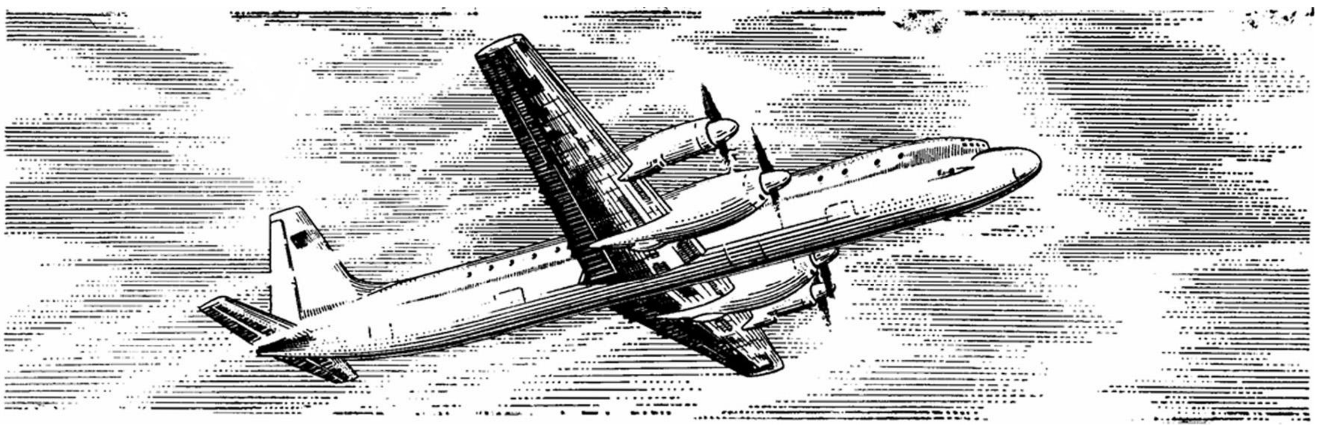
ILYUSHIN IL-18

Passenger and Cargo Aircraft

for Microsoft Flight Simulator 2024



TECHNICAL DESCRIPTION

PART 2 – PLACEMENT OF INSTUMENTS IN THE COCKPIT

by Nemeth Designs Aviation Bureau

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CHAPTER I - PLACEMENT OF EQUIPMENTS IN THE CREW COCKPIT

For study, cockpit equipment divides into several groups: the left and right pilots' instrument panels, the pilots' central console, the equipment on the right and left sides of the cockpit, the equipment on the ceiling above the pilots, and the equipment on bulkhead wall No. 4.

Note: this is a general overview. Exact layout and equipment type vary with the operator's needs; unit-specific differences are covered later.

CREW WORKSTATIONS

Both pilots' workstations sit symmetrically about the aircraft's longitudinal axis, so the equipment is largely placed on symmetrical structures. Everything the pilots must operate or watch is on the Main Instrument Panel, the Left and Right Consoles, the Overhead Panel, and the Central Console.

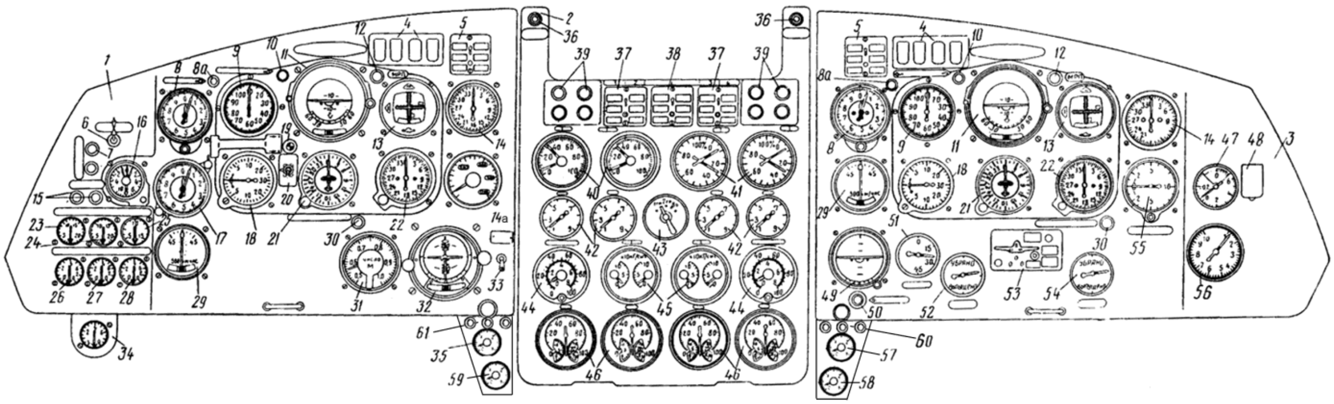
View of the front part of the cabin.

View of the cabin from the left side.

View of the cockpit from the starboard side.

MAIN INSTRUMENT PANEL

The panel is three flat magnesium-alloy panels on rubber shock absorbers: the two outer panels flip up for access, the middle one flips down. The left part carries hydraulic- and nitrogen-system monitoring instruments; opposite the left pilot are the main flight-navigation instruments (outlined in a white frame). The rest of the left panel holds warning lights, radio-compass and radio-altimeter indicators, a backup artificial horizon, a Mach indicator with MS-1 signaling, a turn indicator, etc.



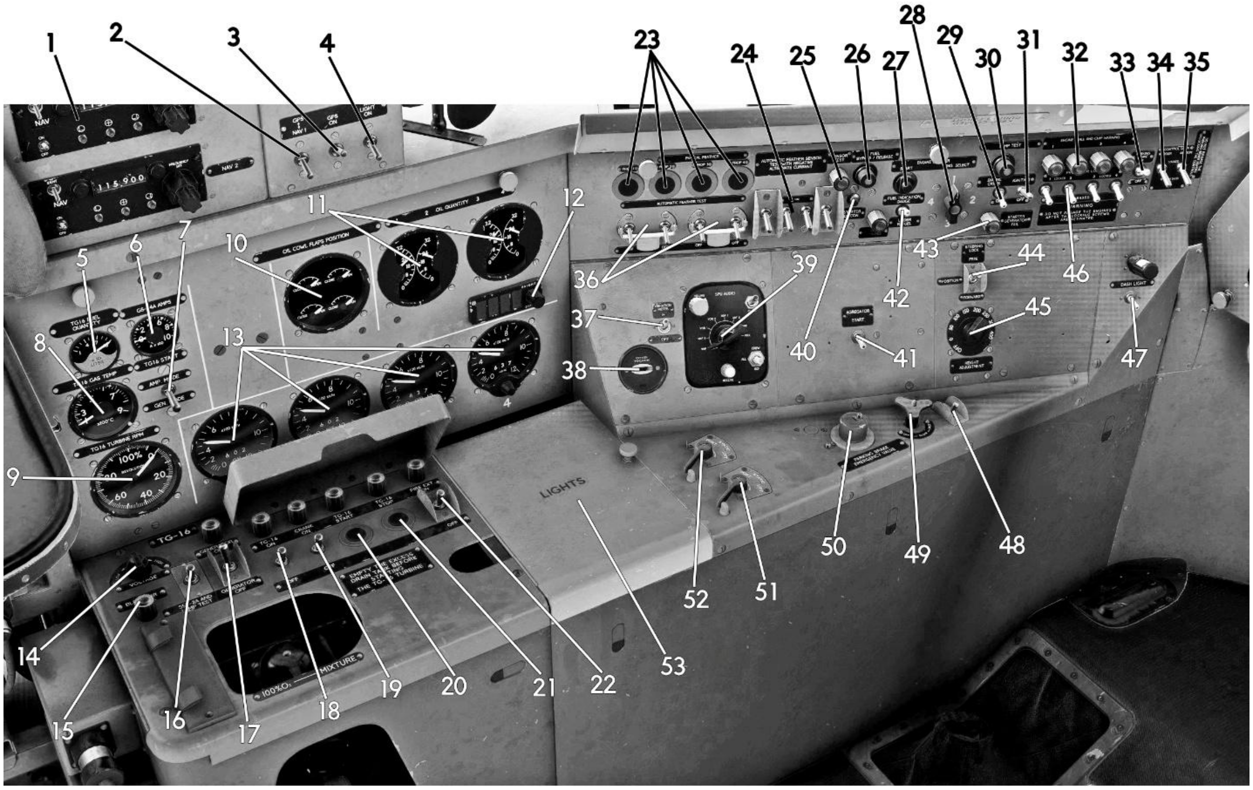
Main instrument panel

1) left panel – **2**) central panel – **3)** right panel – **4**) fire alarm lamps on engines No. 1 and 2 – **5)** panel with lamps signaling: icing, dangerous depressurization, loss of set altitude, exceeding M number, locked position of rudders and open hatches – **6)** braking automatic switch – **7)** braking automatic external and internal signal lamps – **8)** altimeter VD-10 (meters) - **8a**) "Attention" signal lamp from the radar set – **9)** speed indicator KUS-1200 – **10)** Overspeed warning lamp – **11)** attitude indicator AGB-2 – **12)** Low altitude warning from the radar altimeter set – **13)** NAV 1 course indicator – **14)** Nav 2 course indicator – **14a)** Radio altimeter - **15)** left and right hydraulic pump operation signal lamps – **16)** accelerometer AM-10 – **17)** Altimeter (feet) – **18)** variometer VAR-30-3 – **19**) signal lamp for switching on the reserve VK-53RB – **20)** VK-53RB switch from main to reserve – **21)** course and heading indicator – **22)** ADF indicator – **23)** manometer for 220 kg/cm^2 brake hydraulic accumulators – **24)** manometer for 220 kg/cm^2 general system hydraulic accumulators – **25)** manometer for 150 kg/cm^2 emergency braking cylinder – **26)** manometer for 80 kg/cm^2 left brake – **27)** manometer for 80 kg/cm^2 parking brake – **28)** manometer for 80 kg/cm^2 right brake – **29)** EUP-53 turn indicator – 30) signal lamp for unlocked rudder position – **31)** M number indicator with electrical signaling MS-1 – **32)** reserve attitude indicator AGI-1S – **33)** AGI-1S switch – **34)** manometer for emergency feathering cylinder – 35) ammeter for left engine group – **36)** PP-3 potentiometers from radar set – **37)** panel (left and right) with lamps signaling: minimum oil pressure, minimum oil residue and minimum fuel pressure – **38)** panel (middle) with lamps signaling: failure of boost pumps, transfer of additional tanks and 1000 kg fuel residue – **39)** autofeathering system signal lamps – **40)** UPRT-2 unit lever indicators – **41)** ITE-2 engine tachometers – **42)** TVG-26 exhaust gas thermometers – **43)** fuel tank group switch – **44)** SETS-280 fuel gauge indicators – **45)** 20-100 indicators from 2EDMU-100 set – **46)** EMI-3R three-arrow indicators – **47)** UVPD-20 altitude and differential pressure indicator – **48)** depressurization valve switch – **49)** UG horizon indicator from AP-6E autopilot set – **50)** TsGV button-arrester – **51)** UZP-47 flap position indicator – **52)** USH-48 left landing gear position indicator – **53)** PPS-2 signaling panel – **54)** USH-48 right landing gear position indicator – **55)** VR-10 cabin variometer – **56)** URVK flow meter indicator – **57)** V-1 voltmeter for DC 24V system – **58)** Voltmeter for the AC 115V system – **59)** ammeter for the right engine group – **60)** DC, AC system and PT-1000 fail warning lights - **61)** Lamps for smoke detector warning and release valves

LEFT CONSOLE

This console is designed for the aircraft commander (left pilot). It consists of several panels:

Front Upper Panel: Hinges downward. Contains engine start equipment, propeller feathering and wheels braking. It is covered by a duralumin lid during flight so as not to distract the pilot.
Front Slanted Panel: Removable panel containing cargo compartment aggregator, radio altimeter, oxygen indicators, and the SPU-6 intercom.
Front Horizontal Panel: Contains brake taps, windshield wiper controls, and barometric instruments.
Rear Vertical Panel: Shock-mounted. Contains various engine monitoring instruments. Below this is the generator control panel and a storage box for the pilot's personal items, maps, and oxygen masks.

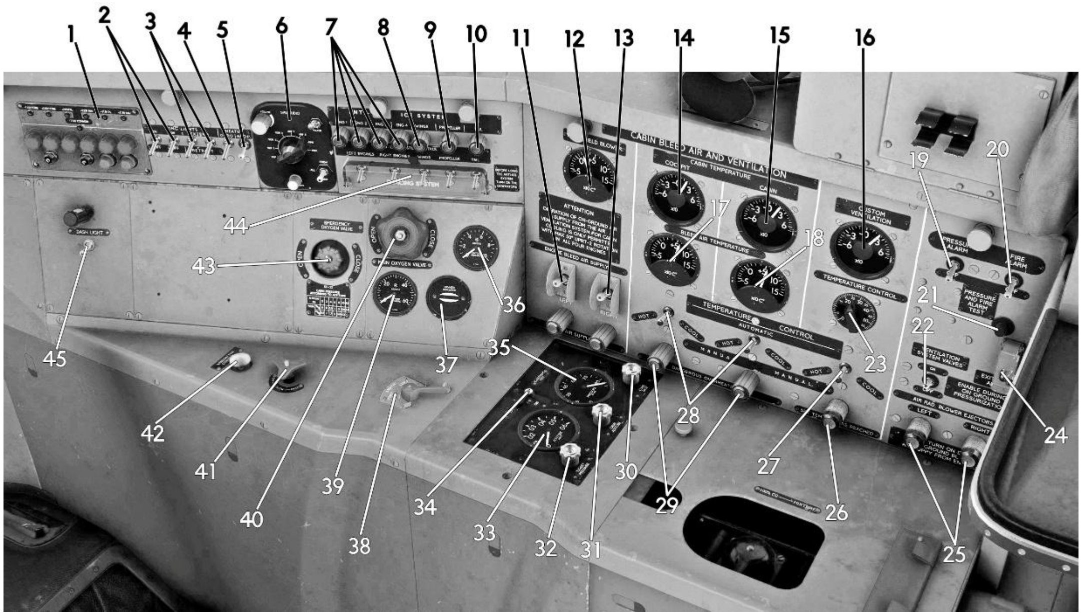


Left pilot console.

1) navigation radios - **2)** GPS/NAV selector switcj – **3)** GPS system switch – **4)** Light control selector switch – **5)** TG-16 fuel quantity – **6)** ammeter A-3 for TG-16 generator – **7)** A-3 ammeter mode switch – **8)** gas temperature indicator TST-29 – **9)** tachometer TE-40M (%) – **10)** oil cooler flap position indicator UIUZ- – **11)** oil gauge indicators MES-1897A – **12)** oil pressure warning lights - **13)** fuel flow indicators – **14)** TG-16 generator voltage regulator – **15)** TG-16 bleed air indicator lamp – **16)** SSP and lamp test switch – **17)** TG-16 generator switch – **18)** main TG-16 switch – **19)** TG-16 cranking switch – **20)** TG-16 starter button - **21)** TG-16 stop button – **22)** TG-16 manual/auto fire extinguisher mode – **23)** partial feathering buttons – **24)** auto-feathering main switch – **25)** auto-feathering sensor test lamp – **26)** fuel bypass switch – **27)** engine starter button – **28)** engine starter selector switch – **29)** engine start/crank mode selector switch – **30)** panel lamp test button – **31)** ignition switch – **32)** propeller locked position signal lamps – **33)** parking brake – **34)** rudder lock – **35)** aileron lock – **36)** auto-feathering test switches – **37)** vibration meter switch – **38)** oxygen indicator – **39)** audio panel – **40)** engine starter disconnection button – **41)** cargo auxiliary power – **42)** fuel indicator "refuel/onboard" mode switch – **43)** starter fail indicator lamp – **44)** steering lock mode – **45)** RV-2 height setter – **46)** propeller locking switches – **47)** pilots' rotational panel light - **48)** emergency wheel release switch – **49)** windshield wiper control – **50)** parking brake valve – **51) 52)** valves No. 623700M of the membrane-aneroid system – **53)** light control panel

Construction mirrors the left panel. The front upper panel carries anti-icing switching, the SPU-6 audio panel, and wing-landing-light controls; the front inclined panel, the crew oxygen-system control and the right pilot's oxygen indicator; the front horizontal panel, the windscreen-wiper valves, moisture-drain control, and membrane-aneroid system; the rear horizontal panel, RUF-O rheostats and a personal-items box (oxygen apparatus and masks inside). The rear vertical panel is the pressurization/ventilation control panel. Above it, on a removable bracket, are the door/hatch signaling system and the second pilot's light-control knobs. Inside the panel are units not needed in flight (siren, windshield-heater automation, altitude indicator, connectors).

RIGHT CONSOLE



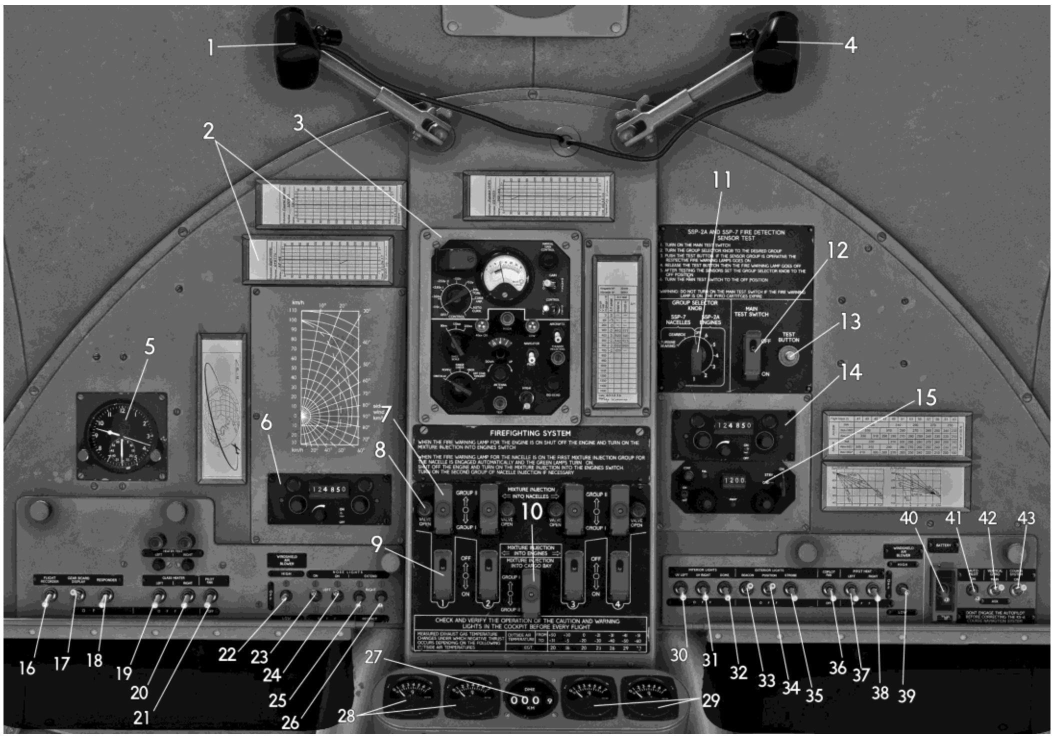
Right pilots' panel

1) fuse box and radar set adjustments – **2)** wing light switches – **3)** wing light control switches – **4)** GA-1 gyro unit heating switch for the KS-6 heading system – **5)** AP-6E autopilot servo heating switch – **6)** SPU-6 audio panel – **7)** engine anti-icing system signal lamps – **8)** wing anti-icing system signal lamps – **9)** propeller anti-icing system signal lamps – **10)** tail anti-icing system signal lamps – **11)** left starter damper control switch and its signaling lamp – **12)** TUE-48 air thermometer for the crew cabin windshield defogging line – **13)** right starter damper control switch and its signaling lamp – **14)** TV-19 thermometers for air supplied to heat the cockpit – **15**) TV-19 thermometers for air supplied to heat the passenger cabins – **16**) TV-11 air thermometer for the individual ventilation line - **17)** TUE-48 thermometers for air supplied to heat the cockpit – **18)** TUE-48 thermometers for air supplied to heat the passenger cabins – **19)** depressurization bell switch – **20)** fire siren switch – **21)** pressure alarm test button - **21a)** KP-24M oxygen device – **22)** ground RAM air switch – **24)** ground temperature control switch – **25)** ground bleed air indicator lamps – **26)** set temperature reached signaling lamp – **27) 28)** switch from automatic to manual temperature control – **29)** cabin overheat signaling lamps – **30)** cabin climb rate setting knob – **31)** cabin altitude setting knob – **32)** target cabin pressure knob – **33)** cabin altitude (m) – **34)** pressurization system mode switch - **35)** cabin pressure (hPa) – **36)** MT-60 pressure gauge – **37)** IP oxygen indicator - **38)** No. 623700M crane of the membrane-aneroid system – **39)** MK-13M pressure gauge - **40)** KV-5 oxygen valve – **41)** windshield wiper – **42)** control handle for the mechanical damper of the crew cabin windshield defogging line - **43)** emergency crane of the KP-32 oxygen device - **44)** anti-icing system switches – **45)** right pilot's rotational panel light

UPPER PANEL

Upper panel - riveted duralumin construction with removable panels on which switches and circuit breakers are located, accessible to both the left and right pilots, as well as to the navigator.

In the left half of this panel are the COM1 radio station control panel APK-5-1, flight recorder, left window heater, nose extension and light control, gear indicator control and pilot fan control. On the right side are the main panel light control, COM2 radio control APK-5-2, external light control, anaerob heater control, right windshield heater control, battery and AP control switches. On the center are the control panel of the radar set and the firefighting system.



9.
Overhead panel

1) left pilot's overhead UV light – **2)** correction table cassettes – **3)** radar channel 1 control and monitoring panel – **4**) right pilot's UV light – **5)** clock – **6)** COM1 radio – **7)** nacelle fire-fighting group selector – **8)** lamps for engine fire extinguishing signal – **9)** engine fire extinguishers – **10)** cargo fire extinguisher – **11)** engine sensor check switch for 1st, 2nd, and 3rd groups of external and internal engine nacelles – **12)** main fire-fighting system test switch – **13)** fire-fighting system test button – **14)** COM2 radio – **15)** transponder – **16)** flight recorder – **17)** landing gear panel switch – **18)** responder – **19)** left glass heaters – **20)** right glass heaters – **21)** left pilot's fan switch – **22)** windshield air blower mode – **23)** left nose light on – **24)** right nose light on – **25)** left nose light extension – **26)** right nose light extension – **27)** DME (km) – **28)** engine 1 and 2 vibration meters – **29)** engine 3 and 4 vibration meters – **30)** left overhead UV light switch – **31)** right overhead UV light switch – **32)** dome light – **33)** rotating beacon lights - **34)** position lights – **35**) strobe lights – **36)** right pilot's fan switch – **37)** left pitot heater – **38)** right pitot heater – **39)** battery – **40)** power supply switch for autopilot – **41)** gyro selector – **42)** K-6 course system

Instructions for extinguishing engine fires: 1. When a fire signal appears (panel lights up), the 1st stage triggers automatically (green lamp lights up), turn off the engine, close the fire valve and feather the propeller. 2. If the green lamp lit up, and the panel turned off after 6 seconds, the fire is extinguished. If the panel continues to burn, turn on the 2nd stage manually after 6 seconds. Attention! If the green lamp did not light up after turning on the 1st stage (distribution valves did not work), turn on the 2nd stage with the same toggle switch. 3. If a fire is detected visually, do not wait for the fire signal to appear, turn on the 1st stage with the corresponding toggle switch, and the 2nd stage after 6 seconds. 4. After finishing extinguishing the fire, be sure to set the toggle switch to the middle position (to close the valves).

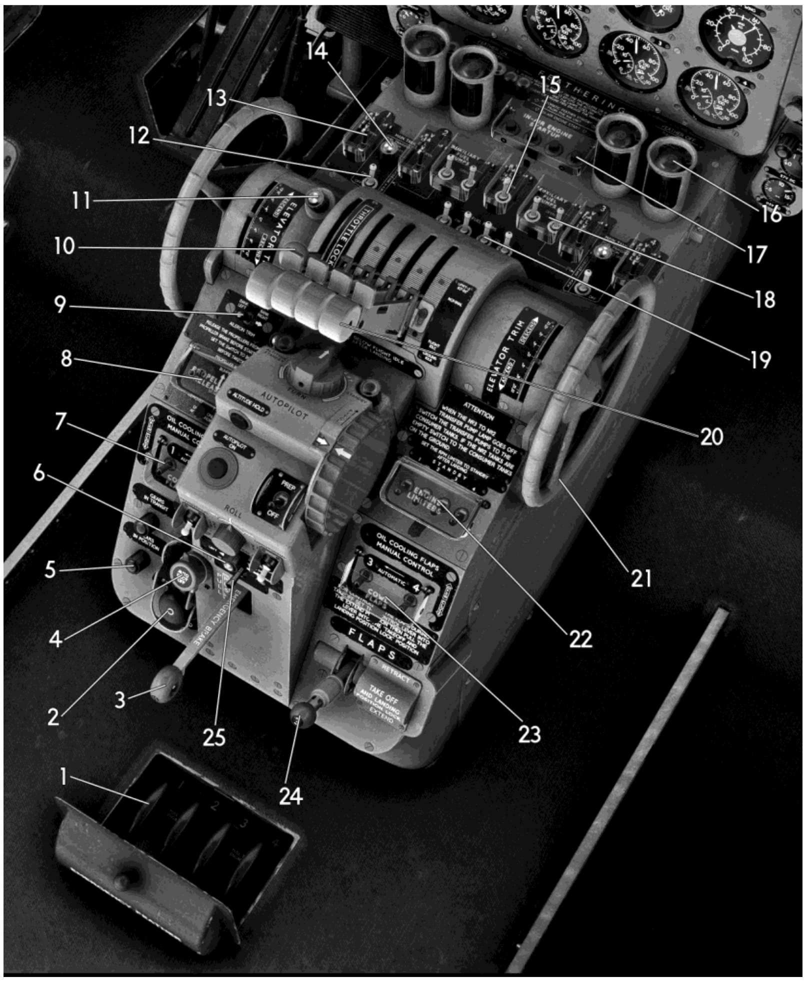
CENTRAL CONSOLE

Installed on the central console are the throttle levers with intermediate stoppers, elements for manual propeller feathering, switches for fuel valves, fuel boost pump and transfer control elements, engine start buttons in the air, and the autopilot control panel.

Installed on the vertical panel of the console are the landing gear and flap control elements, trim switches, oil cooler flaps, engine stop controls, etc.

Additionally, elevator trim wheels are brought out to the right and left sides of the panel.

Cable control for the engines and plug connectors are mounted inside the console. Structurally, the console consists of a cast magnesium frame with panels and walls removable with screws.



Central pilots' panel.

1) emergency feathering handles - **2)** landing gear retraction and extension control buttons - **3)** emergency braking valve - **4)** autopilot disconnect button - **5)** "Landing gear energized" signaling lamps - **6)** rudder trim neutral position signaling lamp - **7)** oil cooler flap control switches for engines No. 1 and 2 - **8)** propeller unfeathering switches - **9)** aileron trim control switch - **10)** locking lever- **11)** elevator trim neutral position lamp - **12)** residual fuel transfer pump switch for left and right groups of tanks - **13**) fuel valve switches - **14)** fuel transfer signaling lamp - **15)** cross-feed valve switch - **16)** manual feathering levers with engine fail indicator lamp - **17)** in-flight engine starters - **18)** transfer pump switches from the additional group of tanks - **19)** booster pump switches from the additional group of tanks - **20)** throttle levers - **21)** elevator trim - **22)** RPM changeover switches - **23)** propeller feathering buttons with engine failure signaling lamp - **24)** flaps control lever – **25)** rudder trim switch – **(26)** auto feather standby and feathering signaling lamps (behind the manual feathering levers)

NAVIGATOR'S WORKPLACE

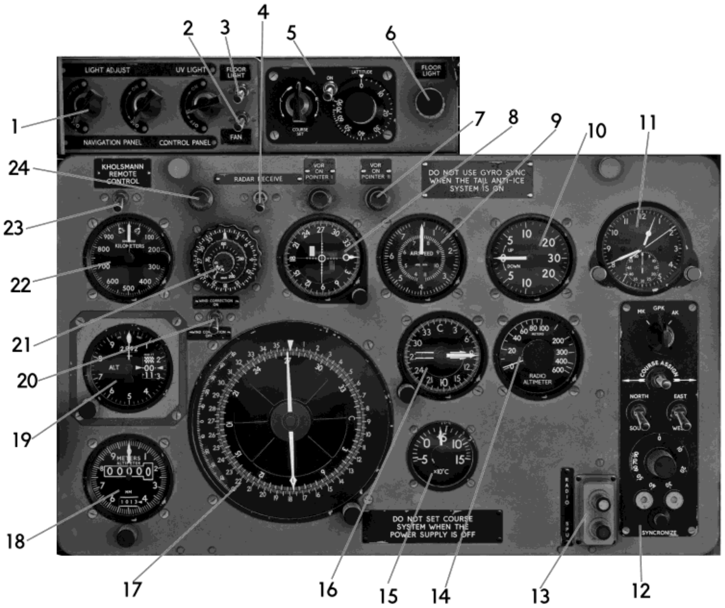
The navigator's seat is located by the left side of the cockpit, behind the left pilot. The navigator sits facing the side.

Navigator's workplace.

The navigator's workplace has the following equipment: **Instrument Panel**; **Table**; **Shelving Unit** with aggregates (under the table); **Central Switchboard** with automatic circuit breakers for electrical networks. All equipment is easily accessible for viewing and control.

NAVIGATOR'S INSTRUMENT PANEL

The instrument panel is made of a sheet of magnesium alloy and is attached to the fuselage structure by means of brackets through rubber shock absorbers.



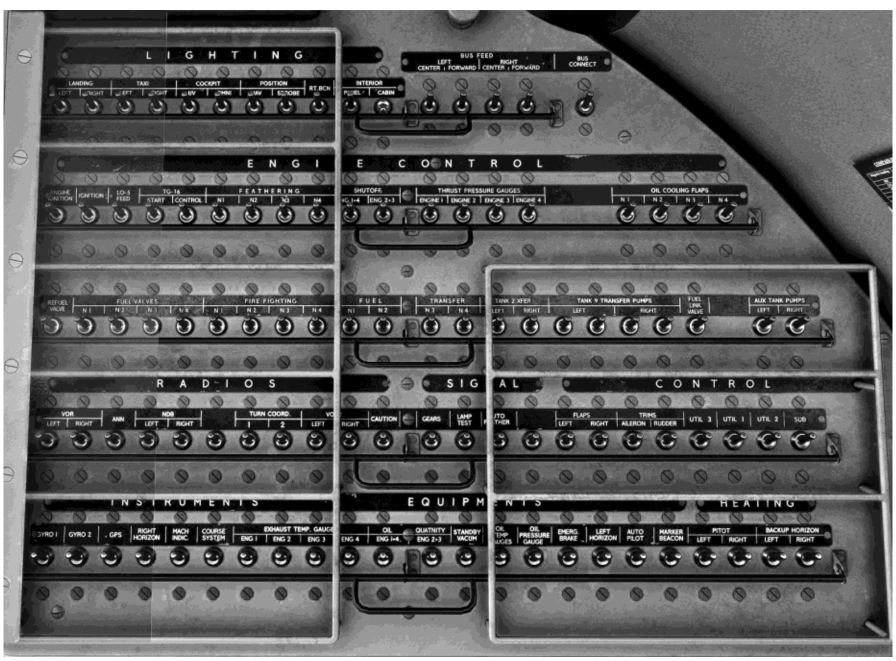
Navigator's instrument panel.

1) navigator's instrument lights – **2)** navigator's fan - **3)** floor light - **4)** radar receive switch - **5)** GPK-52 spare radar course automatic unit control panel - **6)** floor light potmeter - **7)** VOR receiver signaling lamps - **8)** NAV 1 course indicator - **9)** airspeed (km/h) - **10)** variometer (m/s) - **11)** clock - **12)** KS-6 course system control panel - **13)** "Radio" and "SPU" buttons from the SPU-6 set - **14)** radio altimeter - **15)** TNV-15 outdoor air temperature indicator - **16)** UGA-1G track corrector gauge (and KM-4) - **17)** USh dual needle course and bearing indicator - **18)** altimeter (feet) - **19)** altimeter (meter) - **20)** wind corrector switch - **21)** wind corrector setting knobs - **22)** coordinate counter from the NI-50M set - **23)** altimeter pressure switch

NAVIGATOR'S MAIN DISTRIBUTION PANEL

The panel is located on frame No. 4, at the very top, between the side and the door. The panel is a board on which circuit breakers are arranged in horizontal rows.

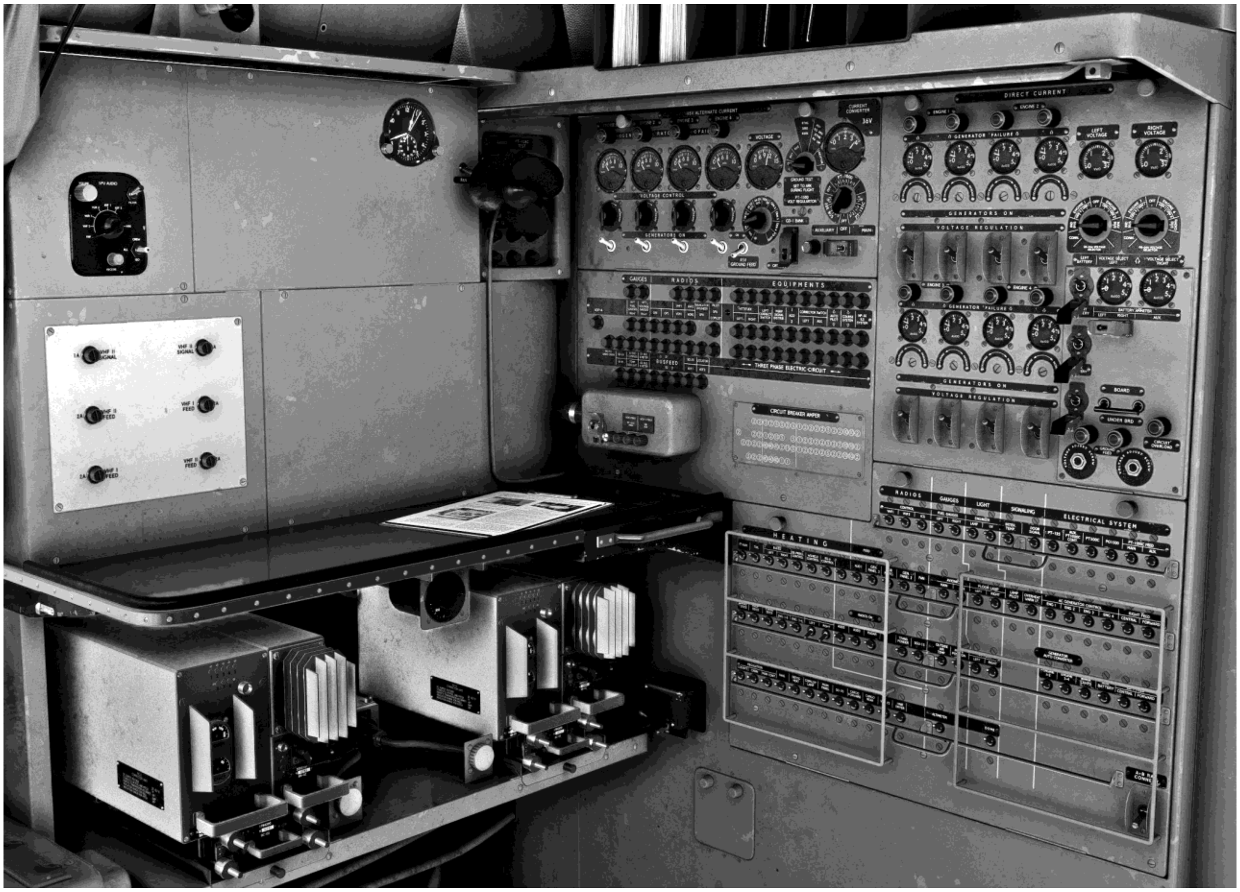
Here is concentrated the protection of the electrical network for lighting, motors, control, signaling, radio, heating, and instruments. Each row of circuit breakers has its own flipping bar for fast activation of all automatics in the row. The panel board is made of magnesium alloy sheets.



Navigator's distribution panel

AC AND DC ELECTRICAL SYSTEM WORKSTATION

This workstation was used initially for radio communication equipment, but after modernization and simplification of the radio communication systems in the reference unit, this station was occupied by the flight engineer. The electrical workstation is located on the right side of the aircraft, symmetrical to the navigator's workstation, and has the following equipment: a table; a rack with units (under the table); a shelf with RSB-5 units; a central distribution panel with circuit breakers and power grid monitoring devices. All equipment is accessible for viewing and control.



Placement of units at the electrical system panels.

On the rear right cockpit wall are located the corresponding control panels for the electrical systems. These panels are made of magnesium sheets but are attached to the aircraft structure without shock absorption. The DC protection panel has a loop at the bottom for opening when approaching for installation, and the AC protection panel is removed entirely after unscrewing the four bolts in its corners.

On the AC protection panel are located the SP type fuses and a group of relays. On the DC protection panel are located three horizontal rows of AZS and AZR type circuit breakers. Each row has its own common change-over bar for simultaneous switching on of all switches in the row.

Above each fuse and AZS there are stencils explaining its affiliation and purpose.

CHAPTER II - AIRCRAFT FLIGHT-NAVIGATION EQUIPMENT

The group of flight and navigation instruments includes all those instruments with which the aircraft's position relative to the ground is monitored and navigation is carried out. Further in this chapter, descriptions of the following systems are provided: KS-6 course system, DAK-DB-5 astrocompass.

KS-6 COURSE SYSTEM

The KS-6 determines and indicates the aircraft's course and turn angle, and—with the ARK-5 radio compass—the magnetic bearings and course angles of radio stations. It is also a course sensor for the AP-6E autopilot. It is a complex of magnetic, gyroscopic, astronomical, and radio devices, additionally using two TsGV-4 central gyro verticals (from the AP-6E set), two VK-53PB correction switches (main and standby), the DAK-DB-5 astrocompass as a course corrector, and ARK-5 radio compasses.

Two UK-1 course indicators sit on the pilots' panels and the UGPK on the left panel. The navigator's panel carries USH and UGA-1U indicators and the PU-1 control panel. The BR-1 unit is under the navigator's table; two GA-1 gyro units (main, standby) and the U-11 amplifier are in the front cargo compartment; the ID-2 induction sensor is in the tail fairing. The KM-4 correction mechanism sits on the pilots' left console for free access to its cam adjusters.

PRINCIPLE OF OPERATION

Three modes: magnetic correction (MK), gyro-semi-compass (GPK), and astronomical correction (AK). In every mode the same GA-1 gyro unit outputs course, displayed on UK-1/UGPK (pilots) and USH/UGA-1U (navigator). Radio-station course angles from the ARK-5 feed the navigator's USH and, combined with gyro readings, give bearings or course correction.

MK MODE: Determines magnetic course. The ID-2 sensor, with the KM-4 mechanism, connects to the main GA-1 and disconnects from the standby. The ID-2 → KM-4 → GA-1 chain continuously orients the course gyro to the magnetic meridian. The gyro averages and stabilizes the readings and feeds the USH/UGA-1U indicators, the AP-6E, and the AK-1 unit of the NI-50M. To remove bank-induced errors, the gyro hangs on an additional frame driven by TsGV-4 roll signals within ±70°.

GPK MODE: determines true/gyroscopic course; the ID-2/KM-4 disconnects from the main GA-1 and connects to the standby. Long-term GPK operation needs frequent manual correction due to low precession rate.

AK MODE: The gyro is corrected by astrocompass signals via the D-62 sensor-transmitter to the GA-1. The standby unit is reserved for AK. This mode serves as the GPS source in the simulator.

DESCRIPTION OF UNITS

GA-1 GYRO UNIT

Includes two gyro units (main, standby) and a U-11 amplifier. On later series the KM-4 is installed on the left side near the DAK-DB-5 computer. Main unit = AK mode; standby = MK mode with periodic correction. For the AP-6E, AK is the main mode.

Each GA-1 uses a three-degree-of-freedom gyroscope (axis horizontal) to average ID-2 fluctuations and yield stable magnetic course. The rotor is a three-phase async motor (36 V, 400 Hz) on the inner gimbal frame. Rotation about the vertical axis = course change; the gyro body turns relative to the outer frame, and a Selsyn sensor converts this into electrical signals. In MK/AK mode the Selsyn stator is continuously corrected by magnetic or astro sensors; a PU-1 coordination button quickly aligns the gyro with the course sensor.

Gimbal error is removed by the additional frame, brought vertical by a TsGV-4-fed tracking system. To keep the main axis horizontal, a pendulum liquid switch on the gyro-motor casing drives a two-phase horizontal motor-corrector. To remove apparent (latitudinal) drift from Earth's rotation, an azimuthal latitudinal corrector (thermo-compensator + azimuthal motor-corrector) is provided. Current course transmits to the remote UY-1 indicator via Selsyn gears, using "coarse" and "fine" differential channels. VK-53RP detects two-degree gyro drift, issuing signals proportional to drift angle.

Three VK-53RB units are fitted: two (main/backup) serve the KS-6, AGB-2, GPK-52, and TsGV-4; the third serves the AGI-1S. The switch exploits a two-degree gyro aligning its spin vector with the turn-rate vector; springs hold it centered. During a turn the gyroscopic moment overcomes the springs and triggers a delay that breaks the correction circuit 5–15 s after the turn begins.

INDUCTION SENSOR ID-2

Determines magnetic heading to correct the gyro unit in azimuth. Its sensitive element is three magnetic probes at 60° (an "induction triangle") with series-connected magnetizing windings; the star-connected signal windings feed the KM-4 Selsyn receiver via a three-wire line. The resulting EMF drives an amplifier and motor that rotates the Selsyn rotor to the zero-EMF position, so any aircraft turn corresponds to an equal KM-4 rotor turn. The sensitive element stays horizontal via a float immersed in liquid on a double gimbal suspension. A deviation device (two longitudinal and two transverse magnet shafts) removes semicircular deviation (W-E and N-S respectively).

Amplifier U-11

Amplifies tracking-system signals across remote channels: the KM channel (ID-2 → KM-4) amplifies 800 Hz signals, converts to 400 Hz, and feeds the follow-up motor; the GA channel (KM-4 → GA-1) handles azimuth correction; the USH channel (GA-1 → USH) feeds the navigator's indicator; the UK-1 channels (USH → UK-1) feed the pilots' three-coil ratiometers. The KM-4 correction mechanism comprises a cam device, gearbox with follow-up motors, body, casing, and Selsyns—one matching the ID-2 element to the field's horizontal component, the other transmitting corrected course signals to GA-1.

Direct magnetic-course measurement via the KM-4 is hard because of oscillations from the slightly pendulous ID-2 element, so the GA-1 gyro stabilizes the readings, connected via remote Selsyn transmission. The roll channel (TsGV-4 → GA-1) converts TsGV DC potentiometer signals to 400 Hz AC for roll correction.

Control Panel PU-1

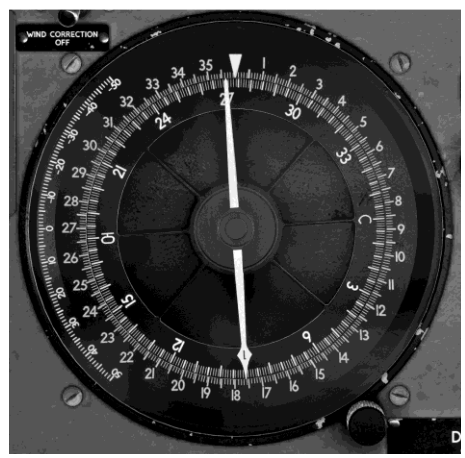
Functions: select mode (MK/GPK/AK); enter latitude correction (both hemispheres); compensate azimuth drift from imbalance; set the indicator scale to a course in GPK mode; rapidly align the gyro with the course sensor; connect indicators/consumers to the main or standby gyro unit. Switches, knobs, and a sync button are on the front.

Navigator's Indicator USH

Displays magnetic/true heading, turn angles, and the bearings and course angles of two radio stations, and outputs heading signals (DC and AC). It combines a heading tracking unit, a heading-output unit, and a remote-communication unit with radio-compass Selsyns. The tracking system's main element is a Selsyn receiver linked to the GA-1; its rotor is driven by a DID-0.5 motor. The output unit uses a Selsyn transmitter (AC) and a ring potentiometer (DC) corrected for magnetic declination. The radio-compass unit has two non-contact Selsyn receivers four-wire-linked to the ARK-5.

The face has three scales (movable, fixed, inclined) and two coaxial hands ("1", "2"). Aircraft course reads on the movable scale via the zero index; course angles read on the fixed scale via the hands; bearings read on the movable scale. Declination is corrected ±50° via rack-and-pinion on the inclined scale. The ring potentiometer outputs course signals to the pilots' UK-1.

In the simulated unit, ARK-UD (NDB) feed was replaced with VOR feed, and the ARK-UD feed connected to the dual-needle ADF instruments on the main panels.



UGA-1U Indicator

A four-hand auxiliary instrument showing whether GPK-mode gyro readings need correction; in the sim it also serves as the KM-4 magnetic-correction instrument. Hands marked A, G, D and one unmarked, on a 0–360° scale: "A" = astro position, "G" = gyro position, "D" = magnetic deviation (right knob, ±15°), unmarked = heading bug (left knob.

Pilot's Indicator UK-1

The course indicator UK-1 serves pilots for visual observation of the course readings of the aircraft's turning angles from the set course. The course sensor for the UK-1 indicator is the navigator's indicator ring potentiometer.

The instrument scale indicates the compass heading. The heading is indicated by an arrow, in the center of which an airplane is depicted. The heading for the Autopilot is set using a knob brought to the front side of the instrument, and has the same graduation as the course scale, but in the opposite direction. The readings of the Autopilot heading scale are indicated by a white index arrow in the window of the course scale.

The bearing angle of the VOR1 transmitter set into the navigation radio is marked by a yellow arrow on top of the compass scale and shows the relative direction of the VOR transmitter station to the airplane.

ASTROCOMPASS DAK-DB-5

A remote astronomical compass providing: true heading along an arbitrary route (geographic coordinates entered manually each time), and continuous heading along an orthodrome up to 1100 km (coordinates entered once at the section start). Used mainly in daytime. On the real Il-18 it works with the KS-6 as an astro-corrector, issuing true-heading signals to correct the GA-1.

Placement of DAK-DB-5 units

Units sit where the navigator can manage and observe them. The BK-63 track corrector and "Astrocompass-KS" switch are on the navigator's panel; the amplifier and D-62 unit are under the navigator's table; the computer is on the pilots' left console. The DKU heading-angle sensor is in the upper fuselage between frames No. 41–42, rigidly mounted.

ASTROCOMPASS UNITS

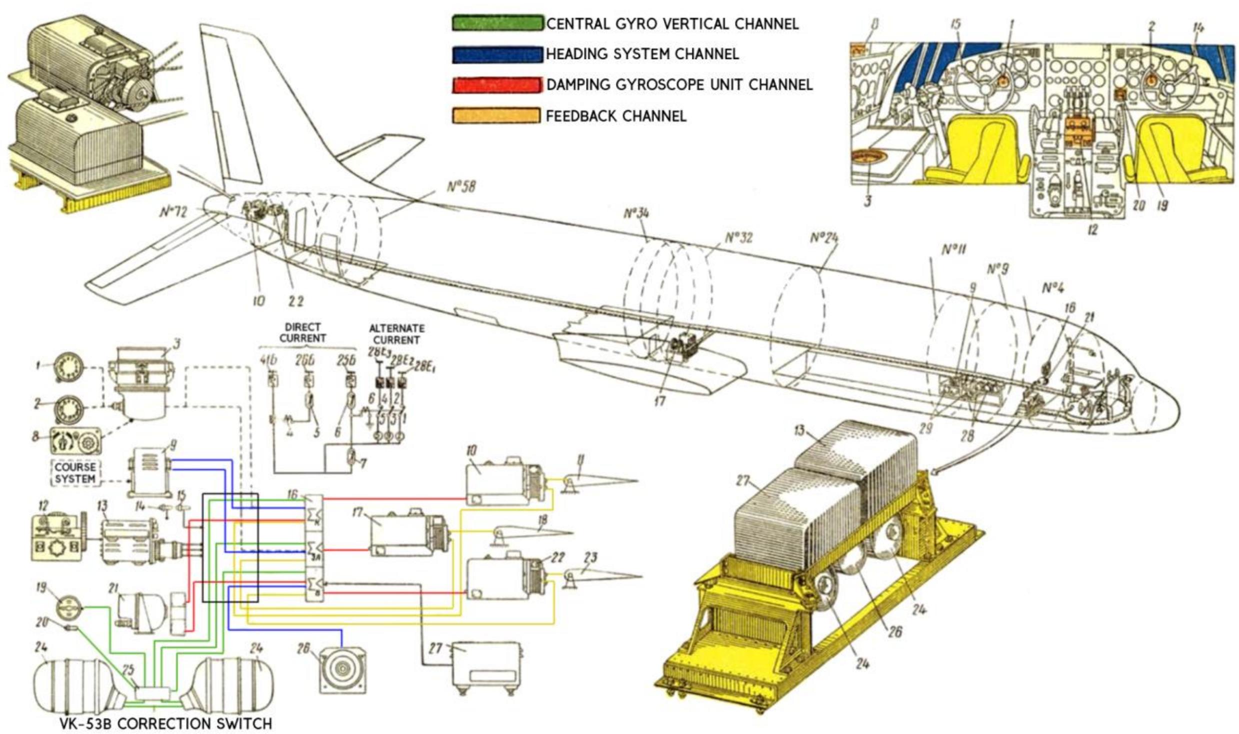
The DKU measures the Sun's heading angle (direction-finding head with two photocells in a differential circuit). The calculator generates the celestial body's azimuth and altitude via a spherite realizing the "zenith-pole-body" parallactic triangle. The BK-63 way corrector dead-reckons distance from a manually set ground speed. The D-62 transition block interfaces with the KS-6 (astrocompass true-course receiver Selsyn, AC amplifier, AC motor, remote-transmission system). The amplifier includes the photoelectric and way-corrector amplifiers, two servo-drive amplifiers (roll corrector and heading Selsyn), an electronic time relay, and a true-course sensor.

CHAPTER III - AUTOPILOT AP-6E

The AP-6E provides automatic stabilization and flight along a set trajectory: stabilization about all three axes; automatic altitude hold; coordinated turns ("Turn" knob); climb/descent ("Descent-Climb" handle); roll/pitch indication to the pilot's visual indicator from the TsGV-4; communication with the KS-6; vertical stabilization of the KS-6 gyro unit; stabilizing signals to the RPSN-2N radar; and a navigation course-following function (never used—unreliable). Without a KS-6 communication unit, a GPK-52AP gyro-semi-compass, GPK-52PU panel, and two UGPK indicators are added.

PLACEMENT OF AP-6E UNITS ON THE AIRCRAFT

The UG horizon indicator and 5K arrester button are on the right panel; two UGPK indicators on the pilots' panels; the control panel on the central console; shutdown buttons on the left yoke. With a GPK-52AP, it sits on the navigator's desk and its control panel above the navigator's panel. The TsGV-4 (main/backup), KV-11 altitude corrector, BU-2 control unit, servo amplifier, and BS communication unit share a common four-shock-absorber platform near bulkhead No. 4, starboard. The rudder and elevator steering gears are on the stabilizer; the aileron gear in the center section.



23.
Layout diagram of the AP-6E autopilot units on the aircraft.

1) UGPK indicator* for the left pilot – **2)** UGPK indicator* for the right pilot – **3)** GPK-52AP gyro compass – **4)** steering gear heating contactor – **5)** steering gear heating switch – **6)** autopilot power switch – **7)** central gyro vertical CGV-4 switch – **8)** GPK-52AP activation panel – **9)** AP-6E autopilot communication unit BS with the KS-6 course system – **10)** rudder steering gear – **11)** rudder **12)** autopilot control panel – **13)** autopilot control unit BU-2 – **14)** steering gear disconnect button for the right pilot – **15)** emergency autopilot disconnect button for the left pilot – **16)** distribution box – **17)** aileron steering gear – **18)** aileron – **19)** horizon indicator UG for the right pilot – **20)** 5K arresting button for CGV-4 – **21)** damping gyroscope unit BDG – **22)** elevator steering gear – **23)** elevator – **24)** central gyro vertical CGV-4 (main and backup) – **25)** CGV-4 switching relay – **26)** height corrector KV-11 – **27)** autopilot servo amplifier U – **28)** correction switches – **29)** GA-1 gyro units for the KS-6 course system - **26B) 41B)** DC buses - **28V1) 28V2)** and **28V3)** AC buses.

PRINCIPLE OF OPERATION

The autopilot is an angle-and-angular-velocity regulator with rigid feedback: angular-deviation and angular-velocity signals stabilize the aircraft, and feedback gives proportional control-surface deflection. Sensing elements: for course, the KS-6 gyro unit (or GPK-52AP); for roll/pitch, the TsGV-4; for angular velocities, the BDG-10-2 damping gyros. Signals are summed on potentiometric bridges, amplified, and converted to impulses driving the steering machines. Drum-mounted feedback potentiometers ensure proportionality, and correction signals coordinate disturbance suppression across course and bank. Altitude stabilization from the corrector feeds the pitch-channel bridge.

In control mode, the "Turn" handle disconnects the heading-system signal and feeds rudder/aileron deflection to the course and bank bridges (summed with damping and TsGV-4 coordination signals) for a coordinated, slip-free turn until the handle returns. The "Descent-Ascent" handle disconnects the altitude corrector and feeds the pitch bridge to climb or descend. The UGPK course indicators are Selsyn servos repeating the GA-1/GPK-52AP; the UG horizon is a potentiometric servo repeating the TsGV-4.

Switch-on. Done via the PU-3 panel: switch "Preparation" on, then press "On AP" after centering—readiness shown by the "Ready" lamp. DC power comes via the AZS-10 breaker ("Autopilot" stencil, navigator's panel) and the "AP Power" switch (upper right panel); the latter closes a relay supplying AC. Protection: three SP-10 fuses. Power is also supplied to the TsGV-4 horizon-indicator potentiometers, semiconductor amplifiers, KV-11, and KS-6 communication unit.

Central Gyroscopic Vertical TsGV-4

Determines the aircraft's attitude relative to the horizon and outputs deviation angles via potentiometric sensors to the autopilot, UG indicator, and other consumers. Sensors provide: aileron deflection (bank), elevator deflection (pitch), slip compensation (course channel), altitude-loss compensation during bank, horizon-indicator signals (also usable for KS-6 vertical correction), radar bank signals, and precise sensors checking installation accuracy. It is a two-gyroscope artificial horizon using power gyroscopic stabilization (unloading motors compensate axis friction), giving high accuracy in accelerated flight. Correction uses low-inertia AC motors driven by a liquid pendulous element; transverse correction is cut during turns by the VK-53RB. A rapid-erection button sits next to the UG indicator.

Altitude Corrector KV-11

Measures deviation from a set barometric altitude and outputs signals to the autopilot. Its sensitive element is a differential aneroid-capsule block; capsule movement rotates an inductive-sensor frame, inducing a phase-coded signal proportional to deviation. The mismatch signal drives a semiconductor amplifier and DID-0.5 motor; the altitude potentiometer connects via an electromagnetic clutch—when engaged it sends deviation-from-altitude signals to the autopilot; when disengaged, springs return it to zero for re-alignment.

Control Unit BU-2

Provides automatic centering of the course and pitch channels before engagement and regulates sensitivity and gear ratios; it houses mode-switching relays. The centering tracking systems use DID-0.5T induction motors.

Potentiometers regulate gear ratios for angular velocities ("Portion PG", "Kr.", "K", "V"), height ("Height Corrector"), course and course-to-roll ratios ("Adjustment"), sensitivity in roll/course/altitude ("Sensitivity"), and turn coordination from navigator and pilot. In the Il-18 config the "Kp." potentiometer is unused and locked at the extreme left. Tracking systems run on 36 V/400 Hz; other potentiometers on 400 Hz; relay coils on 27±2.7 V DC.

Damping Gyroscope Unit BDG-10-2

Houses two damping gyros outputting signals proportional to the aircraft's angular velocities in heading and pitch. Each gyro has an async motor, a frame, and a spring/potentiometer transmission. A turn creates a gyroscopic moment aligning the rotor's spin vector with the aircraft's rotation; oscillations are damped by liquid. A velocity-proportional signal feeds the corresponding autopilot channel; potentiometers run on 27 V/400 Hz from the distribution box

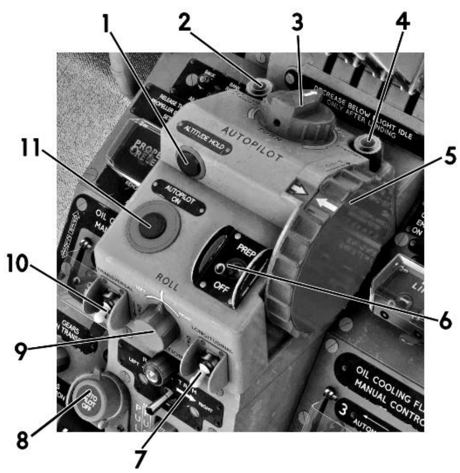
Servo Amplifier U

Amplifies bridge signals and converts them to DC pulses for the steering gears—three identical channels (rudder, aileron, elevator) plus a rectifier. Each channel has amplification, control, and detection stages. The control stage shapes the actuator characteristic so servo speed depends non-proportionally on deviation: very weak signals are blocked, medium signals pass as pulses (non-proportional output), large signals pass continuously. The detector stage rectifies pulses to drive relays that energize the working solenoids (moving the cable drum/rudder) and ensures the direction of operation matches the bridge signal.

Emergency servo disconnect: A button on the right pilot's yoke fires pyrotechnic cartridges that shear locking pins, disengaging the stoppers from the control-sector shaft.

Autopilot control unit

The PU-3 control unit is designed to turn the autopilot and its units on and off, to signal readiness for engaging the autopilot and altitude corrector, and to control the aircraft using the "Turn", "Climb-Descent" and "Bank" handles.



Autopilot control panel.

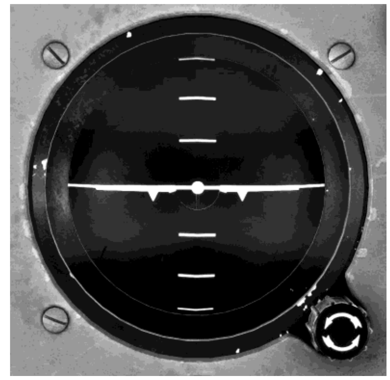
1) button for turning on the altitude corrector – **2)** lamp for signaling readiness to turn on the altitude corrector – **3)** knob for turning control – **4)** lamp for signaling readiness to turn on the autopilot (end of the centering process) – **5)** knob for pitch control – **6)** switch for preparing the autopilot (reset autopilot) – **7)** switch for lateral stabilization – **8)** emergency disconnection button – **9)** roll control knob (INOP) – **10)** switch for longitudinal stabilization – **11)** button for turning on the autopilot

Element functions: "Altitude Standby" lamp signals USH alignment with the corrector midpoint; "Standby" lamp signals end of centering; "Autopilot On" engages the steering-machine brake solenoids; "Altitude Hold" engages the corrector clutch; "Prep/Off" switches the autopilot DC circuits and turns it off (in the sim it resets the autopilot to zero directional values); "Transversal" cuts the rudder/aileron brake solenoids; "Longitudinal" cuts the elevator brake solenoid; the "Turn" handle outputs turn signals and switches stabilization→turn mode; the "Pitch" handle outputs climb/descent signals; the "Roll" handle centers bank and changes bank within 2–3° (not operational in the sim). Power: 27±2.7 V DC; potentiometers 400 Hz.

UGPK Indicator

A remote repeater of the GA-1 (or GPK-52AP) readings, indicating deviation from a set direction and turn angles. A DID-0.5 follow-up system drives the UGPK course axis; mismatch signals between the GA-1/GPK-52AP Selsyn and the UGPK Selsyn drive the motor. Gyroscopic heading reads via a triangular index on the fixed ring; the 360° scale has 2° divisions.

Horizon indicator UI



A remote repeater of the TsGV-4 for roll/pitch. Its sensitive part is three PDK-49 repeaters (one bank, two pitch), each a permanent magnet interacting with a three-coil toroidal coil so the magnet holds a defined position set by the gyro-vertical potentiometer. Three magnets: one drives the spherical horizon screen (bank); two parallel ones drive the aircraft silhouette bar (pitch). A horizon line and ticks read pitch/bank; a knob sets the level-flight pitch by moving the pitch repeaters.

The AP-6E kit includes two 205K buttons (plastic body): the left-yoke button disconnects via internal mechanisms; the right-yoke button is the pyrotechnic emergency disconnect.

Caging button of the central gyro vertical 5K

The 5K button is designed for quick restoration of the TsGV-4 gyro assembly during startup and from toppling. It is located near the UG horizon indicator on the pilots' instrument panel.

Communication unit with KS-6

The communication unit with the course system is designed to transmit signals proportional to the aircraft's deviations from a given flight direction, measured by the gyro unit of the KS-6 course system, to the autopilot's course and roll channels.

Remote transmission of signals is carried out by means of a Selsyn transmission. The control signal in the form of a proportional alternating current voltage is taken from the stator of the Selsyn-transmitter of the course system gyro unit and transmitted to the stator of the Selsyn-receiver of the communication unit with the Control Unit. The alternating current voltage from the rotor of the Selsyn-receiver, after passing through an amplifier, goes to the control windings of the DID-0.5T follow-up motor, on the axis of which there is a Selsyn-receiver rotor and potentiometer USHs, from which the signals are sent to the autopilot.

Communication Block

Transmits aircraft-deviation signals (from the KS-6 gyro unit) to the autopilot's course and roll channels via Selsyn transmission: an AC control signal from the gyro-unit Selsyn-transmitter stator goes to the CU Selsyn-receiver stator; the rotor voltage, amplified, drives a DID-0.5T motor carrying the receiver rotor and a potentiometer, which then feeds the autopilot.

Time Delay Relay Block. Delays connecting gyro-unit signals to the autopilot until a turn completes—an electromechanical device using a heating element; contacts close 0.5–1.5 s after current is applied, and reopen as the wire cools.

Gyro Compass GPK-52AP

A heading-stabilization sensing element: it measures orthodromic deviation and outputs proportional signals to the autopilot's heading channel and to the heading-indicator follow-up systems; due to high precision it also serves as a navigational gyrocompass. It uses a free three-degree gyro maintaining its spin axis in space. The scale (fixed to the cardan vertical axis) reads against a housing index; a DID-0.5 motor sets the scale to a course from the GPK-52PU. Horizontal correction auto-disconnects at turn rates ≥0.3°/s (via the VK-53RB) to reduce post-turn errors.

Control Panel GPK-52PU: enters latitude corrections (to the azimuthal corrector) and controls scale rotation. Front panel: switch, course-setter handle, latitude knob.

On the front panel of the console are a switch, a course setter handle, and a knob for setting latitude corrections.

CHAPTER IV – COLLISION AVOIDANCE AND NAVIGATION RADAR STATION

The radar system of the simulated aircraft is based on the real world RPSN-2 radar system but differs somewhat in functionalities.

The RPSN-2 airborne radar station is designed to give the flight crew a reliable picture of the surrounding airspace, the weather ahead, and the terrain beneath the aircraft. It serves as both a safety instrument and a navigational aid, allowing the crew to detect aircraft, identify thunderstorm activity, observe mountain peaks, and maintain orientation even in poor visibility. In addition to these functions, the station provides the navigator with the ability to determine the aircraft's drift angle and ground speed, which are essential for accurate dead-reckoning navigation.

At the heart of the system is a gyrostabilized antenna mounted in the aircraft's nose behind a radio-transparent radome. This antenna performs the dual role of transmitting and receiving microwave pulses, sweeping a sector of space ahead of the aircraft. The energy generated by the transmitter travels through a pressurized waveguide to the antenna, and the same path is used in reverse when echoes return from targets.

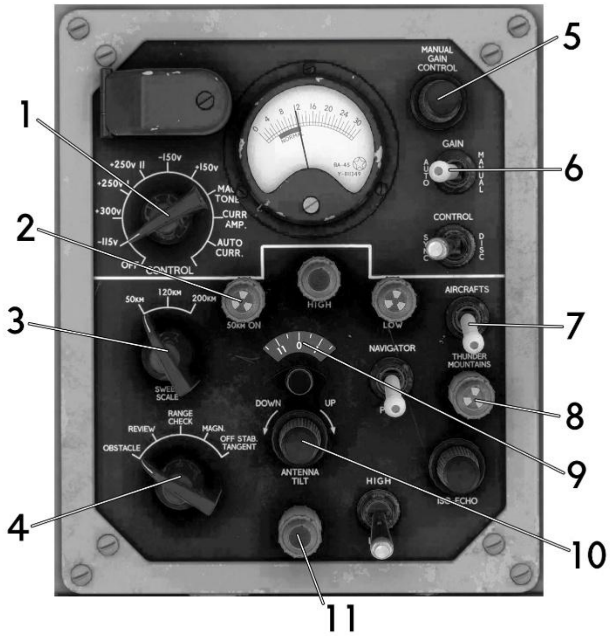
Inside the cockpit, the pilot and navigator each have their own indicator. These are cathode-ray tube displays that show a radial sweep originating from a point near the bottom of the screen. Each sweep corresponds to a transmitted pulse, and as the antenna rotates, the sweeps fan out to form a sector-shaped image. Bright spots appear where echoes are received, and their position along the sweep indicates range. The azimuth grid printed on the screen allows the crew to determine the bearing of each target relative to the aircraft's longitudinal axis. Range marks appear, spaced according to the selected range scale, helping the crew judge distances quickly and accurately.

The pilot's indicator is primarily used for collision avoidance and general situational awareness. The navigator can also use the indicator to measure drift angles by aligning a movable cursor with ground features, and the system then calculates the aircraft's ground speed based on the movement of those features across successive sweeps. In the simulator, the wind speed and direction, along with the true air speed values are already calculated and written out on the small rectangular "drift angle scope's" display on the Navigator's radar control panel. The True Speed then dialed onto the True Speed indicator manually, then that information is fed to the distance calculator system (NI-50). The wind direction and speed are dialed into the distance counter system through the ZV-1 "WIND" setter knob on the Navigator's instrument panel. From these data, the distance counter calculates the travelled distance along the X and Y coordinate system that can be seen on the distance counter indicator on the Navigator's instrument panel.

The system draws power from the aircraft's DC, single-phase AC, and three-phase AC buses, each protected by dedicated fuses or circuit breakers.

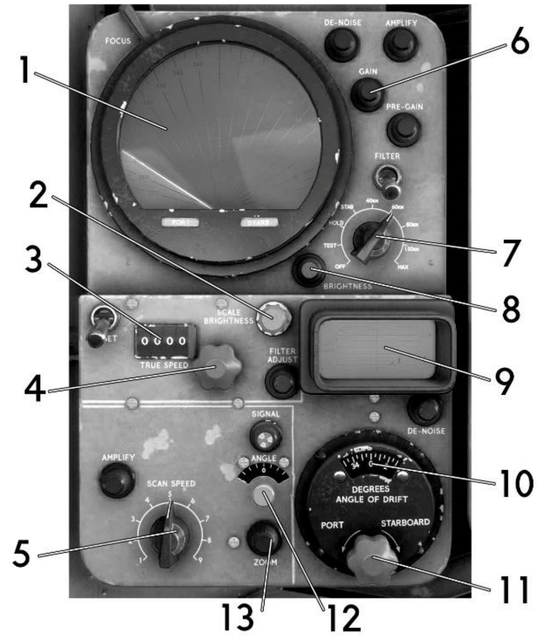
Before operation, the station requires a warm-up period. The transmitter's high-power vacuum tubes must reach operating temperature, and the system enforces a delay of several minutes before enabling the high-voltage circuits. The indicators also activate only after their own warm-up interval. Once the system is ready, the crew selects the desired mode and range scale, adjusts gain and brightness, and verifies that the antenna is scanning correctly. During flight, the radar provides continuous updates, allowing the crew to monitor weather, terrain, and traffic in real time. For the sake of time efficiency, the warmup is reduced to abut 10 seconds.

The system, as it is simulated, has two channels that have their separate control panels. Channel 1's control panel is located on the overhead panel above the pilots, and the control panel of Channel 2 is located at the Navigator's Workstation, at the left side of the Navigator's Panel. The feed from Channel 1 is displayed on the left widow of the central display unit, which is located at the top of the main instrument panel, labelled as Channel 1. The feed from Channel 2 is displayed on the Navigator's control panel and the right window of the central display unit, labelled Channel 2.



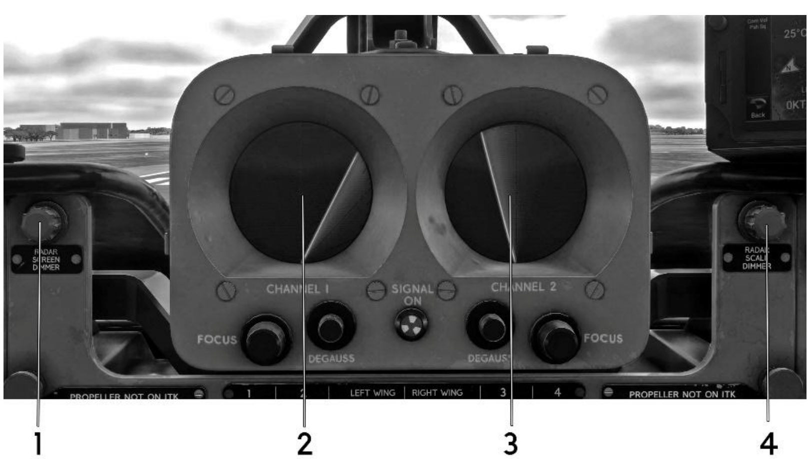
32.
Channel 1 control panel

1) Mode selector – **2)** 50km range indicator – **3)** Range selector – **4)** Diagnostics – **5)** Manual gain control set – **6)** Auto and manual gain mode selector – **7)** Air traffic detection and weather radar mode selector – **8)** Weather radar mode indicator lamp – **9)** Tilt angle indicator – **10)** Tilt angle setting knob – **11)** Warmup indicator light



33.
Channel 2 control panel

1) Channel 2 display – **2)** Drift angle indicator scale brightness **- 3)** True Speed indicator dials – **4)** True Speed setting knob – **5)** Scan speed setting knob for Channel 2 – **6)** Gain control – **7)** Mode and range selector – **8)** radar display brightness setting knob – **9)** Drift angle measuring and indicator scope – 10) Drif angle indicator – **11)** Drift angle setting knob – **12)** Channel 2 tilt angle setting knob and its angle indicator – **13)** Drift angle measurement scope zoom level set.



34.
Central display unit of the radar system

1) Channel 1 display brightness – **2)** Channel 1 display – **3)** Channel 2 display – **4**) Channel 2 brightness

CHAPTER V - THE PERSSURE-ANAEROB SYSTEM

The diaphragm-aneroid system includes basic flight-navigation instruments fed by two TP-156 total-pressure receivers and eight static ports. The TP-156 receivers sit one each side, between frames No. 3–4, below the axis.

Eight static ports lie between frames No. 11–12 (four per side) to equalize true static pressure during sideslip; a ninth emergency port is in the nose fairing. Six of the eight ports pair into three static-line systems. The left pilot's instruments get dynamic pressure from the left TP-156 and static from the first combined line; the right pilot and navigator get dynamic from the right TP-156 and static from the second line. The altitude-system safety valves connect to the second line; the third line feeds the KTA-5F engine command-fuel units. A K2-75 baro-speedograph (with SP-11S recorder) gets dynamic from the right TP-156 and static from a port near frame No. 11. The left-side port near frame No. 11 feeds the KV-11 altitude corrector.

If needed, the left pilot can switch to the right pitot dynamic line and to the second combined or emergency static line; this also backs up the right pilot's static line. Switching between main and backup uses three valves—two on the left console and one on the right. For the emergency static line, both static valves go to "Reserve".

Installation of dynamics and statics valves of the left pilot.

Installation of the static valve of the right pilot.

If necessary, the left pilot can connect their group of membrane-aneroid instruments to the dynamic line from the right side pitot tube, and the static line to the second combined static line or to the emergency static line. This line also serves as a backup power source for the static line of the right pilot.

Moisture traps protect the instruments; static nozzles are plugged (with warning flags) and the TP-156 covered while parked. Wiring is alloy-magnesium (static 8×6 mm, painted white; dynamic 6×4 mm, painted black, with one white ring near connectors).

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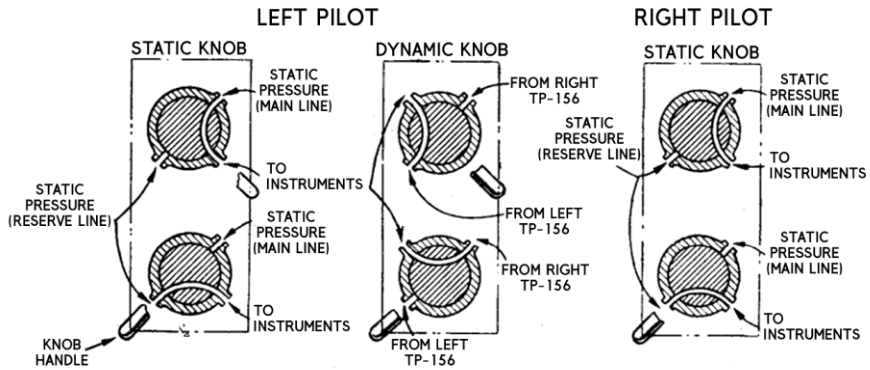
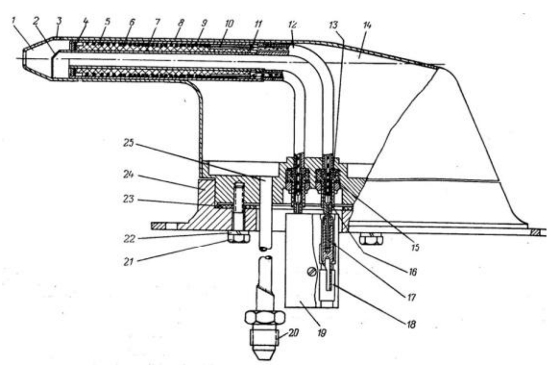


Operational diagram of anaerob valve knob

TP-156 Total Pressure Receiver

The TP-156 receiver serves to transmit the total air pressure to instruments measuring flight speed. Moisture entering the receiving part from the atmosphere flows through hole **3** in the wall of the body **8**. The receiver is equipped with a heating element. The heating element consists of a ceramic frame **9**, on which a nickel wire is wound. The heating element is placed in a metal tube **11**, closed from the receiving chamber side by washer **4**. The voltage is supplied to the heating element via a plug from the aircraft's 27 V DC network. The receiver is inserted into the flange **24** and fastened to it with two bolts. A gasket between the flange and the receiver ensures hermeticity. The receiver with the flange is fastened to the aircraft skin with eight screws.



Design of the TP-156 receiver

1) receiver chamber – **2)** visor – **3**) hole – **4)** washer – **5)** insulation – **6)** nickel wire – **7)** tube – **8)** housing – **9)** frame – **10)** lead ends – **11) – 12**) tube – **13)** washer – **14)** chamber – **15)** nut – **16)** bushing – **17)** pin – **18)** bushing – **19)** insulating cheeks – **20)** fitting – **21)** bolt – **22)** split washer – **23)** gasket – **24)** flange – **25)** tube.

CHAPTER VI - INDIVIDUAL FLIGHT AND NAVIGATION INSTRUMENTS

AIRSPEED INDICATOR KUS-1200

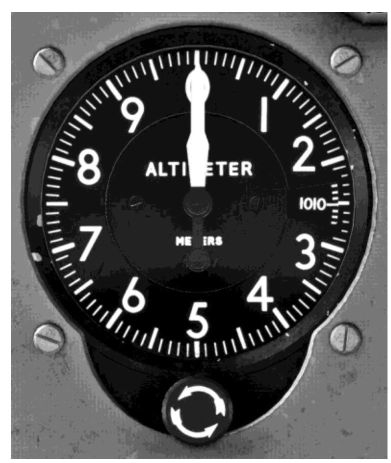
Measures forward airspeed. Three are fitted—two on the pilots' panels, one on the navigator's—each on an 80 mm ring. It measures total-minus-static pressure with aneroid density correction. Scale: 100–1200 km/h, 10 km/h divisions, numbered every 100.

MACH NUMBER INDICATOR WITH ELECTRICAL SIGNALING MS-1-0.65

Measures Mach and signals when a set Mach is reached; on the left pilot panel. A pressure box measures velocity head, an aneroid box measures static pressure (sealed housing fed by static and total-pressure lines). The signaling device opens/closes a circuit at a set Mach. Scale: 0.5–1.0, 0.01 divisions, numbered every 0.1.

ALTIMETER VD-10

A two-hand barometric altimeter for relative altitude; two on the pilots' panels, one on the navigator's. Its aneroid-capsule block connects to the static line. A winding knob zeroes the hands; a barometric scale and two indices set landing-field pressure for altitude in meters/kilometers. A conventional feet-scale altimeter is also fitted on the left pilot's main panel.



VARIOMETER VAR-30-3

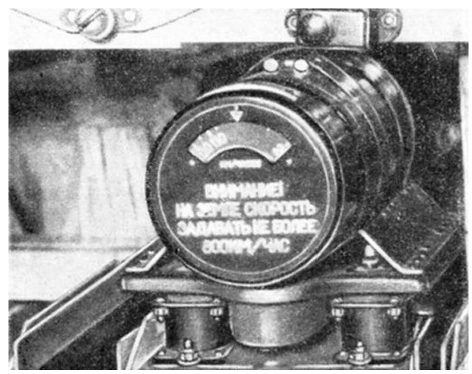
Measures vertical speed (m/s), also serving as a level-flight indicator and, in pressurized cabins, a cabin-pressure-stability monitor. Two are on the pilots' panels. It measures the pressure difference between a sealed case and the atmosphere via a capillary: pressure lag creates a difference proportional to climb/descent rate, sensed by a diaphragm box driving the needle.

NAVIGATION INDICATOR NI-50BM-1

An autonomous instrument showing the aircraft's position in conventional coordinates. Kit: DVS airspeed sensor, AK-1 course computer, ZV-1 wind setter, P-1 thermo-corrector, counter. The AK-1, counter, and ZV-1 are on the navigator's panel; the DVS is under the table; two P-1 correctors are outside under the canopy windows.

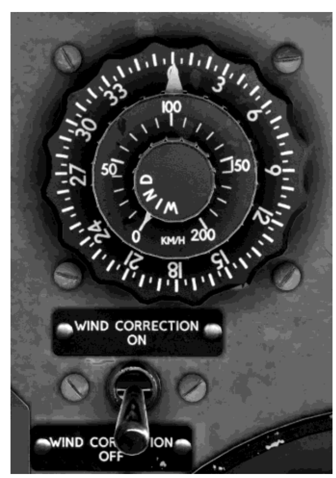
It dead-reckons by integrating two ground-speed components over time. Heading comes from the KS-6; airspeed from the TP-156 and static ports; wind is entered manually. It works with the RPSN-2: with the M-series RPSN-2, only one AK-1 is fitted, and the "Radar–NI-50BM" switch (unit No. 4Sh) goes to "Radar," connecting the path-counter integrating motors to RPSN-2 speed potentiometers.

AIRSPEED SENSOR



Senses total/static pressure and air temperature, converting them to a DC voltage proportional to true airspeed (diaphragm-aneroid assembly). Temperature correction is automatic via a resistance thermometer. The TAS voltage feeds the AK-1, which—with the ZV-1—forms a multiplication system producing ground-speed projections on the X and Y axes.

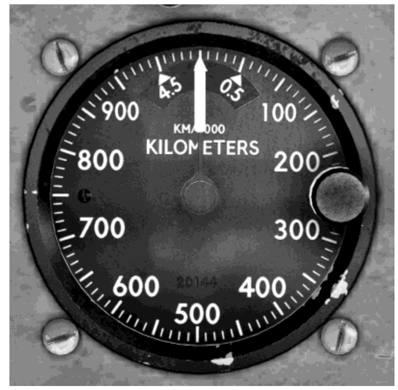
WIND SETTER ZV-1



A potentiometric system for entering wind speed/direction via two knobs. The "WIND" speed scale: 0–200 km/h, 5 km/h divisions. The "Map Angle" (direction) scale: 0–360°, 5° divisions, rotating against the fixed U-K index.

LATERAL MOVEMENT COUNTER

Ground-speed-component voltages drive integrating motors that move two pointers (X = "Z", Y = "S") showing distance traveled in kilometers, transferred to a map grid via a supplied stencil. The main fixed scale: 0–1000 km, 10 km divisions. A second rotating scale below counts thousands along Y: 0–5000 km, every 500. Maximum: 5000 km (Y), 1000 km (X). A knob zeroes the pointers. It works with the wind setter and the True Airspeed setter on the navigator's RPSN-2 instrument.



AGD-1 ARTIFICIAL HORIZON

Determines attitude relative to the true horizon plus slip presence/direction, using a three-degree pendulum-corrected gyro maintaining its main axis vertical. The face has a spherical screen, a horizon bar, an aircraft silhouette, a bank scale, a slip indicator, a launch button, and a silhouette-adjust handle. Pitch and (approximate) bank read from the silhouette vs. horizon; bank reads via the vertical index on the bank scale (range 45°, 15° divisions). Lateral correction cuts off above 0.3°/s (works with the VK-53RB). Two are on the pilots' panels; the right pilot's backup is a UG indicator from the CGV-4.

ACCELEROMETER AM-10

The AM-10 accelerometer is designed to determine the overloads acting on the aircraft in the direction perpendicular to the wing plane, during flights in "turbulence" and during test flights.

The unit of acceleration measurement is the acceleration from the force of gravity, equal to 1G (981 cm/sec^2). The accelerometer is installed on the left panel of the pilot’s instrument board.

MAGNETIC COMPASS KI-13

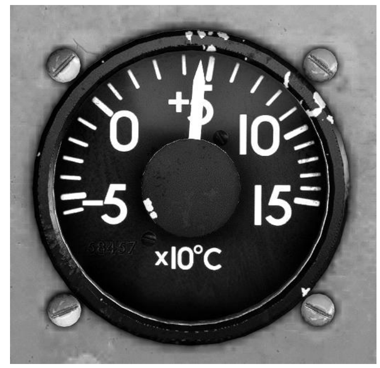
A liquid-magnetic compass for magnetic heading, mounted on the central canopy frame above the panel. Its permanent magnets interact with Earth's field; the vertical card scale has 5° divisions numbered every 30°, with "N" and "S" marked. Course reads against the line between glass and card.

TURN INDICATOR EUP-53

A gyroscopic instrument for correct turns up to 45° bank at 500 km/h; on the left pilot panel. It uses a two-degree gyro aligning its spin axis with forced rotation. Combined with the variometer, it indirectly backs up the artificial horizons.

OUTDOOR AIR THERMOMETER TNV-15

A single-arrow electric thermometer: a P-5 sensor (on the nose skin, starboard) and a TNV-1 indicator (navigator's panel). Nickel wire changes resistance with temperature; the TNV-1 is a magnetoelectric ratiometer with two frames. Scale sweep 210°, marked −5° to +15°; "X10°C" means multiply by 10.



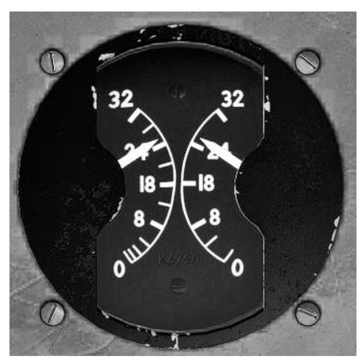
INSTRUMENTS MONITORING THE OPERATION OF THE POWER PLANT

Monitor engines, fuel, and oil systems. List: MES-1897A oil gauges (2); UPRT-2 lever indicators (2); TVG-26 exhaust thermometers (4); ITE-2 tachometers (4); RTMS-1.2-51 flow meters (2); SETS-280 fuel gauges (4); EMI-3R indicators (1); UYUZ-4 flap indicators (2); 2EDMU-100 thrust manometers (2).

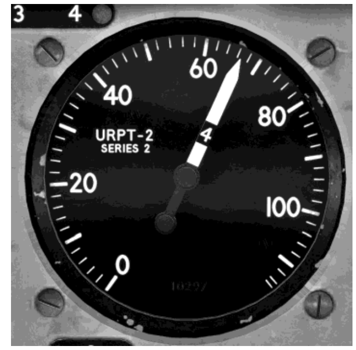
DESCRIPTION OF INDIVIDUAL INSTRUMENTS

OIL GAUGE MES-1897A

Two-pointer electric oil gauge; the set is four rheostat sensors and two indicators (one per two engines), on the left pilot panel. Resistance changes with oil quantity; low-oil signaling triggers at 5 L (252 mm from the flange). Two scales (left/right engine): 0–32 kg/cm², numbered 0/8/16/24/32, 4 kg/cm² divisions

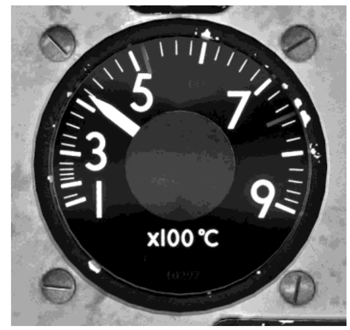


TWO-POINTER FUEL UNITS LEVER INDICATORS UPRT-2



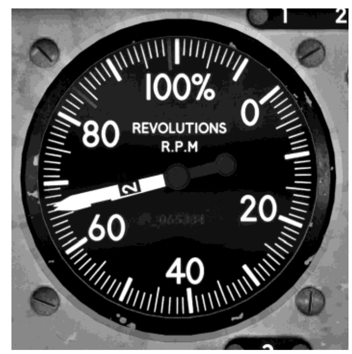
Indicates the KTA-5F fuel-unit lever positions; four sensors and two indicators (central panel). A three-wire potentiometric system (ring potentiometer + three-coil logo-meter): the sensor shaft follows the fuel-unit shaft, redistributing logo-meter current. Scale calibrated in degrees: 0–105°, numbered every 20° to 100°, 2° divisions.

SINGLE-POINTER EXHAUST GAS THERMOMETER TVG-26



Single-pointer thermoelectric; the set is four TVG-2 indicators (central panel) and 16 T-6 thermocouples. Uses thermocouple EMF; four series thermocouples form a thermopile per system, measured by a millivoltmeter. Scale: 100–900 °C.

DUAL-POINTER TACHOMETER ITE-2

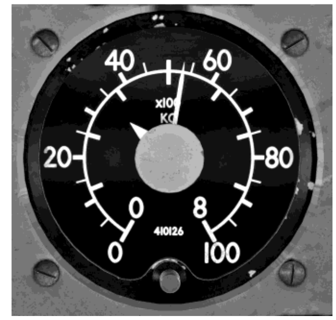


Magneto-induction, % of max RPM; four DTE-1 sensors and two indicators (one per two engines, central panel). The sensor generates a frequency proportional to shaft speed, powering a synchronous motor driving the needle. Scale: 0–105%, 1% divisions; needles numbered 1–4 (left to right).

FLOW METER RTMS-1,2-B1

Measures hourly fuel consumption and reserve per wing half (kg); set to fuel loaded before flight; on the left pilot panel. Fuel drives two impellers proportional to flow. The hourly sensor's magnet drives a Selsyn-transmitter cup (TRP-52-powered) to the indicator (0–1200 kg/h, numbered every 2). The total-consumption sensor uses an inductive-pulse AC bridge (PT-56 thyratron interrupter): a steel core changes coil inductance, the imbalance is amplified by the TG1-0.1/1.3 thyratron, and pulses drive a ratchet/digital counter showing reserve (loaded minus consumed). Upper limit 9990 kg—multiply counter by 10.

FUEL GAUGE SETS-280



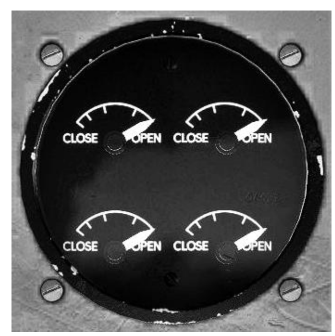
Capacitive; measures total fuel per wing half, per tank group, and in supply tanks; signals reserve. (Refueling functions INOP.) On the central panel. Each wing-half measuring part: power transformer, measuring bridge, amplifier, switching elements, indicator. Capacitor sensors (coaxial pipes with air gap) change capacitance with fuel, measured by self-balancing. Two scales: outer (total/group, 10000 kg, 500 kg divisions), inner (main tanks, 800 kg, 50 kg divisions). AC bridges handle consumption order, reserve signaling, and refueling control.

THREE-POINTER INDICATOR EMI-3R

The three-pointer electrical indicator EMI-3R serves for remote control of engine operation and is a combined instrument measuring fuel pressure, pressure, and oil temperature. The indicators are installed on the central panel of the pilots' instrument board, the sensors in the corresponding engine lines.

1) Fuel pressure: corrugated diaphragm → potentiometer; four-wire transmission to a four-coil ratiometer.
2) Oil pressure: corrugated membrane → potentiometer in a bridge circuit with a magneto-electric ratiometer.
3) Oil temperature: resistance sensor in a bridge with a moving-magnet ratiometer.

FOUR-POINTER OIL RADIATOR FLAP INDICATOR UYUZ-4



Four-pointer magneto-electric logo-meter controlling the MVR-2V oil-radiator flap positions. Four unnumbered scales marked "Closed" (left) and "Open" (right).

DUAL-POINTER ELECTRIC MANOMETER

Measures engine torque (thrust). Set: two 2I-100 indicators (central panel) and four D-100 sensors (one per two engines). Like the EMI-3R, it uses a moving-magnet ratiometer bridge (potentiometer = two variable arms). Torque change disturbs the bridge, rotating the magnet/needle to mark the torque.

CHAPTER VII – AIRCRAFT OXYGEN SYSTEM

The system supplies oxygen to crew and passengers. Only the flying pilot must use oxygen continuously above 4000 m (on cabin depressurization); other crew use it only in emergencies. Passengers use portable cylinders. It is a low-pressure system at an initial 30 kg/cm^2.

Pilot equipment: two KP-24M devices, two IP indicators, two KM-16H masks—the KP-24M on a console wall bracket, IP indicators on the front inclined panels, masks in the console boxes. Other crew (navigator, radio operator, engineer, attendant): the KP-32 device (inner side of the right console's front inclined panel), four IK-32 indicators, four KM-15M masks. The engineer's indicator is above the engineer's table; two are at the navigator's workplace (navigator and engineer); the attendant's is in the buffet's left stand. Crew mask bags are stored with the pilots' masks in the console boxes.

Oxygen control/monitoring devices on the right console front inclined panel: the KV-5 supply valve, MK-13M gauge (portable-device pressure), KP-32 device ("Emergency Oxygen"), and MT-60 gauge (behind the KP-32). The reserve is two stationary KB-1 cylinders and ten portable KB-3 cylinders; the KB-1 are along the right side of baggage compartment No. 1 (frames No. 9–13), clamped to the stringer.

Portable KB-3 cylinders with KP-21 devices are stored in a screwed-down box on the left of the front vestibule (frames No. 16–17A), with mask bags tied to each cylinder neck. The pipeline runs along the right side, branching at the cockpit to all crew stations. The system charges through a starboard fitting at frame No. 13 ("Oxygen charging up to 30 atm"); a KR-15 reducer drops pressure from 150 to 30 kg/cm^2 .

Installation of the oxygen system control panel on the right pilot's panel

OXYGEN SYSTEM OPERATION

Oxygen from the KB-1 cylinders flows to the KV-5 valve (right panel), which when "Open" supplies two lines: the pilots' line and the other-crew line. The pilots' line feeds both KP-24M devices (one fitting to the IP indicator, one to the mask). The other-crew line feeds a KP-32 device, then the MT-60 gauge and four IK-32 indicators, then masks. Passengers use portable KB-3 cylinders with KP-21 devices and KM-15M masks. All cylinders use medical oxygen.

CHAPTER VIII – INSTRUMENTS OF PRESSURIZATION, HEATING AND VENTILATION SYSTEM

The Il-18's pressurized cabin (240 m^3, ventilation-type) is pressurized, heated, ventilated, and humidified by air bled from all four engine compressors. Bleed air ranges 2500–3900 kg/h depending on supply temperature; the system works with two or three engines running. Pressure, temperature, and humidity are maintained automatically with sufficient air exchange; the crew only monitors and intervenes on failure (switching to manual temperature control.

PLACEMENT OF EQUIPMENT ON THE AIRCRAFT

Pipelines run under the floor; heating ducts run above the floor behind both side fairings (heating boxes replace ducts at the center section and rear cabin), with compensators in hot-air pipes/ducts. Check valves sit at hot-air merge points, behind pressure limiters, behind radiators, and at the pressurized-fuselage entry.

Outside the pressurized fuselage: two air-to-air radiators in the electrical compartment (frames No. 24–26, each on four mounts, three free-moving for thermal expansion); two MZK-2-driven air-supply dampers in the hot pipe; absolute-pressure limiters behind the dampers; a turbo-cooler (frames No. 27–28) on rubber mounts; and the MPK-1-driven bypass damper block with bypass valve (frames No. 28–29). A silencer and the air-flow sensor sit before the pressurized entry.

Inside: two hot-air mixing throttles—crew-cabin line (frames No. 4–5) and passenger-cabin line (frames No. 33–34)—with MRT-1 electro-mechanisms on frames No. 4 and 34. A mechanical windshield-defog damper (frame G) has its knob on the right panel. Temperature limiters, silencers, and humidifiers sit in the heating lines. Cockpit thermostat: frame No. 4; passenger thermostat: frames No. 53–54, left. Pressure regulators/safety valves are near the toilets (frames No. 19–19A starboard and frame No. 56) and above the floor to avoid water flooding.

Control panel of the de-pressurization, heating and ventilation

1) height indicator and pressure drop indicator - **2)** switch for the depressurization valve – **3)** air flow meter indicator – **4)** air thermometer TUE-48 for the window blowing line – **5)** switch for left starting flap control system – **6)** switch for right starting flap control system – **7)** signal lamps controlling the position of the starting flaps – **8)** air thermometer in the crew cabin – **9)** air thermometer in the passenger cabins – **10)** air thermometer for the individual ventilation line – **11)** air thermometer for the crew cabin heating line – **12)** air thermometer TUE-48 for the passenger cabin heating line – **13)** temperature setting device from the RTA-16-6 kit - **14)**, **15)**, **16)** switches from automatic to manual regulation of air temperature in the cabin heating lines and in the individual ventilation line – **17)** lamps signaling air overheating in the cabin heating lines and the triggering of 753A temperature limiters – **18)** lamp signaling that the temperature behind the turbo-cooler, set by the RTA-16-6 setter, has been reached - **19), 20)** pressure and file alarming systems - **21)** pressure and file alarm system test button – **22)** exit open alarm system switch – **23)** on ground air ventilation switch - **24)** on ground air ventilation indicator lights

REGULATION OF FLOW AND TEMPERATURE OF AIR ENTERING THE CABIN

Compressor air, combined per side, feeds fuselage units (check valves prevent leakage when an engine stops). Per-side on/off valves (MZK-2-driven, separate control, no intermediate stops) join absolute-pressure limiters holding 3.1 ± 0.2 ata. Air then splits into a cold line (through radiators and turbo-cooler) and a hot line.

The cold line maintains ~2500 kg/h via a critical Venturi tube and a bypass valve. Constant pressure behind the units holds only to ~6 km; above that the units stay fully open and the critical-tube flow drops with pressure, so the bypass valve (sensing the tube pressure drop) opens windows to keep total flow ~constant. It begins opening at a 1.8 ± 0.2 kg/cm^2 drop; the tube doubles as the air-flow meter (URVK), with 3.6–5.2 units indicating normal operation.

Behind the turbo-cooler, temperature is held constant (settable +5 to +55 °C, +15/+20 recommended) by the RTA-16-6 regulator with a valve block (sensor D-2 behind the turbo-cooler). The RTA-16-6 has two linked valves—one in the turbo-cooler bypass, one in the hot-line redirection—driven by the MPK-1: heating opens them, cooling closes them. The hot-line valve opens only after the bypass valve is fully open, unloading the turbo-cooler. Valve positions track post-turbo-cooler temperature automatically; the regulator can be turned off for manual control (don't set below +10 °C to avoid moisture freezing). A 507A silencer follows the noisy 519A turbo-cooler. A 503A limiter in the hot line drops it to 1.45 ± 0.15 ata for stable mixing-damper operation and altitude-independent hot-air supply to windows and lavatories. Check valves isolate damaged units while the rest of the network keeps working.

AIR DISTRIBUTION IN THE PRESSURIZED CABIN

Two pipes enter through the frame-No. 32 wall: cold (right) and hot (left), with check valves preventing rapid depressurization on damage. Under the floor, cold air branches via critical tubes to passenger-cabin heating and the right/left individual-ventilation boxes; three silencers reduce noise. The hot pipe distributes to crew/passenger heating, windscreen blowing, and lavatory heating. Air enters the cabin via the individual-ventilation system, cabin heating, windscreen-blowing line, and lavatory heating line.

INDIVIDUAL VENTILATION SYSTEM

Two ventilation boxes, discharge valves, and ball nozzles serve seats, crew stations, lavatories, and the buffet. Constant air supply keeps all nozzles working; discharge valves relieve excess (each vents ~30 kg/h at 0.04–0.045 kgf/cm^2), keeping the box under slight excess pressure for uniform, quiet operation. The right box feeds windscreens, the crew cabin, buffet, and radio-compartment ventilation; the left box feeds the astrodome DUK block.

CABIN HEATING SYSTEM, FRONT VESTIBULE, BUFFET AND LAVATORY ROOMS

The passenger heating line holds ~+20/+25 °C by mixing cold (~1300 kg/h, dosed by a critical tube) and hot air (0–700 kg/h via a TRTVK-45M-controlled throttle), giving a +15 to +80 °C mixture (at RTA-16-6 = +15 °C); total 1300–2000 kg/h. Air passes a silencer and humidifier into above-floor ducts (compensator-jointed, ~0.06 kg/cm^2 excess for even distribution) and enters via resistance boxes. The center-section and rear-lounge sections use boxes; vestibule/buffet get end grilles; front toilets are fed like the cabins; the rear toilet has a calibrated nozzle. The cockpit line mixes cold (~220 kg/h from the right vent duct) and hot (0–120 kg/h) for +15 to +80 °C; total 220–340 kg/h, then silencer/humidifier to the pilots' pedals and the engineer/navigator seats.

COCKPIT WINDOW DEFROSTING LINE

Protects windows from fogging/freezing by blowing hot air onto four front windows and two vents through nozzles (3 mm perimeter gap, 5 mm from glass). Air mixes from the right vent duct (~100 kg/h) and the hot line via a critical tube (60 kg/h), giving +15 to +100 °C—but never above 100 °C, so monitor the right-panel thermometer. A mechanical shut-off valve (right panel) regulates temperature and can close to cool the cockpit, leaving the windows on individual-ventilation air. A cold-weather damper and an output silencer are also fitted.

HOT LINE

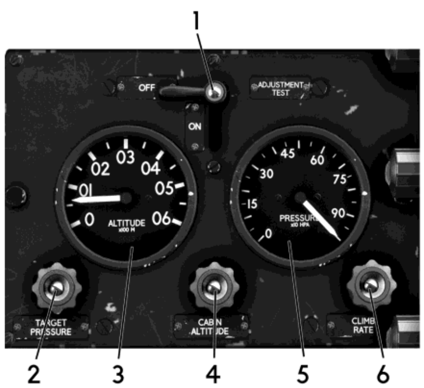
Supplies hot air to cabin heating, window defrosting, and TG-16 heating (~120 kg/h), plus fuel-tank/pipe heating, dosed by critical tubes (~30 kg/h each at ~1.5 atm inlet).

PRESSURIZED CABIN VENTILATION

Total supply 2500–3900 kg/h. Apart from ~210 kg/h to restrooms/TG-16, all air enters the cabin upper part; the underfloor is heated/ventilated by "exhaust" air. The Il-18 achieves 20–30 air changes per hour.

PRESSURE REGULATION

From the ground to ~5000 m, constant absolute pressure (760 mm Hg ground) is held, with excess pressure rising to $\Delta\rho = 0.5 \pm 0.02$ kg/cm^2 at 5000 m and constant thereafter. At 8000 m the cabin "altitude" is 1500 ± 300 m; at 10000 m, 2500 ± 300 m. Two regulators hold the set values to ±15 mm Hg and protect against sub-atmospheric pressure



Control panel of the cabin pressurization

1) main pressurization system switch – **2)** target cabin pressure setting knob – **3)** cabin altimeter (meters) **4)** target cabin altitude setting knob – **5)** cabin pressure (Hpa) – **6)** climb rate setting knob

Safety valves release at $\Delta\rho = 0.545 \pm 0.02$ kg/cm^2. A solenoid valve allows forced discharge (switch on the panel), permitted only when truly necessary (e.g., rapid post-landing depressurization or emergency egress). From ground to 5000 m the cabin pressure-change rate is zero (independent of vertical speed), allowing any climb/descent through cloud without discomfort. Above 5000 m the rate equals the aircraft's vertical speed (e.g., 0.4 mm Hg/s at 6000 m, 0.18 at 8000 m); during rapid descent the 469M regulator limits the rise to 0.5–1.5 mm Hg/s.

TEMPERATURE REGULATION IN THE CABINS

Independent automatic control for cockpit and passenger cabin; each has a thermostat, a reversible electro-mechanism (moving the throttle damper), and a bimetallic limiter. A cabin-temperature change moves the bimetallic-spiral armature, energizing the electro-mechanism to open/close the damper. To counter spiral inertia (which causes over-regulation), feedback via an electromagnet (fed by an electro-mechanism potentiometer) acts opposite to the spiral, anticipating the correction. The setpoint adjuster (+16 to +26 °C) is on the device; +20 °C is recommended.

The bimetallic limiter protects against over-hot air: at 80 ± 2 °C it breaks the damper-opening circuit; if temperature still rises, at 110 ± 2 °C it closes the damper regardless of the thermostat. A four-position switch can disconnect the thermostat for manual control (+15 to +80 °C at RTA-16-6 = +15 °C); the limiter still functions. A red lamp under the switch confirms limiter operation at 110 ± 2 °C. Thermostats sit in the exiting-air flow to react to average cabin temperature.

CONTROL INSTRUMENTS AND SYSTEM MANAGEMENT

Instruments monitor pressure, supply, and temperatures. Ground-A/C fittings (frames No. 6–7, 51–52, sealed hatches) plus tightness-check fittings are to international standard; ground air enters via fabric ducts and floor openings (covered after use). Doors must be closed during heating/cooling.

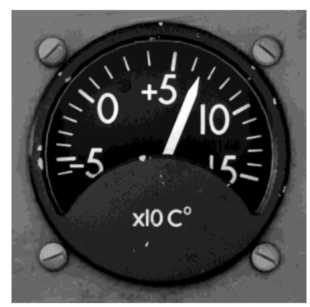
URVK AIR FLOW METER INDICATOR

A single-pointer indicator with a Venturi-tube sensor (behind the turbo-cooler/silencer) measuring air entering the cabin. The wide-section line feeds the manometer box, the narrow section the aneroid box; the axis rotation depends on both the wide/narrow pressure difference and the narrow-section pressure

ALTITUDE AND DIFFERENTIAL PRESSURE INDICATOR UVPD-20

Combines a cabin-"altitude" indicator (aneroid capsule) and a differential indicator (manometric capsule) in one housing, on the right panel. Aneroid movement, via a crank, drives the altitude dial (km, read through a top window); manometric movement drives the differential needle.

THERMOMETER TUE-48



Single-pointer electric thermometer for hot-air temperature in heating/window-blowing lines; indicator plus P-1 sensor. Three sensors: passenger-heating, crew-heating, and window-blowing pipes. A heat-sensitive resistance and a magneto-electric logo-meter drive the needle; "X10°C" means multiply by 10.

THERMOMETER TV-11

Single-pointer electric thermometer for averaged individual-ventilation air temperature; a TV-1 meter plus three P-1 sensors (in the passenger vent pipe behind the turbo-cooler/muffler). Operation matches the TV-19.

PRESSURIZATION, HEATING, AND VENTILATION SYSTEM OPERATION IN FLIGHT

Turn on engine bleed air after takeoff at 200–400 m and 270–300 km/h (switches to "Air supply from engines"); the red lamps go out. A serviceable system needs no intervention. Manual temperature control is allowed only on automatic failure or to speed heating/cooling. Do not exceed +25 °C (individual ventilation) or +115 °C (heating lines—red "Dangerous overheating" lamps indicate limiter activation). A brief rise to 135 °C is allowed for ≤3 min (limiter inertia).

The green "Set temperature" lamp should stay lit at the set individual-ventilation temperature with normal RTA-16-6 operation; it goes out when changing the setter and relights at temperature (flashing allowed). If it stays out 5 min, check the thermometer; if off-target, switch to manual. Set window-blow temperature with the right-panel damper, never above 100 °C. Normal air-flow: 3.6–5.2 units; if above 5.2, isolate the failed unit by alternately cutting right/left engine air. To avoid depressurization above 3000 m, don't stop cabin air for >3 min. If flow drops below 3.6, check pressure/altitude—if normal, continue; otherwise descend to 3000 m.

Cabin overpressure rises to 0.48–0.52 kg/cm^2 by 4500–5500 m, then stays constant (cabin "altitude" 1500 m at 8 km, 2500 m at 10 km; ±300 m tolerance). With passengers, the VR-10 cabin-altitude-rate must not exceed 3 m/s during climb/descent.

EMERGENCY DESCENT

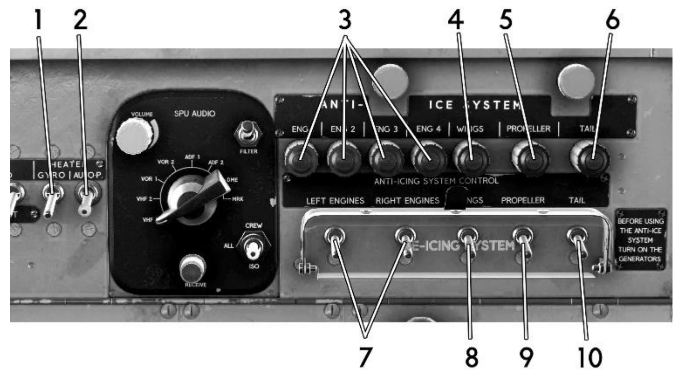
At 3 km during descent, stop with maximum allowed vertical speed until cabin altitude reaches 1500 m. Switch off heating/cooling/ventilation and open "Depressurization." After a long air-supply break the process may lag; perform depressurization only after switching off heating/cooling/ventilation. Depressurize smoothly to 200–300 m, stabilizing cabin altitude at 1500 m.

CHAPTER IX - ANTI-ICING SYSTEM CONTROL INSTRUMENTS

GENERAL INFORMATION

De-icers ensure safety in icing at any altitude, speed, and duration. Protected: wings and tail; propeller blades and hubs; engine air intakes; the four front canopy windows. When switched on, protected surfaces rise above 0 °C, preventing ice and shedding deposits. Engine-intake de-icers run continuously; glass de-icers keep the outer surface at +35 ± 5 °C; wing/tail/propeller de-icers run cyclically (a heating period sheds ice, a cooling period lets a thin layer reform). Cyclical heating uses far less energy—the thin ice acts as insulator, and energy only breaks ice adhesion rather than melting all of it.

Icing onset is signaled by detectors in the engine intakes plus a visual detector on the canopy under the right pilot's windows (a pinned strut in 10 mm sections for measuring ice thickness/intensity).



Control panel of the anti-icing system.

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

PLACEMENT OF SYSTEM AGGREGATORS ON THE AIRCRAFT

Icing detectors are in each engine intake duct (screwed to the engine bracket). The wing and propeller program mechanisms are on the electrical-compartment ceiling (frames No. 24–26, left and right of the axis); the tail mechanism is in the rear unpressurized compartment near the tail distribution device. Contactors sit in the relevant distribution units (center-section in the inner-nacelle CRU, outer wing at the panel end, tail in the rear CRU, propeller in the AC CRU). Thermo-switches sit on the inner skin of the anti-icing boots in special casings.

WING AND EMPENNAGE ANTI-ICERS

Structurally identical, powered by the 28.5 V DC network. The multilayer anti-icing nose has an outer skin (1 mm wing / 0.5 mm tail), 0.5 mm inner skin, insulation, and a heating element. The element covers 10% of the wing chord on the upper leading edge and 6–7% on the lower (8% on the tail), built from fiberglass with brass busbars, constantan wire (0.15 mm wing / 0.12 mm tail), and brass washers (for fastening bolts), with two 0.3 mm fiberglass insulating layers between skins. Current terminals exit through the inner skin; protective plastic flanges prevent shorts. Thermo-switches sit in minimum-heat-removal/peripheral "thermal-knife" zones, one per control contactor.

One to three elements per leading edge, with unheated joints up to 80 mm wide. Specific power varies 0.6–1.42 W/cm^2 via wire pitch: the central "thermal knife" (leading edge) is 1.3–1.42 W/cm^2; the peripheral knife 0.95–1.2 W/cm^2; other zones 0.6–0.8 W/cm^2. Wing/tail elements split into four sections I–IV.

Operation: With the engineer's "Anti-icing wing"/"Tail" breakers and the panel "Wing"/"Tail" switches on, the program mechanisms pulse the contactors to switch sections I–IV sequentially. Cycle time 154 s, duty 1:4 (~38.5 s heat, ~116 s cool). Thermal switches in the contactor-control windings de-energize overheated sections. First-section signal lamps ("Wing"/"Tail") flash ~every 116 s for ~38.5 s, confirming correct operation.

For even generator loading, all sections on one mechanism have equal power, with only one wing and one tail section on at a time (symmetric left/right). Total wing+tail power ~184 kW; each wing section ~35 kW, each tail section ~11 kW—so operating power ~46 kW, suppliable by four DC generators (usable even with two engines failed if DC loads are shed).

PROPELLER ANTI-ICING

Electro-thermal, powered by SGO-8 AC generators (115 V, 400 Hz), transferred to the rotating propeller via a TS-5 current collector and contact-ring block on each engine. Blade elements sit in leading-edge recesses (54% span, 17% chord); specific power constant along chord, varying 1.97 W/cm² (root) to 1.47 W/cm² (tip). The blade element is fiberglass-insulated steel tape (0.1–0.12 mm), covered by a 0.3 mm steel "petal" lining; power 1.6 kVA per blade. The hub-fairing element (under a 2 mm aluminum skin, 110 mm long) is constantan tape (0.2 mm) with a 0.8 mm magnesium inner skin; constant 1.23 W/cm², 1.17 kVA. Elements connect in parallel; per-propeller consumption 7.57 kVA.

PROPELLER ANTI-ICERS OPERATEION

Propeller anti-icers receive power from the anti-icer power buses, through PV-80 fuses, voltage is supplied to the control contactors in the AC central distribution board.

The control contactors are switched on by pulses issued by the program mechanism, with the control contactors of symmetrically located propeller engines No. 1 and 4 or No. 2 and 3 switching on simultaneously.

To turn on the propeller anti-icers, it is necessary to turn on the AZS circuit breaker under the stencil "Propellers and fairing" on the engineer's central distribution board and the switch under the stencil "Propeller" on the anti-icer panel, after which power will flow to the input of the program mechanism. The program mechanism ensures the operation of the propeller anti-icers with a cycle time of ~77 sec. with a duty cycle of 1:2 (during the cycle time the anti-icer is ~38.5 sec. on and ~38.5 sec. off). In the program mechanism, the control wires are routed to two plug connectors. To control the operation of the propeller anti-icers on the aircraft, only the group of terminals combined in plug connector No. 1 is used, and to ensure a cycle with a time of ~77 sec. with a duty cycle of 1:2, pin No. 4 of plug connector No. 1 is connected to pin No. 2, and pin No. 3 - to pin No. 5. To monitor the operation of the program mechanism, a signal lamp installed on the anti-icer panel under the stencil "Propeller" is connected to the control circuit of the contactors for turning on the anti-icers of propeller engines No. 1 and 4. If the program mechanism is operating correctly, the lamp lights up approximately every 38.5 sec. for ~38.5 sec. 38.5.

Operation: Power comes via PV-80 fuses to AC-CRU contactors, switched by the program mechanism—symmetric engines (1&4 or 2&3) switching together. Switch on the engineer's "Propellers and fairing" breaker and the panel "Propeller" switch. Cycle ~77 s, duty 1:2 (~38.5 s on/off). On plug connector No. 1, pin 4→2 and pin 3→5 give the ~77 s cycle. A "Propeller" lamp (tied to engines 1&4) flashes ~every 38.5 s for ~38.5 s

ENGINE INTAKE ANTI-ICING

Air-thermal, continuous; hot air from the last compressor stage. The system is on the left of each engine; the chamber rings the front intake edge, heating ~60 mm along the engine axis. Hot air (up to 280 °C) feeds a remotely electro-mechanism-controlled throttle valve. Switch on the engineer's "Engine I/IV, II/III Anti-Icing" breaker and the panel "Engine Intake" switch; the electro-mechanisms open all four valves and "Eng 1–4" lamps light. Air passes via an ejector into the chamber and is partly recirculated. Switching off de-energizes the relays, closing the valves and extinguishing the lamps.

ENGINE COMPRESSOR GUIDE-VANE ANTI-ICING

Each engine also has an air-thermal, continuous guide-vane system, MP-5-electro-mechanism-controlled via the panel "Eng." switch (detailed in the AI-20 engine description).

WINDSHIELD ANTI-ICING

The left/right pilots use electrically heated glass. Switch on via the engineer's "Control of windshield heating" breaker and the upper-panel "Left/Right glass heating" switches, feeding two AOS-81M heating breakers (inner and outer glass). On the ground (no airflow), reaching +35 ± 3 °C on a glass outer surface cuts its heating, which resumes below +35 ± 5 °C. In negative-temperature flight, the glass usually won't reach +35 ± 3 °C, so heating runs continuously.

CONTROL AND MANAGEMENT OF AIRCRAFT ANTI-ICERS

Wing, tail, propeller, and intake anti-icers are managed from the right-side anti-icer panel; heated glass from the upper panel. Wing/tail power is monitored by A-2 DC ammeters, propeller power by AF-100 AC ammeters (both at the engineer's panel)..

DESCRIPTION OF INDIVIDUAL UNITS AND ASSEMBLIES

SO-4A ICING INDICATOR

A differential pressure gauge with two chambers joined by a jet: a dynamic/static intake (a capped hollow cylinder with 0.7 mm pressure holes and 0.5 mm drains, plus an internal heater) and an electrical differential gauge. The static chamber vents via eight 2.5 mm holes and connects to the gauge's static chamber. A support heater (switched on earlier than the intake heater, at ~250 mm-water dynamic pressure) prevents support icing. Operation: with no airflow the contacts are closed; airflow opens them via velocity head. In icing, the intake holes clog, pressures equalize, the membrane returns, and the contacts close—triggering the "Icing" lamp and the intake heater. The heat clears the ice, reopening the contacts and cycling. De-icing of the holes takes ≤150 s; a full cycle ≤240 s. Detectors operate independently on two parallel "Icing" panels.

PROGRAM MECHANISM PMK-12

Controls cyclic de-icer operation of the wing, tail, and propellers via KM-100D/200D/400D contactors. It has a limit-switch block, program cams, a reducer, and a D-2R motor on rubber-mounted base, with two plugs for the parallel limit-switch groups.

THERMAL SWITCH AD155A-6K

Disconnects wing/tail heating elements above +40 ± 10 °C and reconnects below +30 ± 10 °C. A bimetallic plate carries the movable contact: below +40 ± 10 °C it holds the contacts closed (current flows); above that it bends open (heating cut); at +30 ± 10 °C it recloses.

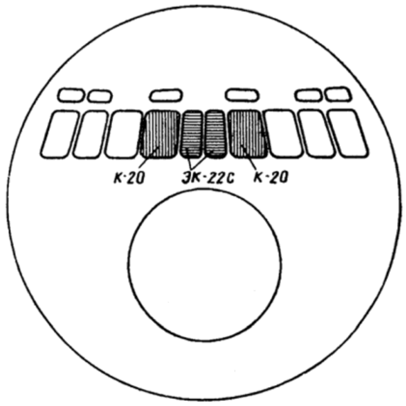
SLIP RING TS-5

Transfers AC power to propeller de-icers on each AI-20 engine; a two-channel cast housing with insulated bushings (spring-pressed against copper contact rings rotating with the propeller). Conductors from each bushing group join a terminal to a plug connector. The contact-ring block (steel frame, insulating washers, rings, cover) carries terminal leads from the blade and hub-fairing anti-icers.

ENGINE AIR INTAKE ANTI-ICER EJECTOR

Lowers and increases the volume of compressor-bleed air before the chamber by mixing in engine-compartment air, also saving compressed air by recirculating spent warm air. It has an inlet pipe (studded to the throttle valve and ejector) and a nozzle that accelerates the air to sonic speed, drawing in compartment air through diffuser holes, mixing in the outlet diffuser. The pipe/diffusers are aluminum alloy; the nozzle is stainless steel.

ELECTRICALLY HEATED GLASSES



Electrically heated glasses in the cockpit canopy

Used as the front canopy windows, AT-type-transformer-powered; types EK-22S and K-20 differ only in area/power. The glass has a 4 mm non-structural outer glass (inner-surface buses and conductive film), a 12 mm structural middle glass, and an 8 mm load-bearing inner glass, all bonded with butyral film, framed in aluminum, with a terminal block for busbars and thermistors. Two TOS-M thermistors (one spare) form a bridge arm of the heating automation.

GLASS HEATING AUTOMATON AOC-81M

Automatically controls EK-22S/K-20 temperature. A chassis-and-panel plus casing; three relays and three polarized differential relays, six resistors, three capacitors; shock-mounted. Three channels, each a bridge with a polarized differential relay plus a load-unloading regular relay driving the contactor. One bridge arm is the TOS-M thermistor; two are the differential-relay coils (equal turns, opposed); the fourth is an adjusting resistor. When balanced, no diagonal current flows; glass cooling shifts the thermistor resistance, unbalancing the bridge—one coil's flux exceeds the other and the relay triggers, switching the heater.

USE OF ANTI-ICING SYSTEMS IN FLIGHT

Switch propeller, intake, guide-vane, and windshield anti-icers on before the icing zone and off only after leaving it. Monitor propeller anti-icers via AC ammeters (60–70 A per generator) and panel lamp flashing. Intake anti-icing is confirmed by the green panel lamps.

Switch wing/tail anti-icers on after ice forms (the "Icing" sign lights or ice deposits on the visual indicator). Warning: switch on at least six generators first. Monitor via DC ammeters and signal lamps 2/4; correct operation raises the total ammeter reading by ~1800 A

Use of anti-icers in emergency flight conditions:

a) If four starter-generators fail (their breakdown or shutdown of two engines), switching on the wing and tail anti-icers is permitted, however, before switching them on, it is necessary to disconnect the maximum number of DC consumers
b) If the outer glass of the K-20 and EK-22S electric heated glazing is destroyed in flight, it is necessary to switch off the heating of this glazing. Flight can be continued in this case, and upon return to base, the glazing must be replaced with a subsequent check of the cabin for airtightness.

END OF DOCUMENT

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