.

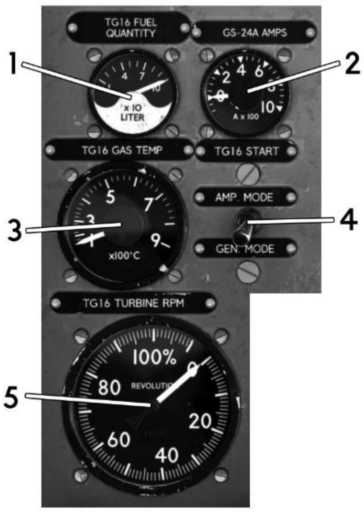
STARTING FROM AIRCRAFT BATTERIES

With 20 batteries the engines can start from the on-board batteries connected to the network (the ground panel permitted), the DC generator switches set to “On” so the running engine's generators connect automatically; after the first engine, the rest start from the batteries buffered by those generators, easing the batteries — otherwise identical to a ground-power start. Where fitted, the TG-16 turbogenerator (a gas-turbine engine, gearbox, generator, and start/control boxes, with three batteries in the center-section electrical compartment and its panel and ammeter/tachometer/thermometer on the left panel) is itself first started from the batteries: with the batteries on the network and the selector at “On-board,” pressing the TG-16 start button runs the PT-16A box's program mechanism through the interlock and intermediate relays to bring up the unit.



Layout of the TG-16 turbogenerator panel on the left side pilot’s panel

1) TG-16 power regulator – **2)** TG-16 fire detection test switch – **3)** TG-16 generator switch - **4)** TG-16 generator function lamp – **5)** power indicator lamp – **6)** crank mode indicator lamp – **7)** TG-16 starter operation indicator – **8)** TG-16 stop lamp – **9)** fire detection system indicator lamp – **10)** TG-16 bleed air available lamp – **11)** main TG-16 switch – **12)** crank mode - **13)** TG-16 starter – **14)** TG-16 stop – **15)** fire detection system switch



1) TG-16 fuel gauge – **2)** TG-16 generator amps – **3)** exhaust gas temperature gauge – **4)** TG-16 generator amp mode switch – **5)** TG-16 tachometer

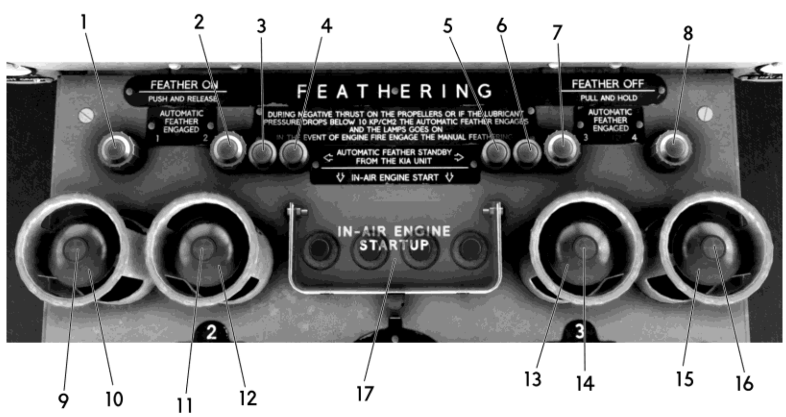
Monitoring instruments for the TG-16 turbogenerator on the left side pilot's panel

COLD CRANKING

For cold cranking, the "Cold cranking start" switch is set to "Cold cranking" with the engine-stop solenoid on, so no working fuel is supplied and the ignition and starting-fuel units stay off. The automation otherwise runs as in a normal start but only spins the cold engine; the RUT-600D regulators are not switched to 48 V, and the starter-generators are cut off at the 25th second. An interlock blocks the DMR-400 and prevents 48 V reaching the network during starting. Cold cranking lasts 30 seconds; with 10 batteries a hot engine can be cranked from the on-board batteries via the ground panel.

FEATHERING ELECRONICS

Feathering sets the blades to the angle of least drag for a stopped propeller, the blade angle changing from 83° to 0° with the propeller held at the 12° intermediate stop. The hydraulic stop at 12° keeps the blades from reaching 0° on a throttle reduction or engine failure (which would create large negative thrust); the stop is removed for starting, taxiing, and the landing roll, where 0° eases starting and braking. In flight, feathering is forced (manual) or automatic — AV-68I series 02/03 propellers having an all-mode system that feathers automatically through a relay system from three engine sensors, forced feathering possible on a running engine with simultaneous shutdown.



Controls of the propeller feathering system

1) Propeller 1 feathering engaged indicator lamp - **2)** Propeller 2 feathering engaged indicator lamp – **3)** Automatic feathering for propeller 1 standby indicator lamp – 4) Automatic feathering for propeller 2 standby indicator lamp – **5)** Automatic feathering for propeller 3 standby indicator lamp – **6)** Automatic feathering for propeller 4 standby indicator lamp – **7)** Propeller 3 feathering engaged indicator lamp – **8)** Propeller 4 feathering engaged indicator lamp – **9)** Power plant 1 fail indicator lamp – **10)** Manual feathering button for propeller 1 – **11)** Power plant 2 fail indicator lamp – **12)** Manual feathering button for propeller 2 – **13)** Manual feathering button for propeller 3 – **14)** Power plant 3 fail indicator lamp – **15)** Manual feathering button for propeller 4 – **16)** Power plant 4 fail indicator lamp – **17)** In-flight engine starter buttons

Each engine has four signal lamps: a red propeller-feathering/powerplant-failure lamp in the feathering button (lit by any auto-feather sensor or the negative-thrust signal, prompting a button press); a green feathering-pump lamp (lit when the pump contactor trips); a red lamp for pitch-lock-channel oil pressure below 12–15 kg/cm^2; and a red lamp for low-pitch-channel oil pressure above 20–25 kg/cm^2. Both red pressure lamps lit together mean the propeller is off the intermediate stop; the low-pitch lamp alone means the feathering system is faulty and the blades cannot be feathered manually or automatically, so emergency feathering is required. These indicators sit on the upper center main panel.

Pitch angle channel indicators on the main panel

CHAPTER XIV – LIGHTING

OVERVIEW

The Il-18 has four lighting systems: cockpit lighting; passenger-cabin and utility-room lighting; external aeronavigation and landing/taxi lights; and lighting of baggage and cargo compartments.

COCKPIT LIGHTING

Cockpit lighting is divided into general visible-light lamps and ultraviolet illumination of the instrument and control panels. The visible-light set is a ceiling light, cabin lamps, an exhaust lamp, and a hinged lamp. The ceiling light — a body whose inner surface is the reflector, with a single-contact lamp holder — gives general cockpit lighting, its circuit protected by a breaker on the on-board source panel in cargo compartment No. 3 so it works with the network dead, switched from the pilots' electric panel. The cabin lamps light the instrument and control panels with white light, one for each pilot on the left and right panels with its own switch; each is on a combined hinge allowing 360° rotation and tilt, with a spherical reflector and a rheostat to switch it and vary the brightness. Floor lights illuminate the navigator's and engineer's lower stations, working like the pilots' panel lamps.

Ultraviolet fixtures illuminate the instrument scales, whose phosphor-coated divisions glow under UV. Each fixture is a plastic housing with a socket, a mercury fluorescent lamp, and an aluminum reflector, with a rheostat to switch it and regulate the intensity. Two UV lights sit on the overhead panel, two on the left and right pilots' panels, and two at the navigator's and engineer's stations.

LANDING AND TAXI LIGHTS (WING AND TAIL LIGHTS)

The landing/taxi lights illuminate the runway and taxiways at night. Each has a dual-filament bulb, an extension electro-mechanism, a housing, a fairing, and fittings; four are fitted — on the lower forward fuselage left and right and at both wing ends. The reflector and front glass form a single evacuated bulb with two filaments (one for landing, one for taxiing) built into the housing; a burnt filament or cracked glass requires replacing the whole bulb. The extension mechanism deploys the light before it is switched on, with two limit switches setting the lower limit and stopping the mechanism when fully retracted.

The fuselage lights are worked by “Extend–Retract” switches and landing/taxi switches on the overhead panel, the wing lights by similar switches on the right pilot's panel. Power and control circuits are protected by breakers — fuselage-light breakers in the navigator's panel, wing-light breakers in the engineer's panel — with KM-25D contactors in the navigator's panel and the nacelle CDUs.

AERONAVIGATION LIGHTS

The aeronavigation lights are four wing navigation lights, two strobe lights, two rotating beacons (under the tail fuselage and atop the fin), and a tail navigation light, with relays in the nacelle CDUs. The circuit and the wing-light relays are protected by a breaker in the engineer's panel, the wing lights drawing from two CDU breakers; all are switched from the right side of the overhead electric panel.

END OF DOCUMENT

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