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# Ty-16 AIRCRAFT OPERATING LIMITATIONS

1. The maximum take-off weight is 75.8 tons.
2. The normal design landing weight is 48 tons.

Note: Landing with a gross weight exceeding 50 tons is FORBIDDEN. In emergency cases, landing with a gross weight of up to 55 tons is permitted under the condition that it will be made on a concrete runway with utmost attention on the part of the pilot.

3. During flight the IAS should not exceed:

IAS=645 km/hr for gross weights from 75.8 to 70 tons at altitudes from 0 up to 7000 metres.

IAS=685 km/hr for gross weights from 70 to 55 tons at altitudes from 0 up to 6250 metres.

IAS=700 km/hr for gross weights of 55 tons and less at altitudes from 0 up to 6000 metres.

IAS=420 km/hr at all altitudes with the undercarriage down.

The values of the indicated airspeed are given with account of aerodynamic correction of the airspeed indicator equal to minus 10 km/hr.

4. The permissible aircraft accelerations and the values of the angles of bank considerably vary, depending on the weight, altitude, and flying speed, whereas the minimum airspeeds change versus the weight and flight altitude. While studying the flight mission, the aircraft commander should determine the take-off and landing characteristics of the aircraft and the permissible values of aircraft accelerations, angles of bank, and minimum airspeeds according to the charts.

5. The maximum permissible indicated Mach number is equal to 0.9. As an exception, at altitudes above 10,000 m. it is permitted to employ a descending manoeuvre, at which the Mach number may exceed 0.9.

6. The maximum permissible IAS with deflected flaps:
-400 km/hr at the flaps deflection angle of up to 20°;
-340 km/hr at the flaps deflection angle exceeding 20°.

7. The maximum permissible IAS during extension and retraction of the undercarriage is 400 km/hr.

8. The operational location of the centre of gravity (CG):
- forward C.G. limit is 18.4% MAC;
- aft C.G. limit is 32.3% MAC.

WARNING: 1. To ensure normal landing, the aircraft should have the operational location of the centre of gravity equal to 21.7% MAC. During landing with more forward location of the centre of gravity, it is necessary to increase the landing speed by 8 to 10 km/hr per each per cent of the centre of gravity location.

2. It is necessary to take into account the instrumental correction for all the given values of the IAS and Mach numbers. The Ty-16 aircraft has a small reserve of longitudinal stability during flights at the aft operational location of the centre of gravity. Due to this fact, the crew should pay utmost attention to maintaining the prescribed speed and altitude of flight while flying the aircraft with the location of the centre of gravity close to the aft.

9. With cross-wind velocity in excess of 15 m/sec. at an angle of 90° to the runway, the take-off clearance must not be given to the Ty-16 aircraft.

## Part One

## AIRCRAFT MAINTENANCE AND OPERATION

### I. PRE-FLIGHT INSPECTION

### Pre-Flight Inspection of Aircraft

10. The commander of the ship begins the exterior inspection from the nose section of the fuselage and carries it out according to the route of aircraft inspection shown in Fig.1.

During the aircraft exterior inspection the aircraft commander will inspect and check:

(1) nose section of the fuselage:

- intactness and cleanness of windows;
- intactness and good condition of the АРК-5 loop antenna;
- intactness of the РБП-4 radar bombsight radome;

(2) port side of the fuselage:

- absence of canvas covers on the Pitot-static tubes and plugs closing the static pressure vents;
- good condition of the entry door and sealing of hatches;
- intactness of the landing lights and their tight fit to the fuselage, and also the reliability of the taxi light attachment;

(3) nose wheel leg:

- the hook of nose wheel uplock is opened;
- the collapsible brace strut and its fixing lock are in good condition;

Note: There should be no gap between the front link rests and the flat framework, when the lock is normally closed, the strut should have deflection of 8 - 10 mm downwards, and the lock side links should have deflection of 0.5 - 1 mm upwards relative to the axis of rotation of the crank. (It should be checked visually through the inspection ports in the lock links).

- the terminal switches are securely fastened;
- the pneus of the front wheels are not damaged and their inflation is normal;
- there is no hydraulic liquid leakage from under the inner tube sealing of the strut;
- the nose wheel steering mechanism is in good condition and there is no leakage of hydraulic liquid;
- the charging of the additional shimmy damper is normal;

Note: Under the normal charge (the wheels are positioned parallel to the aircraft axis) the check pin should protrude not in excess of 4 mm, or submerge not over 6 mm from the body tip face-piece.

- the hatch of the nose-wheel bay is closed;
- there is no leakage of fuel and hydraulic liquid, the oxygen discharge ports are clean;

(4) port side of the fuselage (behind the nose wheel leg):
- intactness and cleanness of the port side fuselage skin;
- intactness of the pop out stoppers of the fire extinguishing and neutral gas fire suppressing systems;
- availability of the corresponding set of signal flares in the signal flare launcher;

(5) port engine nacelle:
- there is no damage to the engine air intake and to the nacelle skin;

- the stopper is removed from the engine air intake and there is no dirt on the air intake, skin, and the aircraft parts mounted near the air intake;
- the stopper is removed from the fuel venting inlet and the apertures are not clogged;
- the locks of the underside lids of the cowlings are locked;
- there is no leakage of fuel and oil;
- the stoppers are removed from the engine nacelle air outlets and from the venting inlet of the oil system, the air blow-off band of the engine compressor is opened;
- the stopper is removed from the engine jet nozzle;
- the fuselage side protector is not damaged and has no cracks;

(6) port main leg and the undercarriage fairing:
- the chocks are placed under the wheels;
- the condition of the wheels pneus and their inflation is normal, the automatic brake control unit transmitters and electric wiring to them are normally fastened;
- there is no leakage from the brake chambers and hoses;
- compression of the shock absorber is normal and there is no hydraulic fluid leakage from under the sealing of the strut inner tube;
- the taxi light is intact and securely fastened;
- the push-pull rods and the universal joints of the undercarriage fairing doors are in good condition;
- the leg uplock hook is opened;
- there is no leakage of the hydraulic liquid;

(7) underside the port wing:
- the flaps are fully up;
- the skin of the lower surface is clean and has no mechanical damage;
- there is no fuel leakage;
- the electro-static dischargers and aeronavigation lights mounted on the wing tips are intact;

- deflection of the aileron and its trim tab corresponds to the displacement of the control column and to the trim tab control switches (after the check, position the aileron and trim tab neutral);

(8) inspect the skin of the port side of the fuselage and make sure that it is not damaged.

Check whether the suspended bombs meet the flight mission requirements.

Inspect the loading of the ЦОСАБ colour flare bomb bay.

Inspect intactness of the СД-1 range finder antennae.

Check whether the canvas covers are removed from the cannon of the ventral gun mounting and make sure that the cannon are in the inoperative position.

Inspect the tail bumper and the МРП-48П marker receiver antenna.

Make sure, that the lock of the drag chutes jettisoning is securely closed, and check through the inspection ports that the lock of the parachute container doors is fully closed.

Check intactness and cleanness of the windows of the rear pressurized cabin. Make sure that the emergency exit hatch of the gunner-radio operator fits tightly and the entry door is in good condition;

(9) tail unit:

- the surfaces of rudder and elevator and trim tabs are not damaged, the direction of their deflection corresponds to the displacement of the control column, pedals, and trim control switches; the magnitude of their deflection is normal (after the check, position the trim tabs neutral);

- the skin of the tail unit is clean and is not damaged; the tips of the stabilizer and fin are not damaged;

- the plug is removed from the air inlet for rear cabin ventilation;

- the electro-static dischargers, mounted on the fin and stabilizer tips, are not damaged;

- the radome of the ПРС-1 fire control radar is not damaged;

(10) check whether the canvas covers are removed from the cannon of the rear turret and make sure, that the cannon are in the inoperative position.

Check intactness of the tail unit aeronavigation light;

(11) go to the starboard side of the fuselage and make the same inspection but in the reverse sequence.

On the starboard side of the fuselage additionally check:

- intactness of the 1РСБ-70 VHF radio set fixed antenna;

- loading of the launcher with signal flares;

- good condition of the folded-dipole antenna of the 1РСБ-70М VHF command radio set, the antennae of radio altimeters and the transponder antenna;

- whether the front pressurized cabin ventilation air intake is closed;

- whether there is fuel leakage in those places where the fuselage fuel tanks are installed;

(12) make sure, that the aircraft is earthed.

Pre-Flight Inspection of Cabins and Crew Stations

11. When entering the cabin each member of the crew should first make sure that:

- the safety pins of ground lock with red warning flags are screwed into their proper places;

- the pins of the seat-to-hatch door lock are in their proper places and are locked;

- the cables of the seat-to-hatch door blocking are securely fastened to the pins and hatch doors;

- the handles of the emergency jettisoning of the hatch doors and canopy, actuated by mechanical as well as pneumatic systems, have no external damage and are locked and sealed;

- the safety devices of the firing handles (left and right), the handles proper and the face curtains have no external damage and are placed into the initial position and locked;

- behind the movable part of the ejection seats and near the seats themselves there are no foreign objects which may hamper assuming the ejection position.

Note: Before the take-off each member of the crew should make sure that the safety pins of the ground blocking with the warning flags are screwed out of his seat.

After the above mentioned inspection, each member of the crew commences further inspection of his station and checks the presence, external good condition, time of charging, fastening, and locking of the fire extinguisher bottle.

12. The commander of the ship performs inspection in the following sequence:

(1) prior to taking his seat, he will check and make sure that:

- the cock of the АРД-54 automatic cabin - pressure regulator is in the operating position (fully turned clockwise) and is locked; the same check is carried out by the aerial gunner in his cockpit;

- the circuit breakers on the left and right panels of the pilots are switched ON and all the switches and selector switches on the pilots' instrument boards are OFF (the circuit breakers "$CO_2$ bottles control" and "Neutral gas", which are placed on the co-pilot's circuit breakers panel, should be OFF; these circuit breakers will be switched ON directly before the engines are started);

- the push-buttons of the main undercarriage extension and retraction cock are in the raised position and under the small button of extension and the button of retraction the locking clips are inserted (after the inspection close the lid of the cock);

- there is a seal on the lid of the emergency undercarriage extension and retraction system control cock;

- the emergency hydraulic accumulator charging cock is closed;

- the nose wheel steering unit button is depressed and locked;

- the automatic pilot control handle is in the stowed position and locked, the cover is removed, and the function switch of the control handle is in the OFF position;

(2) take the seat and then:

- make sure that the ПКИ collimator sight is in non-operative position and its light filter is securely fastened;

- set the emergency brakes levers to the working position (move them up and test smoothness of their travel);

- adjust the seat and pedals to fit your size; check reliability of the pedals fixing and that their neutral position corresponds to the neutral position of the rudder;

WARNING: It is STRICTLY FORBIDDEN to re-adjust the pedals in flight:

- inspect the control panel of the APK-5 No.1 automatic radio compass;

- make sure that the automatic brake control unit switch is ON;

- put on the parachute pack, adjust and buckle the harness and make sure that the harness locking mechanism is in order;

- put on the helmet and connect it to the intercom plug;

- unlock the aircraft controls and make sure that the controls locking lever is fixed in the extreme rear position;

- check smoothness of the aircraft controls travel;

(3) having taken your seat, inspect the control panels on the port side of the cockpit and make sure that:

- the emergency bomb jettison lever is locked;
- the emergency canopy-jettison and control column disconnect pneumatic cock is in the CLOSED position and locked;
- the fuel jettison cock is in the CLOSED position and locked;
- the pressure in the pneumatic system is 80 - 150 kg/cm$^2$;
- the emergency pressure release valve button is fully pulled up;
- the cock for switching to emergency static line is closed;
- the correct code is set on the transponder code panel;
- the transponder destruction button cover is locked and sealed;
- the selector switch of the СПУ-10 intercom is set to the NETWORK No.1 position;
- the flaps extension and retraction switch is positioned neutrally and is fixed reliably;
- the rheostats of the ultraviolet lights and cockpit top lights are OFF and the accessory wiring is securely fastened;
- the localizer and glide-path receivers are OFF;
- the radio-range finder is OFF;
- the engine throttle levers displace smoothly and are securely retained by the idle rating stops;

(4) order the second navigator: "Switch on the storage battery and inverter" (having made sure in advance, that the ground power unit is connected to the aircraft). Check the neutral position of the elevator trim tab, aileron trim tabs, rudder trim tab and the simultaneous operation of the aileron trim tabs by the warning light and by the reports of the co-pilot and the mechanic in charge of the aircraft;

(5) switch on the gyro instruments and inspect the instrument panels from left to right, making sure that the principal instruments initial readings are correct:

- the ДУЖК remote liquid oxygen level indicators: with power supply on, the needles indicate the quantity (in kg) of liquid oxygen in the КПЖ-30 liquid oxygen converter;
- the oxygen pressure gauges МК-13М: when the КПЖ-30 liquid oxygen converters are ready for operation and the КВ-5 oxygen shut-off valve is opened, the needles indicate the actual oxygen pressure in the system (8 - 10 kg/cm$^2$); when the oxygen valve is closed, and the pressure is released from the oxygen converter, the needles read zero;
- the АМ-10 (or А-8) accelerometer: both needles are in the zero position;
- the УЗП-47 flaps position indicator: the needle indicates actual position of the flaps (the flaps must be retracted);
- the МС-1 Machmeter: the needle reads the scale division 0.5;
- the КУС-1200 IAS and TAS indicator: both needles are in the zero position; the misalignment of ±2 mm along the arc of the scale is allowed;
- the ВАР-30$_3$ rate-of-climb indicator: the needle is in the zero position; the misalignment of ±0.5 m/sec. along the instrument scale is allowed;
- the ВД-20 altimeter: both needles read zero, the barometric pressure scale indicates pressure in the given point of terrain;
- the АГБ-2 artificial horizon: with the ПАГ-1Ф inverter OFF, the movable index occupies an arbitrary position;
- the ГПК-52 directional gyro: the needle indicates an arbitrary heading;
- the ЭУП-53 electric turn and slip indicator: the needle is at the central index of the scale; the misalignment of ±1 mm along the arc of the scale is allowed; when the aircraft is in horizontal attitude, the ball of the slip indicator is in the central position (between the fixed indexes);

- the ТЭ5-2 tachometer: the needles read zero;
- the ТВГ-11 exhaust-gas temperature indicators: the needles are at the beginning of the scales;
- the ЭДМУ-3 electric remote-reading fuel pressure gauges: the needles are in the zero position; the misalignment of ±2 mm along the arc of the scale is allowed;
- the ТВ-45 cabin air temperature gauge: the needle must indicate air temperature in the cabin;
- the РТС-16 fuel flow indicators: the needles indicate actual amount of fuel in the tanks (the needles should be preliminary set in accordance with the actual amount of fuel);
- the КИ-12 magnetic compass: the card indicates the magnetic heading of the aircraft on the parking apron;
- the МГ-250 brake systems pressure gauges: the needles indicate actual pressure in the hydraulic system of the main (left-hand gauge) and emergency brake (right-hand gauge); normal pressure in the brake systems must be equal to 150 $kg/cm^2$;
- the МГ-250 main hydraulic system pressure gauge: the needle is in the 0 - 157 position;
- the ДГМК-7 indicator of the remote-reading gyro-magnetic compass: the needle indicates the heading equal to the reading of the УШ navigator's course indicator;
- the 3-needle indicator ЭМИ-3Р: the needles of the oil and fuel pressure gauges read zero; the misalignment of ±2 mm along the arc of the scale is allowed; the needle of the oil-temperature gauge indicates actual temperature of oil;
- the ТНВ-15 outside air temperature indicator indicates actual temperature of outside air;
- the indicators of the СЭТС-60М fuel quantity gauges: with power supply on, the needles indicate actual amount of fuel in the tanks;
- the indicator of the УВПД-15 cabin altitude and pressure differential gauge: the needles are in the zero position;

- the РВУ-46У air flow indicator: the needle is in the zero position;

- the ТЦТ-13 de-icer thermometers: the needles indicate actual temperature in the wing leading edge;

- the ТСТ-29 turbo-starter thermometers: the needles indicate actual temperature of the turbo-starter;

- the ТЭ-45 turbo-starter tachometer: the needle reads 0;

Besides, check:

- the undercarriage position indicator (green lamps must burn);

- correspondence of the readings of the fuel quantity gauges by the groups and total scales to the actual amount of filled fuel; if the needles of the fuel quantity gauges were preliminary set in accordance with the actual amount of fuel, the reading of the "Sum" scale must correspond to the readings of the fuel quantity gauges;

- the fuel supply panel: whether the lamps are in proper condition and all the switches are OFF;

- good condition of the anti-fire system;

Notes: 1. Check of operation of the fuel pumps manual control and check of the fuel control unit should be made directly before starting the engines.

2. The check and operating procedures of the systems are described in Part Two of the present Instructions.

3. Shutters of all the warning lights must be opened completely during day-time flights and closed during night flights according to Para.195 of the present Instructions;

(6) check readiness of the oxygen equipment.

Press-button control of the low altitude ventilation of the cabin, located on the upper electric panel, set to the CLOSED position, keep it pushed for 15 - 20 seconds and then release it.

Switch on the intercom networks No.1 and No.2. Inspect control panels of the РСИУ-4П radio set. Make sure that the volume control knobs are set to the LOUD position, switch on the radio set power supply on the port side of the cabin and the required channel on the control panel.

Check operation of the intercom in both channels, good condition of the РСИУ-4П radio set, artificial horizons (the main one from the aircraft mains and the emergency one from the aircraft mains and the storage batteries), the directional gyro, the turn and slip indicator, and the automatic pilot, switch on the power supply of the IFF transponder.

Check operation of the tail unit de-icing system by the warning light, which burns for 40 seconds and does not burn for 80 seconds; during this test the second navigator will watch by the ammeter the value of the consumed current which must be equal to 480 - 500 amperes (for the de-icers).

Check heating of the cabin windows by means of the ammeter. Consumption of current must be equal to: for the navigator's windscreen heating - 90 amperes, for the pilots' windows heating - 100 amperes.

Check operation of the heater fan (assy 107) and its operation by sections.

13. The co-pilot (deputy aircraft commander) performs pre-flight inspection and his seat inspection following the same procedure and scope as the aircraft commander.

Besides, he checks:

- condition of the skin and wing fences on the upper part of the wing;
- amount of filled main fuel (through the necks of the tanks of each group) and that the filler neck lids are reliably closed;
- amount of filled starting fuel through the filler neck (the tank must be filled completely) and that the filler neck lid is reliably closed.

During inner inspection of the cockpit the co-pilot must check air-tightness of the entry and emergency hatches sealing system. For this purpose it is necessary:

- to make sure that all the emergency and entry hatches are closed and one of the crew members is in the rear pressurized cabin;
- to make sure that there is pressure before the reducer as indicated by the high-pressure gauge located on the hatches sealing panel;
- to open the valve of the HIGH PRESSURE MAINS reducer;
- to make sure that there is pressure after the reducer as indicated by the low-pressure gauge located on the hatches sealing panel;
- to open the valve SEALING OF HATCHES. At this, the pressure indicated by the low-pressure gauge must sharply decrease, and then, as the rubber bladders are being filled with compressed air, must gradually increase to the initial value;
- to close the valve of the HIGH PRESSURE MAINS reducer after the bladders have been filled with the compressed air and the pressure has been restored. Make sure that there is no leakage of air from the system by watching the low-pressure gauge for 0.5 - 1 minute;

Note: The pilot must know that the period of the pressure drop from 4 to 3 kg/cm$^2$, as indicated by the low-pressure gauge, must not be less than 20 minutes.

- to close the cock SEALING OF HATCHES and release pressure from the sealing bladders of the entry hatches. For this purpose, pull the pressure release ring mounted on the cover of the hatch of the front cabin, and in the rear cabin - push the entry hatch cover jettison lever, on the axis of which there is a cam which pushes the rocking arm of the two-way air cock;

WARNING: In order to prevent jettisoning of the entry hatch cover of the rear cabin, the hinged lever with the roller of the hatch mechanism should be hinged aside before the pressure is released from the sealing bladder.

- to interlock again the two-way cocks with the pressure release mechanisms;

- to check air-tightness of the cabin pressurization shut-off valves control systems and of the wing de-icing system. For this purpose it is necessary:

- to make sure, that the valve SEALING OF HATCHES is closed;

- to open the valve of the HIGH PRESSURE MAINS reducer and to make sure that there is pressure after the reducer as read off the low-pressure gauge;

- to open the cocks of cabin pressurization and the cock of the wing de-icing system; during this the pressure read off the low-pressure gauge must drop and quickly restore up to the initial value;

- to close the valve of the HIGH PRESSURE MAINS reducer and by means of the low-pressure gauge make sure that the pressure does not drop; the pressure drop will indicate that the system or valves are not air-tight;

- to close the valves of cabin pressurization and the wing de-icing system valve.

WARNING: It is STRICTLY FORBIDDEN to fly with leaking bladders of hatches and with leaking shut-off valves of the cabin pressurization system and the wing de-icing and engine de-icing systems.

After the checks mentioned above, the co-pilot must make sure that:

- the function switch of the АРД-54 automatic cabin-pressure regulator is in the NORMAL position;

- the control valve handwheel of the ККД combined pressure valve is in the 0.4 kg/cm$^2$ position, locked and sealed, and the button of the valve is fully depressed;

- the cabin air supply regulator is in the CLOSED position;

- the РСБ-70М command radio set is in good condition and the wireless control is in the REMOTE CONTROL position.

14. The rest of the crew members perform their pre-flight inspection and inspection of their working places in the sequence and scope prescribed by the specialized instructions to each member of the crew.

## Pre-Flight Inspection of Ejection Seats

### Inspection of Pilots' Ejection Seats

15. While inspecting the seats make sure that:

- the АД-3 safety harness automatic unlock mechanism is cocked and its cord is connected to the seat carriage which stays in the aircraft on ejection;

- the cord of the КАП-3 parachute release control unit is connected to the ring mounted on the seat;

- the chain for actuating the КП-23 parachute oxygen breathing apparatus is connected to the seat carriage and to the КП-23 safety pin; the КП-23 hose is connected to the hose of the aircraft oxygen mains and the hoses are not damaged and have no bends;

- the shorter oxygen hoses are passed through the slots in the sides of the seats;

- pressure in the КП-23 parachute oxygen apparatus equals 150 kg/cm$^2$.

Besides, it is necessary:

- to check travel of the carriage together with the ejection seat up to the extreme rear position and reliable fixing of the seat (the retainers should enter the holes);

- to make sure that in the extreme rear position of the pilots' seats, the interlocking retainer (mounted on the stationary frame) is depressed and the bracket mounted on the axis of the face-blind shaft, does not touch the retainer;

- to check intactness of seals and locks on the handles of the control column disconnect;

- to make sure that the air cock of hatch cover jettison, mounted on the central panel, is sealed;

- after the back travel of the seat has been checked, it is necessary to move it forward, adjust it to fit the size, fix it, and check its reliable fixing by the position of the fixing handle; the handle head must be on one level with the elbow-rests or somewhat lower.

WARNING: It is strictly forbidden for all the crew members to insert the belt buckles, inverted by 180°, into the lock, otherwise the buckles may not get out of the lock.

## Inspection of Aircraft Navigator's Ejection Seat

16. During the inspection make sure that:

- the hose of the КП-23 parachute oxygen apparatus is connected to the hose on the seat and the safety pin of the КП-23 hose is connected to the ring of the КП-23 cut in mechanism;

- the oxygen hose on the seat is connected to the hose of the aircraft oxygen mains, the disconnect pin of the hose is connected to its chain and the hoses are not damaged;

- the shorter oxygen hose is passed through the slot in the right elbow-rest of the seat;

- the oxygen hose, running to the КП-23 oxygen apparatus along the back and the right side of the seat, is located in such a way that when the seat is moved back it cannot accidentally get on the ejection roller;

- pressure in the КП-23 oxygen apparatus equals 150 kg/cm$^2$;
- the АД-3 safety harness automatic unlock mechanism is cocked and its cord is connected to the aircraft side;
- the free end of the КАП-3 parachute release control unit cord is connected to the seat;
- the seat moves freely along the guide rails and stops in the rear position;
- the КП-23 and АД-3 pins disconnecting mechanism is cocked.

Besides, it is necessary:
- to put on the parachute, adjust and lock the harness, and check operation of their locking mechanism;
- to check operation of the oxygen equipment.

Inspection of Navigator-Radar Operator's Ejection Seat

17. During the inspection make sure that:
- the shorter oxygen hose is passed through the slot in the rear part of the right side of the seat and the hoses are not damaged;
- pressure in the КП-23 oxygen apparatus equals 150 kg/cm$^2$;
- the АД-3 automatic unlock mechanism is cocked;
- the КП-23 oxygen apparatus hose is connected to the aircraft oxygen mains and the snap hook of the КП-23 safety pin and the АД-3 unlock mechanism cord are connected to the ring of their cut in mechanism;
- the pins pull-out mechanism of the КП-23 and АД-3 devices is cocked;
- the free end of the КАП-3 parachute release control unit is fastened to the seat.

Besides, it is necessary:
- to test travel of the seat up and down with the help of the hoist;

- to put on the parachute, adjust the seat harness, and check operation of their locking mechanism;
- to check operation of the oxygen equipment.

Inspection of Gunner-Radio Operator's Ejection Seat

18. During the inspection make sure that:
- the emergency jettison lever, mounted on the hatch cover, is set to the operating position and locked, and the cover cap is closed;
- pressure in the КП-23 oxygen breathing apparatus equals 150 kg/cm$^2$;
- the hose of the КП-23 apparatus is connected to the aircraft oxygen hose and the hoses are not damaged and have no bends;
- the snap hook of the КП-23 apparatus is connected to the aircraft side by means of a chain;
- the АД-3 and КАП-3 automatic devices are cocked, the АД-3 cord is connected to the aircraft side, and the cord of the КАП-3 device is connected to the seat.

Besides, it is necessary:
- to test smoothness of travel of the seat and reliable fixing of the seat;
- to put on the parachute, check good condition and operation of the straps tightening mechanism and the condition of their locks;
- to check travel of the collapsible part of the back of the seat and efficiency of its locking;

Notes: 1. Before the radio-gunner will take his seat it is necessary to screw out the safety pin of ground lock with red warning flags because it is impossible to screw it out after the seat has been taken.

2. Do not let the parachute move too far towards the back of the seat because in this case the oxygen hose will be jammed by the right handrail of the seat.

- to check operation of the oxygen equipment;
- to make sure that the function switch of the АРД-54 automatic cabin-pressure regulator is in the NORMAL position; the control handwheel of the ККД cabin combined pressure valve is in the 0.4 kg/cm$^2$ position, locked, and sealed, while the valve button is completely depressed; the cabin low-altitude ventilation cock is closed.

## Inspection of Aerial Gunner's Ejection Seat

19. During the inspection make sure that:
- the emergency jettison lever, mounted on the hatch cover is set to the operating position;
- pressure in the КП-23 oxygen apparatus equals 150 kg/cm$^2$;
- put the parachute with the КП-23 oxygen apparatus on the seat, having connected the chain to the aircraft side at the КП-23 cut-in snap hook; make sure that the oxygen hoses are not damaged;
- check charging of the АД-3 and КАП-3 automatic devices and connection of the АД-3 cord to the aircraft structure and the КАП-3 cord to the seat;
- take the seat, put on the parachute, close the lock, lock the harness, and check the straps tightening mechanism and condition of the straps locks;
- check travel of the ejection seat and reliability of its fixing in the ejection position;
- make sure that the button of the emergency pressure release valve is pulled upward completely;
- check operation of the oxygen equipment.

20. After the inspection of his seat each crew member should check communication with the rest of the crew members through the СПУ-10 intercommunication system.

## II. STARTING AND GROUND TEST OF ENGINES

### Starting the Engines

21. Before starting the engines, the members of the crew must make sure that the safety pins of ground lock with red warning flags are screwed out of their ejection seats.

Notes: 1. It is forbidden to start the engine with the air blow-off band closed.

2. To check efficiency of the hydraulic pumps of the main hydraulic system, it is necessary to begin starting the engines from the port engine on one day of flight and the starboard engine on the other day.

22. Before starting the engines, the aircraft commander should make sure that:

- the messenger is present;
- there are no foreign things within the zone of exhaust gas stream;
- the chocks are put under the wheels;
- there are no foreign things and waste in front of the engine air intakes;
- there are fire-extinguishing facilities near the aircraft;
- the aircraft controls are unlocked;
- the cover of the rear cabin entry hatch is locked (by the radio-gunner's report);
- voltage of the aircraft electric mains under load is within 24 - 28 volts (by the navigator-radar operator's report).

After that open the fuel shut-off valves.

23. During starting and running the engines the servicing personnel must not be nearer than 10 metres from the air intakes and 50 metres from the jet nozzles.

24. Before proceeding to start the engines the aircraft commander should order the crew to report readiness for flight through the intercom.

On receiving the order all the crew members must report their readiness as soon as they are ready to flight.

25. The engine should be started on the ground as follows:

- apply the parking brakes;

- when starting the engines by means of the ground power units, engage the master selector switch mounted on the engine starting panel, the ПО-4500 inverter, and the automatic fuel control;

- when starting the engines by means of the aircraft storage battery, engage the master switch mounted on the engine starting panel, set the AUTOMATIC - MANUAL selector switch on the automatic control panel to the MANUAL position and switch on the booster pumps of the tank groups which are first to deliver fuel;

Notes: 1. When starting the engines from the first group of tanks, the pumps of the engine to be started should be switched on only, as this group is fitted with two booster pumps for each engine. Therefore, if the first groups of both engines are engaged, four pumps will be on and the storage battery will get discharged.

2. The power supply master selector switch is ON during the whole flight, except an urgent cutting out of the engine.

- after the master selector switch, mounted on the engine starting panel, has been cut in, check opening of the turbo-starter exhaust duct baffle plate through flashing of the warning light;

- make sure that the fuel shut-off valves are fully open through the presence of fuel pressure before the ПН-28-15 pumps (it must equal 1 to 1.4 kg/cm$^2$);

- set the throttle lever of the engine to be started on the transiént slow running limit stop;

- command: "Keep off engines" and on receiving the reply: "Engines cleared", push the START button on the engine ground starting panel, and release it after 1 or 2 seconds.

<u>Note</u>: During the turbostarter spinning, watch oil pressure in the turbostarter by means of the warning light. If the warning light does not burn, the starting must be discontinued immediately. (The light should go on 10 or 12 sec. after the starting button has been pushed).

After the starting button has been pushed, it takes the engine no longer than 120 seconds to arrive at the slow running rating automatically, smoothly and without suspended r.p.m. Gas temperature after the turbine should not exceed 680°C.

During starting some bursts of flame may appear from the jet nozzle, which does not testify to the abnormal operation of the engine.

<u>WARNING</u>: 1. During the engine starting avoid setting the throttle lever above the slow running transient limit stop, as in this case continuous flame, accompanied with a sharp rise in gas temperature, may appear from the jet nozzle. In this case the engine starting should be discontinued.

2. If during starting the readings of the instruments checking operation of the turbostarter and engine do not correspond to the required values, the starting should be discontinued by setting the throttle lever to the STOP position and switching off the master power supply selector switch.

In 1 or 2 seconds the master power supply selector switch should be engaged again to open the starter exhaust duct baffle plate (to avoid overheating of the starter).

3. Repeated starting should not be made before the cause of failed starting has been found out and the defects have been removed.
4. Repeated starting should be made only after the engine has been completely stopped (to avoid damaging the turbostarter).
5. If the engine was started by means of the aircraft storage battery, it is necessary to change over to the automatic fuel control after the engine arrives at the slow running rating and the generators of this engine are switched on.
6. It is FORBIDDEN to push the IN-FLIGHT STARTING button both on the ground and in the air if the engine is running.

After the START button has been pushed, see that the turbostarter arrives at the operating conditions. During this:

- gas temperature in the turbostarter exhaust duct must not exceed 800°C during the starter acceleration, 680°C during operating rating at an ambient temperature of up to +15°C, and 700°C at ambient temperatures higher than +15°C;
- operating rating of the turbostarter must not exceed 31,000 - 33,500 r.p.m.;
- time of the turbostarter operation from the moment of pushing the starting button up to its cutting off must not exceed 80 seconds;
- momentary increase in r.p.m. during spinning must not be more than 35,000 r.p.m.

## Engines Warm-Up and Testing

26. Before testing the engines, warm them up by running them at slow running rating for one minute.

After the readings of the instruments and operation of the engines at the slow running rating have been checked, increase the engine speed up to 4100 r.p.m.

When switching the engine to this rating it is necessary to check:

- the revolutions at which the turbostarter exhaust duct baffle plate shuts (to be determined by the moment the warning light goes out); they must be equal to 1850 - 1950 r.p.m.;

- the revolutions at which the air blow-off band shuts (to be determined through the messenger whether the engine nacelle doors close or not).

27. At the engine speed of 4100 r.p.m. check the high altitude equipment in all pressurized cabins. During this it is necessary to check feeding of the compressed air to the cabins from the port and starboard engines separately.

For this check it is necessary:

(1) to check pressurization of the cabins by the starboard engine. For this purpose:

- open the valve of the HIGH-PRESSURE MAINS reducer on the hatch sealing panel and make sure that there is pressure after the reducer;

- set the starboard engine sliding cock handle, mounted on the control panel of the pressurization shut-off valves, to the OPEN position;

- make sure that the circuit breakers of the TPTBK automatic cabin temperature regulators in pressurized cabins are in the ON position;

- make sure that the starboard engine revolutions are equal to 4100 r.p.m.;

- set the switches of the TPTBK cabin temperature regulators, mounted on the co-pilot's instrument panel and the radio-gunner's panel, to the HOT position (the complete shift of the baffle plate from one extreme position to the other one takes 30 - 45 seconds; all this time the selector switch should be kept pressed, after that release it and the switch must set to the neutral position by itself);

- make sure by the flowmeters that there is no air supply to the cabins when the РПВ cabin air supply regulators are closed;

- slowly transfer the РПВ air supply regulator throttle lever forward and check the air consumption; during this the flowmeter needle must smoothly shift clockwise and read the consumption in conventional volume units of consumption from 0 to 10;

- check the temperature of the supercharged air by reading of the ТУЭ-48 thermometer indicator, mounted on the co-pilot's instrument panel; the engine speed being equal to 4100 r.p.m. and the air consumption being equal to 6 - 8 units per cabin, the temperature of the incoming air, read by the ТУЭ-48 thermometer, must equal +50 to +90°C depending on the ambient air temperature; temperature of the incoming air in the rear cabin is not determined by the instrument; the supply of the hot or cold air to the rear cabin is determined by feeling the temperature of the air flowing from the ducts by hand and also through change in the readings of the cabin thermometer;

- set the selector switch of the by-pass valve of the ТРТВК cabin air temperature regulator on the co-pilot's instrument panel and the radio-gunner's panel to the COLD position for 30 - 50 seconds; 1 - 2 min. later, the ТУЭ-48 thermometer must indicate decrease in temperature of the supercharged air, and the flowmeter must indicate decrease in the supply up to 3 - 4 units;

Notes: 1. Before changing over the TPTBK cabin temperature regulator from HOT to COLD it is necessary to reduce the air supply to the cabins by the supply regulator to avoid sharp pressure change in the cabin due to different efficiency of the TXY turbo-cooler and the PKH cabin air pressure reducing valve. After change over to COLD open the PПB cabin air supply regulator completely.

2. While setting the switch to the HOT or COLD position see that the selector switch of the TPTBK cabin temperature regulator returns to its neutral position.

3. If during change over to COLD, consumption and temperature do not decrease to the values mentioned above, stop the air supply to the cabin for a short time (close the PПB cabin air supply regulator and open it again).

- set the selector switches of the TPTBK by-pass valves to the AUTO position;

- set the handle of the sliding cock with the inscription RIGHT, mounted on the co-pilot control panel, to the CLOSED position; feeding of the air into the cabin must stop;

- close the cabin air supply regulator;

(2) check supercharge of the pressurized cabins by the port engine in the same sequence as by the starboard one.

WARNING: 1. It is not recommended to increase temperature of the incoming air above 100°C when supplying it through the PKH cabin air pressure reducing valve.

2. To avoid damage of the flowmeter indicator, the supply of more than 10 units through the PKH cabin pressure reducing valve must not be performed.

3. Change over from the PKH cabin pressure reducing valve to the TXY turbo-cooler and vice versa should be done by pulses and the air supply should be choked by means of the baffle plate of the PПB cabin air supply regulator.

28. When checking the high altitude equipment, the navigator-radar operator should check the upper blister heating system by setting in turns the heating shut-off cock two or three times into the OPEN and CLOSED position checking whether the warm air is blowing at the blister from the collector ducts.

Notes: 1. During the whole period of engine test the shut-off valves of the cabin pressurization by the engines and the PПB air supply regulators should be opened in both cabins; the air bleed baffle plate to the TXY turbo-cooler is set during this either on HOT or COLD depending on the ambient air temperature. The shut-off valves of the cabin pressurization by the engines and the PПB cabin air supply regulators should also be opened in both pressurized cabins during taxiing and in flight at all altitudes, except for fire in the cabins and engines.

2. If the crew is in the cabins before the engines are started and there is no pressurization of cabins, and the take-off is delayed, the hatches of both cabins must be opened for ventilation after 10-minute stay in the cabins.

After the check is finished, the co-pilot and the radio-gunner report on the high altitude equipment operation to the aircraft commander.

29. Check the wing leading edge de-icing system operation. For this purpose:

- the sliding valve of the de-icers, mounted on the control panel of the shut-off valves (co-pilot's cockpit), should be turned by $90^{\circ}$ to the left, having raised the locking clip in advance;

- check by the ТЦТ-13 de-icer thermometer indicators the hot air supply; the indicator should indicate temperature increase in the wing leading edges up to $+100^{\circ}C$ and higher; when the temperature has increased in the wing leading edges higher than $+100^{\circ}C$, the sliding valve should be closed and locked by the clip.

WARNING: 1. The shut-off valves of the wing de-icers should be opened for a minimum time (1 or 2 minutes). It is strictly forbidden to open them for a longer period, because during a prolonged hot air supply into the wing, the wing skin may scorch and corrugation may form on the leading edge skin.

2. When the engines are running and the wing de-icers system is not checked, watch that the sliding valve of the shut-off valves control of the wing de-icers is always in the CLOSED position and is locked by the clip; the ТЦТ-13 de-icers thermometer, mounted on the co-pilot's panel, should not read the temperature above the ambient temperature.

30. Check operation of the АК-150Н air compressors by the air system pressure gauge. If the pressure is lower than 150 $kg/cm^2$ with the engines running, the pressure in the air system must increase. Separate check of good operation of the compressors and hydraulic pumps is done by starting the engines in turns.

31. After the engine has been running at a speed of 4100 r.p.m. for not less than one minute, check the operation of the engine at the normal and maximum ratings by transferring the engine to the normal and then to the maximum rating smoothly for not less than one minute.

WARNING: 1. It is forbidden to allow the engine to develop the maximum rating earlier than 3 minutes after the engine has developed the slow running revolutions during starting and testing.

2. The second development of maximum revolutions is allowed after 10 minutes of the engine running at normal engine rating or after 5 minutes of the engine running at a rating not higher than 0.8 of the normal engine rating.

3. When the engine runs at maximum rating (both on the ground and in the air) it is forbidden to bleed the air into the aircraft de-icing system.

4. When the engine is brought from slow running to the maximum rating, a short time increase in gas temperature after the turbine is allowed up to 690°C with a gradual decrease of temperature during 1 - 1.5 minutes up to the temperature not in excess of 660°C.

After testing the normal and maximum ratings decrease the engine speed up to slow running rating by smoothly shifting the throttle lever during 25 - 30 seconds, checking the engine operation at transient ratings and the engine speed at which the air blow-off band is opened.

At the steady and transient engine ratings the engine should run smoothly, without vibration and flame bursts from the jet nozzle.

WARNING: When the engine is operated on the ground and in flight, it is forbidden to set the engines control levers below the transient slow running limit stops, except for the cases when the engine should be cut out.

32. After the engine has been run at slow running rating for not less than 1 minute, check the engine for acceleration. For this purpose, shift the throttle lever smoothly, without sharp jerks, from the transient slow running limit stop, to the maximum rating limit stop for 1 or 2 seconds. During this the engine should develop 4700 ±50 r.p.m. smoothly and without surge.

The time of the engine acceleration during the acceleration test is determined from the moment the throttle lever starts moving up to the time the engine develops 4700 ±50 r.p.m. This time period should not exceed 17 seconds.

After the engine acceleration test and after the engine has been run at maximum rating for 8 - 10 seconds, decrease the revolutions to slow running rating; for this purpose shift the throttle lever down to the transient slow running limit stop for 1 or 1.5 sec. During this the engine should decrease its speed to 1750 ±50 r.p.m. smoothly, without irregularities and smoke from the jet nozzle.

WARNING: During the engine acceleration test when the engines are run up, the short time increases in revolutions and gas temperature are possible:

- the revolutions increase not in excess of 4800 r.p.m. with the following decrease of the engine speed down to the maximum rating not later than after 5 - 7 seconds;

- the gas temperature increase not higher than 720°C; during this short bursts of flame may appear at the jet nozzle outlet.

The instrument readings which indicate the normal engine operation during their test on the ground are given in the Ту-16 aircraft engine instructions.

## Starting Engine on the Ground with Manual Correction of Main Fuel Supply

33. In case the engine starting automatic equipment fails to operate and it is necessary to urgently start the engine, it is allowed to start the engine, with manual correction of main fuel supply.

In this case it is necessary:

- to make sure that the engine control lever is in the STOP position;
- to open the fuel shut-off valve;
- to switch on the power supply master switch;
- to switch on the aircraft fuel booster pumps;
- to switch on the ENGINE COLD STARTING switch 3 or 4 seconds later after the power supply master switch has been cut in;
- when the engine develops 220 - 280 r.p.m., press the IN-FLIGHT STARTING button and by slowly shifting the engine control lever gradually open the main fuel supply into the engine so as to ensure a smooth acceleration of engine speed and a smooth (without surges) increase of gas temperature after the turbine;
- when the engine develops 740 - 880 r.p.m., release the IN-FLIGHT STARTING button;

WARNING: The duration of pressure exerted on the IN-FLIGHT STARTING button should not exceed 30 seconds to avoid the overheating and failure of the ignition system;

- when the engine develops 1150 - 1250 r.p.m., but not later than 80 seconds after the ENGINE COLD STARTING switch has been cut in, switch off the switch and gradually move the engine control lever up to the transient slow running limit stop.

Notes: 1. The operation characteristics of the starter and engine should be identical to those of the automatic starting during the above mentioned starting.

2. If due to some reason the starting is discontinued by switching off the power supply master switch, it is necessary to switch on the switch for opening the baffle plate of the starter exhaust tube after 1 or 2 seconds.

## III. TAXIING AND ENGINES STOPPING

### Taxiing Out from Parking Apron and Taxiing

34. Before taxiing the aircraft commander should:

- make sure that the selector switch of the instruments power supply from the storage battery is in the GENERATORS position and to close the safety cap;
- check that the IFF transponder is switched on and the code corresponds to the required one;
- make sure that the automatic brake control unit switch is on;
- for 30 - 40 seconds manually switch on the booster pumps of the third groups of tanks in order to check their efficiency; after this, change over to the automatic fuel consumption, having left the A3C-5 circuit breaker of the manual control of the booster pumps of the third groups of tanks in the ON position;
- make sure that the AUTO - MANUAL selector switch is in the AUTO position;
- make sure that the automatic fuel system functions normally and there is normal pressure in the main and brake hydraulic systems;

- make sure that the cabin pressurization system functions properly;

- set the heading-indicating pointer of the ДГМК-7 remote-reading gyromagnetic compass at the take-off heading;

- make sure that all the gyro instruments are switched on;

- turn to the right the on/off control knob of the АГБ-2 artificial horizon (remove the flag indicator);

- request and obtain the taxi clearance through the wireless; warn the crew about the taxiing out by giving a command: "Crew, taxiing out"; in the process of taxiing and flight in the airfield area the aircraft commander is continuously listening to the commands coming from the command radio set operated in the take-off network;

- switch on the nosewheels steering mechanism.

Having received the crew report that there are no obstacles on the taxiway, the aircraft commander releases the parking brakes and begins taxiing straight, increasing the speed of both engines simultaneously.

With the beginning of the aircraft movement the engines control levers must be set to the SLOW RUNNING position and after that test the operation of the main brakes.

If during the main brakes test the aircraft does not stop, it is necessary to immediately brake the aircraft by the emergency brakes until it stops completely. The levers of the brakes must be kept pressed until the chocks are put under the wheels, after that the engines must be cut out.

The Ty-16 aircraft is easily controlled during taxiing. The turns during taxiing should be made by turning the nosewheels and whenever necessary assisted by brakes.

<u>WARNING</u>: IT IS FORBIDDEN:

- to use the nosewheel steering mechanism before the aircraft starts moving;

- to sharply brake the aircraft when taxiing with the nosewheels turned to avoid damage of the self-centering device;
- to taxi and turn at a speed higher than 30 km/hr.

While taxiing to the pre-take-off checks position, test the emergency braking system on the straight sections of the taxiway, after that order the co-pilot to charge the emergency hydraulic accumulator to capacity.

As a rule, taxiing should be performed at the slow running rating (1750 r.p.m.). If it is necessary to increase the speed of taxiing (but not more than 30 km/hr) on the straight and free sections of the taxiway, the engines speed should be increased up to 2000 - 2100 r.p.m.

During taxiing the aircraft commander operates the engines control levers by his left hand, whereas by his right hand he controls the nosewheel steering mechanism; the co-pilot keeps the control wheel and pedals in the neutral position.

While taxiing along the taxiway the aircraft commander should orient himself by axial line of the taxiway as shown in Fig.2; with such projection of the taxiway axial line on the windscreen the nosewheels will move in the centre of the taxiway.

During taxiing the radius of the undercarriage inner bogie turn should not be less than the width of the main wheels track. IT IS FORBIDDEN to turn the aircraft if one of the undercarriage bogies does not move.

The radius of turn, when taxiing at a higher speed, should not be less than 30 metres.

If the main braking system fails, one should use the emergency braking system to stop the aircraft. For this purpose it is necessary to pull the emergency brakes levers smoothly and simultaneously, avoiding sharp braking of the wheels and lowering of the aircraft nose. It is not recommended to fully release the emergency brakes levers to avoid rapid pressure drop in the emergency hydraulic accumulator.

WARNING: The emergency brakes are not connected with the automatic brake control units. Therefore, if the emergency brakes levers are pulled vigorously, damage and destruction of the tyres are possible.

If the automatic brake control unit operates normally the blue warning light of the automatic brake control unit blinks when the brakes are applied. Continuous shining of the warning light indicates failure of the automatic brake control unit. In this case the automatic brake control unit should be switched off immediately and the braking should be done without it by pushing both brake pedals smoothly avoiding sharp braking.

Before stopping the aircraft, the nosewheel should be directed along the longitudinal axis of the aircraft.

It is necessary to stop the aircraft smoothly with gradual decrease of its speed so as to prevent the longitudinal pitching of the aircraft from sharp braking.

IT IS FORBIDDEN TO TAXI:

- if the main or brake hydraulic systems are out of order;
- if the ground is not good for taxiing;
- if a pneu of even one of the undercarriage wheels is damaged or the braking drums are smoking (except for the urgent necessity to clear the runway);
- if the undercarriage warning lights are out of order;
- if leakage of fuel or hydraulic liquid appears;
- with the flaps down.

Note: When preparing for circular flights IT IS FORBIDDEN to taxi along the taxiway with the flaps extended by $20^{\circ}$.

In all the cases, mentioned above, the aircraft commander must discontinue taxiing, report the case to the flight control officer, and act according to his instructions.

After the landing run is over, switch on the nosewheels steering mechanism and using the aircraft roll inertia proceed to taxi at a safe speed (10 - 15 km/hr).

At the end of the landing run order the co-pilot: "Flaps up". Clear the runway, report it to the control tower over the radio, and continue taxiing in the direction prescribed by the flight control officer.

IT IS FORBIDDEN to direct the jet stream to aircraft and other objects when taxiing along the taxiway and while taxiing to the parking apron.

## Taxiing to Parking Apron and Engines Stopping

35. Before taxiing to the parking apron the aircraft commander should make sure of normal operation of the brakes and availability of normal pressure in the braking hydraulic systems.

Taxiing to the parking apron is allowed if the parking apron is intended for and has enough place for the Ty-16 aircraft. If the parking aprons are closely located, IT IS FORBIDDEN to taxi to the parking apron. The aircraft in this case must be towed to it by a towing vehicle.

In the process of taxiing to the aircraft parking apron all the crew members should observe the taxiway and timely report all the noticed obstructions to the aircraft commander.

WARNING: After taxiing to the parking apron IT IS FORBIDDEN to apply parking brake before the wheels are cool in order to avoid damage of the expander tubes.

After taxiing to the parking apron the aircraft commander should order the crew to switch off all the consumers of electric power and, keeping the aircraft by the brakes, set the engines control levers on the slow running limit stop. After the crew members' report that power supply of the equipment is off (except for the intercom, anti-fire equipment, and stand-by booster pumps) the engines should be cut off. For this purpose the engines speed should be smoothly increased up to 2500 - 3500 r.p.m. and the engines should be run at this speed for 1 or 2 minutes, after that unlock the engines control levers and smoothly shift them to the STOP position.

Note: It is also necessary to preliminary run the engine at a speed of 2500 - 3500 r.p.m. for 1 or 2 minutes when stopping the engine at any other rating.

To avoid engine smoking during the engines stopping it is necessary to keep the engines control levers in the extreme (pulled) position until the engine revolutions drop to zero.

When stopping the engine one should make sure by ear that there is no foreign noise in the engine. If there is such noise, the engines should not be started again before the cause of noise is found out and eliminated.

WARNING: Emergency stopping of the engine is performed by a quick shift of the engine control lever to the STOP position and it is allowed only in the following cases:

- if there is sharp drop of oil pressure at the engine inlet;
- if there is fuel or oil leakage which is dangerous in fire respect;
- if gas temperature after the turbine sharply increases above the permissible limit;
- in case of abnormal burst of flame (torching) from the jet nozzle;
- if strange noise in the running engine is detected;
- if the engine begins vibrating;
- in case of ice formation in the engine intake;

- if the aircraft unexpectedly rushes forward from the parking apron as a result of failure of the brakes or slipping off the chocks during the ground engine test.

After the engines have been stopped and the aerial gunner reported that the chocks had been put under the wheels, release the brakes, switch off the booster pumps, the main power supply switches, and close the fuel shut-off valves.

## IV. FLYING AIRCRAFT BY DAY UNDER SIMPLE WEATHER CONDITIONS

### Pattern Flying

36. Rectangular pattern flights for instructing and training the crew in flight technique should be performed with the undercarriage down. The aircraft should be fuelled for these flights in such a way that the aircraft gross weight when making the first landing does not exceed 50 tons.

Before performing flights the aircraft commander must know the calculated values of the take-off run length and take-off distance for the given take-off conditions, and also the approximate aircraft unstick points, and the altitude to clear obstructions. For the calculations use the charts shown in Figs 3 and 4.

### Preparation for Take-Off

37. When preparing for take-off the aircraft commander must:

(1) In the pre-take-off checks position:

- stop the aircraft on the taxiway at a distance of 30 - 50 metres from the runway edge by pushing the brake pedals;
- check the altimeter setting to the 0 division;
- switch on the low altitude radio altimeter and check whether all the instruments are on and whether their readings are correct;

- check setting of the ailerons and rudder trim tabs to the neutral position according to the warning lights on aircraft commander's instrument panel (the lights must be on), check the position of the elevator trim tab by the indicator scale on the small handwheel (depending on the aircraft gross weight, the pointer of the handwheel should be in the take-off position at 0.5 - 1 division backward);

- order the co-pilot: "Flaps 20° down", make sure of the flaps extention by 20° by the flaps position indicator and through the aerial gunner's report;

- check reliability of the seat locking;

- make sure that the runway is clear and there are no aircraft on final approach;

- request over the radio the permission from the flight control officer to taxi to the take-off position. Clearance obtained, taxi out to the runway;

- set the aircraft in the take-off direction exactly along the runway centre line; switch off the nosewheels steering mechanism, fix the button in the depressed position, taxi straight 10 - 15 metres and make sure of the nosewheel setting along the longitudinal axis of the aircraft by its rectilinear motion; the aircraft setting in the take-off direction being correct, the runway centre line will project on the windscreen as shown in Fig.5. After the aircraft is stopped it should be kept at rest by means of the brakes.

WARNING: 1. Before take-off the aircraft should be set on the runway not farther than 100 metres from its beginning irrespective of the aircraft gross weight.

2. IT IS FORBIDDEN TO USE THE NOSEWHEEL STEERING MECHANISM WHEN THE AIRCRAFT IS AT REST.

(2) In the take-off position:

- make sure that there are no obstacles on the runway;

Note: The co-pilot switches on the instruments and prepares his working place in the same sequence as the aircraft commander.

- make sure that the automatic fuel control is on;
- request take-off clearance over the radio;
- warn the crew of take-off by giving a command: "Crew, taking off".

## Take-Off

38. Take-off by the Ty-16 aircraft should be performed by means of the same flight technique methods over the whole range of operational gross weights with an accurate maintenance of recommended speeds in accordance with the initial gross weight of the aircraft.

## Take-Off Run

39. Set the control column to the neutral position; keeping the aircraft by the brakes, develop the maximum possible engines speed under the particular braking conditions but not less than 4100 r.p.m. by smooth and synchronized motion of the throttle levers, and by the instruments make sure of normal operation of the engines.

Note: 1. The aircraft taxiing for more than 3 minutes is sufficient for the normal engine warm-up.

2. If the take-off is to be performed directly after the engine starting, the engines should be allowed to develop the maximum rating not earlier than 3 minutes after the slow running rating has been developed.

3. Jerks of the control column are observed as a result of the gas stream effect on the elevator when the engines speed is increased before the

take-off run and at the beginning of it. Jerks disappear as the aircraft forward speed increases.

Release the brakes by smooth and simultaneous motion of both legs so that the aircraft should start moving straight. Maintenance of direction at the beginning of the take-off run depends on correct releasing of the brakes. Having started the take-off run, push forward to the rest the engines control levers.

The engines control levers pushed forward to the rest, the aircraft commander will order the co-pilot: "Keep r.p.m.". After the co-pilot's reply: "Keeping r.p.m.", the aircraft commander should transfer his left hand on the control wheel.

Note: 1. After the report: "Keeping r.p.m.", the co-pilot watches the engines speed and exhaust gas temperature and if the speed is slow or the gas temperature in one or both engines is higher than the permissible one, he will immediately report it to the aircraft commander.

2. During take-off, after the engines have developed the maximum rating, the co-pilot and the radio-gunner will watch air consumption in the cabins not allowing its rise above 10 units.

During the take-off run the aircraft commander will from time to time look at the air speed indicator and tachometers.

When taking off into wind and in still air, the Ty-16 aircraft is stable during the take-off run and has no tendency to turn.

If the aircraft deviates from the take-off direction at the beginning of the take-off run, its rectilinear motion should be maintained with the help of the brakes (by short pulses); as an air speed of 130 - 150 km/hr is attained,

at which the rudder becomes effective, the rectilinear motion will be maintained by deflection of the rudder.
At an air speed of 150 - 160 km/hr begin unloading the nose-wheel by smooth pulling of the control column; at 200 - 205 km/hr IAS and the aircraft gross weight of up to 50 tons the take-off angle of attack, equal to $8^{o}$, should be given to the aircraft.

The elevator trim tab being in the take-off position and the aircraft centre of gravity location equal to 22 - 23% MAC unsticking of the nosewheel from the ground is accompanied by small loads on the control column from the elevator.

After the nosewheel has been lifted it is necessary to fix the given take-off angle by proper movements of the control column, otherwise, involuntary increase of the take-off angle of attack may happen as the forward speed during the take-off run is growing. This may result in the aircraft unsticking at a low speed.

WARNING: 1. During take-off the aerial gunner should observe the rear hemisphere, and if spontaneous release of the drag chutes happens he will report it to the aircraft commander immediately. If it is reported to the aircraft commander in the first half of the take-off run, the aircraft commander will:

- discontinue take-off (if the remainder of the runway length ensures the aircraft stopping;
- if it is reported in the second half of the take-off run, the aircraft commander will immediately drop the drag chutes holding the aircraft by means of the control column from lowering its nose while the chutes are unfolding, and continue take-off.

The aircraft commander will report the case to the flight control officer.

2. Unsticking of the aircraft at low speed is dangerous as the aircraft lateral stability becomes insufficient which makes the aircraft control difficult. THE AIRCRAFT UNSTICKING AT A SPEED LOWER THAN THE SPEED OF NORMAL UNSTICKING IS FORBIDDEN.

3. Decrease of the take-off angle of attack results in considerable increase of the take-off run length and the unstick speed.

Projection of the sky-line on the front window (Fig.6) can serve as a visual reference feature for the pilot to check the correct lift of the nosewheel for take-off.

## Unsticking and Initial Climb

40. If the take-off angle of attack is set correctly, the aircraft quits the ground without additional manipulation by the control column as soon as the aircraft develops the unstick speed.

With the gross weight of up to 50 tons the aircraft becomes airborne at 250 - 260 km/hr IAS.

After take-off it is necessary to smoothly brake the undercarriage wheels at an altitude of 5 - 10 metres.

After take-off, the flight should be continued without banking and deviations from the take-off heading and with gradual lift at a vertical speed of 2 - 4 m/sec. until a forward speed of 370 - 380 km/hr (depending on the aircraft gross weight) is developed.

After a speed of 370 - 380 km/hr has been attained the aircraft commander should order the co-pilot: "Set 4100 r.p.m." and personally make sure that this engine speed has been set. This engine speed provides a smooth transition to climb with a vertical speed of 5 - 6 metres per second.

41. THE CO-PILOT IS FORBIDDEN TO CHANGE THE ENGINES RATING WITHOUT THE AIRCRAFT COMMANDER'S PERMISSION.

WARNING: 1. IT IS FORBIDDEN TO TAKE-OFF:

- if the flaps are not set to the take-off position ($20^{\circ}$);
- if the ailerons and rudder trim tabs are not set to the neutral position.

2. In all kinds of flight:

- it is allowed to run the engines at the maximum rating for not longer than 8 minutes, after that the engine should be switched to the normal rating or to a slower one;
- while climbing at the maximum rating one should not let the gas temperature rise after the turbine above $720^{\circ}$C, for this purpose one should decrease the engine speed if necessary.

## Crosswind Take-Off

42. When taking off at crosswind, the Ty-16 aircraft tends to turn against wind, especially when the nosewheel is raised.

The heading at the beginning of the take-off run up to 130 - 150 km/hr IAS should be kept by braking the wheels of the corresponding undercarriage bogie.

At a speed of 130 - 150 km/hr the rudder becomes effective, therefore, in the second half of the take-off run the heading should be maintained by proportionate deflection of the rudder to the required direction. Effectiveness of the rudder increases with the increase of speed during the take-off run, and the deflections of the rudder made at the beginning of the ground run may prove to be excessive which may sometimes result in a reverse turn (downwind) or yawing motions. Therefore, when taking off at cross wind, one should pay more attention to observation of the take-off direction, timely and accurately react upon the aircraft turns, especially into wind.

Depending upon the velocity of crosswind one should begin lifting the nosewheel more smoothly and at a speed by 10 - 15 km/hr (IAS) higher than during the take-off into wind.

During ground run with the lifted nosewheel, the heading will be maintained at cross wind by deflection of the rudder to the corresponding direction; if necessary, apply the main brakes. When the brakes are applied, the aircraft tends to lower the nose by jerks, which makes the maintenance of the constant take-off angle difficult. In this case the aircraft commander should keep the prescribed take-off angle of attack by a smooth motion of the control column.

After take-off the aircraft should be prevented from banking and deviations from the take-off direction by means of the ailerons and the rudder.

After the aircraft unsticking one should compensate for drift by changing the heading into the wind.

Permissible velocity of crosswind for the Ty-16 aircraft take-off and landing is 12 metres per second. Performance of take-off and landing at such wind requires that the pilots are good and confident in flight technique.

## Climb after Take-Off

43. Climb after the aircraft take-off with the flaps down by 20° and extended undercarriage should be performed at 370 - 380 km/hr IAS depending on the aircraft gross weight.

The co-pilot should begin retracting the flaps on the aircraft commander's order after an altitude of 100 - 150 metres has been gained. The flaps will be retracted in two stages: by $5^{\circ}$ and by $15^{\circ}$.

When retracting the flaps by $5^{\circ}$, it is necessary to make sure that both of them are being retracted synchronously. This is determined by the aircraft behaviour and through the aerial gunner's report: "Right and left flaps are going up". After that complete the retraction of flaps.

<u>WARNING</u>: Whenever the aircraft behaviour during the flaps retraction changes (banking, turning) the aircraft commander should discontinue their retraction by ordering the co-pilot: "Stop flaps retraction". Upon this order the co-pilot should immediately set the selector switch to the neutral position. The aircraft commander will report the case to the flight control officer and then act according to his instructions.

Pitching moment appears during the flaps retraction. The loads, which appear on the control column during this, can be fully eliminated by the elevator trim tab by means of pushing the handwheel of the elevator trim tab forward. The air speed during this should not be lower than 370 - 380 km/hr.

<u>WARNING</u>: IT IS FORBIDDEN TO USE ELECTRIC CONTROL OF THE ELEVATOR TRIM TAB AT ALTITUDES BELOW 1000 METRES.

Complete retraction of the flaps should be checked by means of the flaps position indicator and through the aerial gunner's report.

After the flaps have been retracted it is necessary to set a speed of 400 km/hr IAS.

44. Crosswind turn should be made at an altitude of not less than 200 metres after retraction of the flaps and the aircraft balancing by means of the elevator trim tab.

45. When climbing the aircraft commander should keep in his field of vision the flight instruments, which control the aircraft attitude: the artificial horizon, rate-of-climb indicator, directional gyro, airspeed indicator, altimeter, and the engine instruments.

46. When proceeding from climb to level flight one should not change the engines rating until the aircraft is in the attitude corresponding to level flight (by the artificial horizon and rate-of-climb indicator).

Note: In all kinds of flight the co-pilot will hold the engine-control levers prior to crosswind turn and he maintains the prescribed engine rating according to the aircraft commander's directions. If the engine speed drops, he immediately reports it to the aircraft commander.

## Formation of Pattern Flying Route

47. At an altitude of not lower than 200 metres, when the estimated time from the beginning of the take-off run has elapsed, the aircraft commander orders: "Left (or right) turn". Having made sure that there are no aircraft on the left (or right) and having got the aerial gunner's report: "Left (or right) hemisphere is clear", the aircraft commander makes a crosswind turn with a $15^{0}$ bank and an air speed of 400 km/hr, watching at the same time the readings of the flight instruments and maintaining the prescribed rate of climb.

WARNING: In all kinds of flight the turns at an air speed of 400 km/hr and less should mainly be performed with the help of the ailerons and the rudder should only be used for coordination of turn, because at the excessive deflection of the rudder, the loads on the pedals may decrease to zero (See Appendix 1, Aerodynamic Features of Ty-16 Aircraft).

When flying the rectangular pattern, the route should be formed by means of the ГПК directional gyro. The readings of the directional gyro for recovery from turns at the left-hand rectangular pattern will be: 270°, 180°, 90°, and 0°; for recovery from turns at the right-hand rectangular pattern they will be: 90°, 180°, 270°, and 0°.

48. Having gained the prescribed altitude of the rectangular pattern flight (400 metres), bring the aircraft to the level flight and after that set the engines speed at 3500 - 3900 r.p.m.; while in level flight, maintain an air speed of 400 km/hr.

WARNING: It is not recommended to fly at the engines speed of 3620 - 3750 r.p.m., as at this speed the air blow-off band opens and closes periodically and the engines operation is unstable.
If the engines speed, required to provide the necessary airspeed for the rectangular pattern flight (400 km/hr), is within the above mentioned limits, it is permitted to set one engine speed somewhat lower than 3600 r.p.m. and the other engine speed - somewhat higher than 3900 r.p.m. In this case the aircraft commander should check uniform consumption of fuel from the groups of the port and starboard engines.

The КУР relative bearing (RB) of radio station being equal to 240°, turn to downwind leg by 90° until the directional gyro reads 180°, taking the drift angle into account (180° ± drift angle). The magnetic course read by the ДГМК-7 remote-reading gyromagnetic compass should correspond to the heading reverse to the landing one with the drift angle taken into account.

In level flight the aircraft stability and control are good. The loads which appear on the controls are completely eliminated by the trim tabs. When flying the aircraft one should avoid excessive manipulations with the ailerons and especially with the rudder, as it results in the aircraft yawing and fatigues the pilot.

Continuously watch the prescribed altitude and airspeed.

49. The aircraft navigator and co-pilot will see to it that the prescribed course, altitude, and airspeed are maintained and report the detected deviations to the aircraft commander at once.

50. During the whole flight the aircraft commander and co-pilot must watch the operation of the engines by the readings of the instruments and by ear, and they should also watch the operation of the automatic fuel control.

51. The КУР relative bearing being equal to 240°, turn to base leg by 90° until the directional gyro reads 90° and the heading read by the ДГМК-7 compass is more than the landing heading by 90°.

On the base leg, check pressure in the main and emergency braking hydraulic systems. If the pressure in them is lower than 150 kg/cm$^2$, charge the systems to capacity. Besides, make sure that the automatic brake control unit is switched on.

52. When flying at low altitudes (lower than 1000 metres) it is necessary to check the altitude of flight by the ВД-20 barometric altimeter taking into account the instrument and aerodynamic corrections (See Figs 7 and 8).

When flying at altitudes lower than 300 metres the altitude should be checked by means of the radio altimeters.

For approximate account of aerodynamic corrections to the ВД-20 barometric altimeters, when flying the Ту-16 aircraft at low altitudes (lower than 1000 metres), the pilots should remember, that when flying at an IAS of 300 km/hr the correction should be considered to be equal to minus 40 metres and with every IAS increase by 50 km/hr the correction should be increased by minus 10 metres.

## Landing Approach, Judgement, and Landing

53. The beginning of the final turn should be determined by means of the APK-5 automatic radio compass (in still air the relative bearing of radio station must be 290°). The final turn should be made in level flight with a 15° bank and at an airspeed of 400 km/hr. To accurately align the aircraft on the runway centre line it is allowed to decrease or increase the bank by up to 20°.

During the final turn the co-pilot and the aircraft navigator will watch the maintenance of altitude and airspeed with utmost care; if they differ from the prescribed values, they will immediately report the case to the aircraft commander.

54. During final approach the following flight and navigation instruments must be constantly in the pilots' field of vision: artificial horizon, airspeed indicator, rate-of-climb indicator, altimeter, ГПК directional gyro, APK-5 automatic radio compass, and ПСП-48 ILS indicator.

<u>Note</u>: After the final approach and up to the landing the aircraft commander himself should shift the engines control levers and maintain the required airspeed by changing the number of r.p.m.

55. After the aircraft has been aligned on the runway it is necessary to set the engines speed of 3400 - 3600 r.p.m. and extend the flaps by 20° when flying straight and level.

The co-pilot extends the flaps in two stages (by 5° and up to 20°) upon the aircraft commander's command "Flaps down by 20°".

During the flaps extension by 5° one should make sure of synchronized motion of the flaps of both wings through the aircraft behaviour, and, having got the aerial gunner's report: "Starboard and port flaps are going down", extend the flaps up to 20°.

<u>WARNING</u>: If during the flaps extension the lateral balance of the aircraft is broken, the aircraft commander should immediately discontinue their extension by the order: "Stop flaps extension", report the case to the flight control officer and act according to his directions.

Insignificant diving moment (the aircraft lowers the nose) appears during the flaps extension. During the flaps extension procedure and descent after the final approach the aircraft commander must balance the aircraft by the elevator trim tab so that there should be no load on the control column from the elevator.

After the flaps have been extended by 20° and the aircraft has been balanced by the elevator trim tab, he should continue level flight (the airspeed during this will gradually decrease). At an IAS of 340 km/hr the flaps should be extended by 35° (upon the aircraft commander's order to the co-pilot: "Flaps down by 35°") and simultaneously start descending at a vertical speed of 2 - 4 metres per second. When flying under these conditions after the flaps extension by 35°, it is necessary to balance the aircraft by the elevator trim tab again.

56. During and after the flaps extension by 35° the airspeed must gradually decrease and be equal to 300 km/hr when passing over the ДПРМ outer homing beacon, and 290 -

280 km/hr when passing over the БПРМ inner homing beacon, and 270 - 280 km/hr before starting to level-off.

57. The aircraft is stable during descent. While descending avoid unnecessary movements of the controls as it results in the aircraft swinging and makes its control difficult.

58. The aircraft alignment on the runway centre line should be made more accurate immediately after the recovery from the final turn. Correction turns will be made with a 5 - 8° bank.

59. The aircraft navigator will watch the altitude and speed of flight and, if they deviate from the prescribed values, report it to the aircraft commander. The ДПРМ outer homing radio marker beacon will be passed at altitudes of 220 - 200 metres and the БПРМ inner homing radio marker beacon at altitude of 80 - 70 metres.

60. The Ту-16 aircraft glide path is gentle. Having passed over the ДПРМ outer homing radio marker beacon set the rate of descent of 3 - 4 metres per second by the rate-of-climb indicator. The loads, which appear on the control column, should be removed by the elevator trim tab.

Having passed over the БПРМ inner homing radio marker beacon at altitudes of 80 - 70 metres, specify the judgement and proceed to smooth decrease of the engines speed so as the airspeed by the beginning of levelling off is 270 - 280 km/hr and the engines control levers before the beginning of levelling-off are not fully shifted to the slow running rest.

61. If the glide path is maintained correctly, the point of the beginning of levelling-off must be planned at a distance of 150 - 200 metres from the beginning of the runway.

62. Taking the aircraft actual landing weight into account, before levelling-off make sure once more that

the speed of flight equals 270 - 280 km/hr. Increase of the above mentioned speed by 10 - 20 km/hr results in marked increase of levelling-off and floating distance. But the decrease of airspeed below 270 km/hr during descent results in sharp coming down and premature touchdown of the aircraft. IT IS STRICTLY FORBIDDEN TO DESCEND AT A SPEED LOWER THAN 270 km/hr.

Before levelling-off pay attention to correct position of the feet on the pedals. Position of the feet on the pedals being wrong (the feet are on the upper parts of the pedals), involuntary braking of the wheels may happen before touchdown when the pedal is pressed to compensate for drift.

63. Begin levelling-off at an altitude of 8 - 10 metres. Before levelling-off smoothly throttle down the engines to the "Slow running" rest. Having set the engine-control levers to the slow running rests, the aircraft commander will order the co-pilot: "Keep r.p.m.". The co-pilot must reply: "Keeping r.p.m." and keep the throttle levers in the extreme rear position up to the end of the aircraft landing run. IT IS FORBIDDEN TO SET THE ENGINE-CONTROL LEVERS TO THE SLOW RUNNING RESTS AT HIGHER ALTITUDE, as it may result in the loss of airspeed, errors in judgement, and pancake landing.

Throttling of the engines does not result in marked change of the longitudinal balancing of the aircraft, and it therefore does not require additional deflection of the elevator trim tab.

Complete levelling-off at an altitude of floating of 1 or 0.5 m.

To avoid ballooning at the end of levelling-off fix the aircraft at the given altitude.

64. Floating should be made with gradual descent in such a way that the main undercarriage wheels touchdown softly when the control column is smoothly pulled a bit back. Touch-

down speed equals 220 - 235 km/hr depending on the aircraft gross weight before landing.

After the touchdown it is necessary to check the motion of the control column, as at even negligible pulling of the control column the aircraft will quit the ground. If the aircraft clears the ground after the touchdown, it is necessary to pay attention to the fact that the brake pedals of both pilots are not pressed because pressing of the pedals in the air will result in destruction of the wheels after touchdown.

WARNING: IT IS STRICTLY FORBIDDEN:

- to land on the ground before the beginning of the runway;
- to correct overshoot by landing at higher speed (by pushing the control column during floating);
- to push the brake pedals before the aircraft touchdown because the wheels will be braked (even with the automatic brake control unit switched on) and this will lead to destruction of the wheels after touchdown.

65. Braking of the Ty-16, aircraft during the landing run should be made in all cases (except for landing at cross-wind velocity higher than 5 m/sec.) in the following way.

2 - 3 seconds after touchdown when the aircraft is on two points, begin braking the wheels by fully pressing the brake pedals (automatic brake control units must operate). At this the nosewheel tends to lower, and it should be smoothly and gradually lowered on the runway giving a support by means of the control column. As the aircraft begins "nodding", which occurs at the end of the landing run at low speeds, it is necessary to somewhat reduce pressure in the brakes to the value which ensures ceasing of the longitudinal swinging.

If the velocity of crosswind is higher than 5 metres per second, it is necessary to brake the aircraft after touchdown in the following way.

The touchdown speed should be equal to 220 - 235 km/hr (depending on the gross weight). To reduce the aircraft turn caused by the crosswind, force the nosewheel smoothly down. It is necessary to begin braking 2 - 3 seconds after touchdown irrespective of the fact whether the nosewheel is up or down. Depending on the crosswind velocity it is necessary to bracke the wheels of the undercarriage bogie opposite to the turn more vigorously.

At strong crosswind simultaneous braking of the wheels of both bogies requires great practical experience and is not always a success; to prevent the aircraft from turning it is necessary to brake the wheels of one bogie only. Therefore at crosswind the length of landing run increases and, if the drag chutes are not used, it may reach as much as 2500 metres.

To reduce the length of the landing run at the crosswind velocity of more than 8 metres per second it is necessary to release the drag chutes after touchdown and perform the whole landing run with the drag chutes cut.

66. At the end of the landing run, switch on the nosewheel steering mechanism and, using the aircraft run inertia, turn at safe speed (10 - 15 km/hr) to taxiing along the taxiway or to the aircraft parking area.

67. If the main brakes fail, report the case to the flight control officer, release the drag chutes after touchdown, and apply the emergency brakes. For this purpose pull the emergency brakes levers moothly and simultaneously and stop the engines if necessary. When applying the emergency brake do not brake sharply to avoid destruction of the tyres and after the emergency brakes levers have been smoothly pulled, do not release them, because the movement of the

levers forward and backward results in rapid pressure release from the emergency hydraulic accumulator. As the speed during the landing run decreases, the levers of the emergency brakes should be pulled harder. At the end of the landing run at safe speed (10 - 15 km/hr) turn to the taxiway, drop the drag chutes, stop the aircraft, and cut the engines out (if they were not cut out before).

68. The landing characteristics of the Ty-16 aircraft under standard weather conditions in still air are given in Table 1.

To calculate the length of the landing run use the chart shown in Fig.9.

Table 1

Landing Characteristics of Ty-16 Aircraft

| Use of brakes and drag chutes | Landing weight, t. | Position of flaps, deg. | Length of landing run, m. | Time of landing run, sec. | Landing speed, km/hr |
|---|---|---|---|---|---|
| With brakes less drag chutes ................ | 44 | 35 | 1400 | 34.5 | 220 |
| With brakes less drag chutes ................ | 48 | 35 | 1550 | - | 230 |
| With brakes and drag chutes ................ | 44 | 35 | 1000 | 28.5 | 220 |

## Go-Around

69. Safe go-around of the aircraft with a gross weight of up to 55 tons with the undercarriage down and the flaps extended by 35° is ensured from an altitude of not less than 50 metres.

Having decided to go-around the aircraft commander should:

- warn the crew by the order: "Go-around";
- increase the engines speed up to the maximum rating without changing the rate of descent;
- report his decision over the radio to the flight control officer;
- bring the aircraft to level flight as the airspeed becomes equal to 300 - 310 km/hr and to climb at an airspeed of 330 - 340 km/hr;
- retract the flaps and, if necessary, the undercarriage at an altitude of not less than 100 metres and at an airspeed of 330 - 340 km/hr; the flaps should be retracted by pulses in two stages: by 5° and fully; the load which appears on the control column should be removed by means of the elevator trim tab;
- increase the speed of flight up to 370 - 380 km/hr versus the aircraft gross weight, after that climb to an altitude of 400 metres and repeat the landing approach.

Extension of the undercarriage (if it was retracted) is to be done in usual manner.

## Landing Approach and Crosswind Landing

70. When approaching for landing at crosswind it is necessary to compensate for the aircraft drift by introducing the required angle of advance into the aircraft heading. Before the touchdown it is necessary to apply the pedal which corresponds to the direction of drift, turning the aircraft along the axis of the runway.

To maintain the heading after touchdown in the first half of the landing run it is necessary to use the rudder simultaneously with braking.

WARNING: 1. When landing at crosswind, an accurate approach of the aircraft to the ground and smooth touchdown are obligatory. High levelling-off and rough touchdown are not allowed in this case.

2. Landing at a crosswind velocity in excess of 12 metres per second (at 90° to the runway) is made as an exception.

## Landing with Drag Chutes

71. The drag chutes must be used during landing in the following cases:

- when landing on the runway, the length of which is limited;
- when the brakes fail to operate;
- when landing at the crosswind velocity in excess of 8 metres per second and at an angle exceeding 70°;
- when the aircraft is running off the runway;
- when landing on wet runway;
- when landing on ground;
- when landing with the unserviceable flaps extension system;
- in other cases upon the aircraft commander's decision when it is necessary to reduce the length of the landing run.

It is allowed to release drag chutes for the purpose of training the pilots in the performance of landing run with released drag chutes.

72. The drag chutes will be released immediately after the touchdown irrespective of the fact whether the nosewheel is up or down.

Notes: 1. Strength of the drag chutes made of capron fabric of ПТ-16 type ( ПТ-2923-53, series 2) ensures the possibility of their release at any stage of the aircraft landing run up to an IAS of 270 km/hr.

2. If the aircraft is equipped with the drag chutes made of cotton fabric (ПТ-3033-53), it is allowed to release them in all cases at a speed of not more than 210 km/hr. When the chutes are released with the nosewheel up, the aircraft lowers the nose vigorously, which can be compensated rather effectively by pulling the control column.

To release the drag chutes, push the RELEASE button.

73. The drag chutes should be dropped at the end of the landing run or after taxiing off the runway.

## Advanced Manoeuvres

74. When flying to the zone for training in flight technique, the take-off is performed in the same way as during pattern flying.

After the aircraft take-off, at an altitude of 5 - 10 metres, brake the wheels of the undercarriage and order the co-pilot: "Retract undercarriage". An airspeed of 370 - 380 km/hr reached, one sets the engines speed at 4100 r.p.m. The IAS should not exceed 400 km/hr until the undercarriage has been retracted completely.

WARNING: It is strictly forbidden to brake the wheels during the undercarriage retraction.

Upon receiving the order: "Retract undercarriage", the co-pilot should make sure that the handwheel of the nosewheel steering mechanism is in the neutral position and the button to switch it on is fully depressed and locked; open the cap of the main cock of retraction and extension of the undercarriage, make sure that the big and small buttons of the undercarriage extension are in the upper initial position and a lock is fit under the small button; remove the lock from under the RETRACTION button, fully push the button and turn it clockwise to the limit stop, after that release it. The button must get checked (locked) in the depressed position by itself.

<u>Note</u>: If the system of the undercarriage retraction and extension operates normally, the pressure in the main hydraulic system, read by the UNDERCARRIAGE - BOMB BAY pressure gauge, must be equal to 146 - 157 kg/cm$^2$. After the RETRACTION button has been pushed, all three green lights, indicating the extended position of the undercarriage, must go out, pressure in the system must first drop to 70 - 100 kg/cm$^2$, and then, as the undercarriage is being retracted, the pressure must begin growing. As soon as all three red lights, indicating the retracted position of the undercarriage, go on, the pressure must sharply increase to the maximum value of 146 - 157 kg/cm$^2$.

After the last red light starts shining keep the system under the pressure of 146 - 157 kg/cm$^2$ during 5 seconds and then turn the RETRACTION button anti-clockwise to the rest and release it. The button must pop out (come out) to its initial upper position. Make sure that the buttons of the main cock of the undercarriage are in their initial (upper) position and all 3 red warning lights of the retracted position of the undercarriage are shining.

75. At an altitude of 100 - 150 metres, upon the aircraft commander's order the co-pilot will retract the flaps in two stages: by 5° and 15°.

The aerial gunner reports the complete retraction of the undercarriage and flaps to the aircraft commander.

76. Training flights to zone should be performed at altitudes of 5000 - 8000 metres.

## Climb to Prescribed Altitude of Flight

77. To obtain the best rate of climb, the climb should be performed at the normal engines rating (4350 r.p.m.).

78. For all aircraft gross weights (maximum take-off weight of 75.8 tons inclusive) the climb should be made at constant IAS equal to 570 km/hr up to an altitude of 7000 metres. During further climb IAS will be reduced by 20 km/hr every 1000 metres.

Note: At the normal engines rating the gas temperature must not exceed 610°C when the air is not bled into the wing de-icing system and 620°C when the air is bled.

Table 2

Vertical Speeds, Time, and Optimum Climbing Speeds Versus Altitude of Flight at Normal Engines Rating

| Altitude, m. | Vertical speed of climb (standard), m/sec. | | Time for climb (standard), min. | | Optimum climbing speed, km/hr | |
|---|---|---|---|---|---|---|
| | Gross weight 59 t. | Gross weight 72 t. | Gross weight 59 t. | Gross weight 72 t. | Gross weight 59 t. | Gross weight 72 t. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 20.2 | 16.0 | 0 | 0 | 570 | 590 |
| 1000 | 18.8 | 14.9 | 0.9 | 1.1 | 562 | 578 |
| 2000 | 17.4 | 13.7 | 1.8 | 2.2 | 553 | 567 |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 3000 | 16.0 | 12.5 | 2.8 | 3.5 | 543 | 556 |
| 4000 | 14.7 | 11.3 | 3.8 | 5.0 | 533 | 544 |
| 5000 | 13.3 | 10.1 | 5.0 | 6.5 | 523 | 533 |
| 6000 | 12.0 | 9.0 | 6.2 | 8.2 | 512 | 522 |
| 7000 | 10.6 | 7.8 | 7.8 | 10.2 | 500 | 511 |
| 8000 | 9.2 | 6.6 | 9.4 | 12.6 | 486 | 500 |
| 9000 | 7.9 | 5.4 | 11.3 | 15.5 | 470 | 486 |
| 10,000 | 6.5 | 4.2 | 13.6 | 18.8 | 454 | 464 |
| 11,000 | 5.2 | 3.0 | 16.5 | 23.5 | 432 | 430 |
| 12,000 | 3.0 | - | 21.0 | - | 401 | 380 |
| 12,100 | - | 0.5 | - | 35.5 | - | 365 |
| 13,100 | 0.5 | - | 32.5 | - | 355 | - |

Note: The time required for aircraft take-off and acceleration to the optimum climbing speed (equal to 2 minutes on the average) is not taken into account in the Table.

At an altitude of 2000 metres the aircraft commander will order the co-pilot and the radio-gunner: "Seal the cabins".

The cabins will be sealed and oxygen will be consumed as recommended in Section "High Altitude Flights".

### Execution of Mission in Advanced Manoeuvres Zone

79. After the prescribed altitude has been gained, bring the aircraft to level flight and balance it by the trim tabs at a prescribed speed of flight.

During turns and banked turns the aircraft is stable within the authorized limits up to M=0.87.

At altitudes below 8000 metres steeply-banked turns with $45^{\circ}$ bank should be performed at IAS of 500 - 550 km/hr, and shallow turns with a bank of up to $30^{\circ}$ at IAS of 450 - 500 km/hr.

Permissible load factors and angles of bank during execution of banked turns versus altitude of flight, airspeed, and gross weight will be determined by means of the charts given in the Appendix to the present Instructions.

Enter a banked turn and recover from it at all speeds (up to M=0.9) by coordinated deflection of the ailerons and rudder.

At an altitude of 10,000 metres the banked turns will be performed at IAS of 400 - 450 km/hr with a bank not in excess of $30^{\circ}$.

As the altitude of flight increases one should be more careful in creating the load factor during banked turns and turns, because sharp overpulling of the elevator and creation of load factors in excess of the permissible ones result in vibration and stalling of the wing.

Turns and banked turns at altitudes above 11,000 metres should be performed with a bank of not more than $20^{\circ}$ and at Ma = 0.74 - 0.75 or at IAS of not lower than 380 km/hr.

It is not recommended to perform turns and banked turns at these altitudes at lower speeds, because errors in the aircraft control are possible; this may result in vibration and stalling of the wing due to small range of speeds and decrease of the aircraft stability reserve relative to load factor.

When performing steeply-banked turns do not let the aircraft lower its nose, because it is difficult to correct this error due to great loads created by the rudder. If the aircraft has lowered the nose, it is necessary to recover the aircraft from the bank, to establish level flight, and to enter the banked turn again.

It is strictly forbidden to simultaneously eliminate the bank and lead the aircraft out from descent because the aircraft may stall.

80. The spiral will be performed with the bank of 25 - 30° at IAS of 450 - 500 km/hr.

CHECKING OPERATION OF AIRCRAFT EQUIPMENT IN FLIGHT

81. The co-pilot must:

- help the aircraft commander to control the aircraft (by his permission) during execution of the mission; at the same time he must check by the instruments the fuel pressure, oil pressure, oil temperature in the engines; check fuel consumption from the groups of fuel tanks by means of the fuel quantity gauges, check total fuel remaining, compare the latter with the readings of the fuel quantity gauges and report it to the aircraft commander;

Note: When using the readings of the fuel quantity gauges, take into account the fact that a fuel quantity gauge indicates the fuel consumption only in that case when the engine is fed with fuel passing through the transmitter of the given fuel quantity gauge.

For example, if there is fuel leakage (tank leakage) or a fuel booster pump is out of order, the fuel quantity gauge of the engine with leaking tanks or failed booster pump will not indicate correctly the fuel remaining. If, for example, the starboard engine is fed through the cross-feed valve from the tank groups of the port engine (when the port engine does not operate), the fuel quantity gauge of the port engine will not indicate any consumption despite the decrease of fuel in the tanks of the port engine. The starboard engine fuel quantity gauge in this case will also wrongly indicate the fuel remaining because fuel from the tank groups of both engines flows through its transmitter.

In these cases the fuel remaining should be checked by means of the fuel quantity gauges only.

- check functioning of the cabin high altitude equipment by the readings of the air flowmeter (normal air consumption must equal 7 - 9 units), by the readings of the cabin altitude and pressure differential gauge (maximum permissible pressure differential is 0.4 kg/cm$^2$), and by the reading of the air low pressure gauge on the hatch sealing panel (the pressure gauge must read the pressure of 3.8 - 4.5 kg/cm$^2$); if the pressure differential increases (above 0.43 kg/cm$^2$), it is necessary to reduce it by turning the control handwheel of the ККД cabin combined pressure valve to the right; if during this there is pressure fluctuation painfully felt by the crew members, or if the pressure does not drop while the handwheel of the ККД pressure valve is being vigorously rotated and continues to grow, it is necessary to change over to the combat pressure rating by setting the АРД-54 selector switch at COMBAT; if after changing over to the combat rating the pressure still continues to grow above 0.43, it is necessary to report it to the aircraft commander and make an emergency pressure release;

Note: If pressure in the cabin drops below the prescribed value the warning horn is switched on automatically.

- check functioning of the oxygen equipment.

82. Functioning of the high altitude equipment in the rear cabin is checked by the radio-gunner. He must continuously watch proper operation of the high altitude equipment and immediately report all troubles to the aircraft commander.

## Stopping and Starting Engine in Flight

83. Stopping one of the engines for training purposes is allowed in the training zone at an altitude of 6000 -

8000 metres. To stop an engine it is necessary to set the throttle lever of the engine to be stopped at 2500 - 3500 r.p.m. and run the engine at this rating for not less than a minute, after that shift the throttle lever to the STOP position up to the rest.

84. In emergency cases, if an urgent stopping of an engine is necessary, the throttle lever should quickly be shifted from its initial position to the STOP position, the master selector switch should be switched off, and the fuel shut-off valve of the engine to be stopped should be closed.

The emergency cases include:

- appearance of intensive vibration of an engine;

- excessive and sharp gas temperature rise (above the permissible limit) after the turbine;

- sharp oil pressure drop (below the permissible limit) at the inlet to the engine;

- appearance of fire.

85. If an engine stops spontaneously in flight or after it has been stopped for training purposes, as well as in all other cases of engine stopping in flight when stopping is not due to engine trouble, the engine should be started in flight as follows:

- immediately after the engine stopping the throttle lever of the stopped engine should be shifted to the STOP position (if the throttle lever is not in the STOP position, the engine will be overfed with fuel and the starting may fail; in this case it is necessary with the throttle lever in the STOP position to scavenge the engine, using autorotation);

- the engine should be started in flight at an altitude of not lower than 7500 metres at IAS of 400 - 500 km/hr and the corresponding to this speed the autorotation speed of the engine of not less than 900 r.p.m.

Limitations in gas temperature after the turbine and oil pressure in the engine during the in-flight starting of the engine are the same as during starting the engine on the ground.

The engine will be started in flight in the following sequence:

- open the fuel shut-off valve (if it was closed) and make sure that the master power supply switch is on;

- make sure that the engine-control lever is in the STOP position, and switch on the automatic fuel control (if it was switched off);

- make sure(it concerns the navigator) that the starting circuit breakers (the second row from the bottom on the left-hand circuit breakers panel) are on;

- push the IN-FLIGHT STARTING button and keep it pushed;

- after 6 or 8 seconds after the IN-FLIGHT STARTING button has been pushed, energetically set the engine-control lever to the slow running rest and check the increase in the engine speed.

If the engine speed increases steady and energetically, release the IN-FLIGHT STARTING button.

If increase of the engine speed is delayed within 1300 - 2100 r.p.m., it is necessary to shift the throttle lever slightly backward and after the speed begins increasing energetically, set it on the transient slow running rest again and release the IN-FLIGHT STARTING button.

Transition of the engine to the rating required for the flight should be made not earlier than one minute after the engine has developed the slow running speed;

- if the engine speed does not increase during 60 seconds since the IN-FLIGHT STARTING button has been pushed, the engine starting should be discontinued, for this purpose it is necessary to release the IN-FLIGHT STARTING button and set the throttle lever of the engine to be started in the STOP position.

Before the second attempt to start the engine is made, it is necessary to scavenge the engine at the autorotation rating for not less than 2 - 3 minutes and in such a way that there should not be any jettison of fuel from the jet nozzle.

Notes: 1. When starting the engine in flight it is strictly forbidden to push the START button on the panel of ground engines starting.

2. The maximum speed should be developed for not less than 3 minutes since the slow running speed has been reached.

3. If two attempts to start the engine have failed, it is necessary to increase the autorotation speed or decrease the altitude of flight before the next starting.

## Descent

86. Descent from high altitudes (up to the service ceiling) should be performed with the throttled down engines (the throttle levers being positioned at the slow running rests).

As the aircraft descends, the engines speed, with the throttle levers positioned at the slow running rests, decreases and at an altitude of 500 metres the engine speed will be equal to about 2000 r.p.m.

Stable operation of the engines during descent from high altitude (above 10,000 metres) is ensured if fuel pressure before the injectors is not lower than 9 - 10 kg/cm$^2$.

WARNING: WHEN THROTTLING DOWN THE ENGINES SEE TO IT THAT THE THROTTLE LEVERS ARE NOT POSITIONED AFTER THE SLOW RUNNING TRANSIENT STOPS AS IT MAY RESULT IN THE ENGINES STOPPING.

87. Good longitudinal controllability of the aircraft when flying at great Mach numbers (up to M = 0.9) makes it possible to descend at high vertical speeds (up to 25 - 30 metres per second).

The optimum average IAS of flight when descending from high altitudes equals 500 km/hr. At this speed the longest distance of glide with the lowest fuel consumption is achieved.

88. The undercarriage will be extended on the downwind leg at an altitude of 400 metres. To extend the undercarriage the aircraft commander will reduce IAS up to 380 - 400 km/hr and after that order the co-pilot: "Undercarriage down".

Having got the command the co-pilot will make sure that the pressure in the main hydraulic system equals 146 - 157 kg/cm$^2$ (as read off the pressure gauge UNDERCARRIAGE - BOMB BAY ).

Open the cap of the main cock for the undercarriage retraction and extension and make sure that the RETRACTION button is in the extreme upper position and put the lock under it. Push smoothly the smaller button (without shifting the big one) and keep it in this position for 2 - 5 seconds until the pressure in the system is 146 - 157 kg/cm$^2$, then, pushing the smaller button, fully depress the big button and turn it clockwise to the stop, after that release both buttons.

During this the smaller button must return to its upper initial position and the big button must remain fixed in the depressed position.

Make sure that the smaller button has returned to its initial position and put the lock under it.

Notes: 1. If the smaller button does not return to its upper initial position, it is necessary to pull it out by force.

2. It is necessary to take the required precaution measures while putting the lock under the smaller button in order not to push the smaller button and pay attention to the correct fitting of the lock. It is strictly forbidden to put the lock on the top of the smaller button, because the smaller button will be pushed when the cap is being closed and it will lead to retraction of the undercarriage.

3. The system of the undercarriage retraction and extension operating normally, the pressure in the main hydraulic system, read by the UNDER-CARRIAGE - BOMB BAY pressure gauge, must be equal to 146 - 157 kg/cm$^2$.
4. During extension of the undercarriage the lock from under the smaller button must be removed, because it is impossible to push the smaller button if the lock is not removed and extension of the undercarriage without counterpressure will be accompanied with an impact to the joints.

After the big button has been locked and the smaller button returned to its initial position, the red lights indicating the retracted position of the undercarriage must go out, the pressure in the system must first drop to 70 - 100 kg/cm$^2$ and then begin growing. After all the three green lights indicating the released position of the undercarriage are on, the pressure in the system must sharply increase up to the maximum value of 146 - 157 kg/cm$^2$.

After the last green light is on it is necessary to make sure that the pressure in the hydraulic system equals 146 - 157 kg/cm$^2$, wait for 5 seconds and close the cap of the cock, leaving the big button fixed in the depressed position.

Note: During landing and taxiing the aircraft the hydraulic system of the undercarriage control remains under pressure.

The aircraft commander makes sure of the undercarriage extension through shining of green warning lights and through the report of the navigator-radar operator that the mechanical indicators are extended and through the gunner's report that the main struts are extended.

After the aircraft has been taxied to the parking apron and the engines have been stopped (or in the pre-take-off position, if another flight is to be made but taxiing to parking area and stopping the engines are not to be performed) the co-pilot must open the cap of the main cock for the undercarriage retraction and extension and, without removing the lock from under the smaller button, release the big button of the undercarriage extension by turning it counter-clockwise up to the rest (after that the button must return to its upper initial position), close the cap of the cock and lock it.

WARNING: When letting the big button out of the lock as well as in all other cases of the undercarriage cocks operation, be careful so as not to push the smaller button of the undercarriage extension, because this action will result in the undercarriage retraction.

## Flying Range and Endurance

89. At the prescribed fuel reserve the range and endurance depend upon altitude and airspeed. With the increase of altitude of flight the range and endurance also increase. The maximum endurance of flight at all altitudes is achieved at 370 - 380 km/hr IAS.

90. The airspeeds which correspond to the longest range of flight versus flight altitude are given in Table 3.

Table 3

Indicated Airspeeds Corresponding to Minimum Fuel Consumption per Kilometre

| Alt., m. | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 | 8000 | 9000 | 10,000 | 11,000 | 12,000 | 13,000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IAS, km/hr | 680 | 680 | 680 | 650 | 600 | 580 | 560 | 540 | 530 | 500 | 470 | 430 | 400 |

Note: When flying with gross weights from 75.8 to 70 tons, it is forbidden to maintain the indicated in the Table airspeeds of 680 km/hr IAS because in this case the airspeed limitation at altitudes from 0 to 7000 metres equals 645 km/hr IAS.

91. The maximum range of flight is achieved when flying 600 - 900 metres lower than the aircraft service ceiling.

Maximum range flight is performed as follows: after climbing to the altitude of 10,000 - 11,000 metres, which depends on the initial gross weight, the aircraft is brought to level flight at the maximum range rating. IAS at this must be equal to:

- 500 km/hr for an altitude of 10,000 metres;
- 485 km/hr for an altitude of 10,500 metres;
- 470 km/hr for an altitude of 11,000 metres.

These speeds approximately correspond to Mach number = 0.75.

The Mach number and true airspeed (read by the narrow needle) achieved at the given IAS remain constant during the whole flight. During this the aircraft will fly with a gradual continuous climb due to decrease in the aircraft gross weight as fuel is consumed. The indicated airspeed, as the altitude is gained, will gradually decrease and at altitudes of 12,800 - 13,200 metres it becomes equal to 410 - 390 km/hr.

If the ambient temperature does not change in the course of flight, the engines speed remains constant during the optimum ceiling flight. If the ambient temperature changes relative to the initial one, it is necessary to change the engines speed: if the temperature increases, it is necessary to increase the engines speed approximately by 40 r.p.m. for every 5°C of the ambient temperature rise, but not more than 4250 r.p.m., if the temperature decreases, the engines speed should be reduced by 40 r.p.m. for every 5°C of the temperature decrease.

92. If it is impossible to determine the change in the ambient temperature in the course of flight, the correct maintenance of the flight conditions should be checked by the altitude of flight; if the aircraft does not gain altitude in accordance with the estimated vertical speed or the profile of flight plotted on the engineer-navigator chart, the engines speed should be somewhat increased; if the aircraft gains altitude faster than it is required by the chart, the engines speed should be somewhat reduced. During this the altitude of flight over the target and the final altitude of flight must correspond to the estimated values. When flying at the optimum ceiling profile, the Ту-16 aircraft must gain 450 - 500 metres of altitude per hour.

93. An optimum ceiling flight can be performed with the АП-5-2М automatic pilot switched on. In this case the altitude of aircraft flight is controlled with the help of the РС-5 formation stick.

From the point of view of the aircraft control the optimum ceiling flight does not practically differ from the flight at constant altitude; the engines speed is within 4000 - 4100 r.p.m. versus the ambient air temperature.

94. When flying for max. range, after passing the initial point of route, the co-pilot will switch on neutral gas by setting the NEUTRAL GAS switch, mounted on the pilots' upper electric panel, into the ON position.

Switching on of the neutral gas system creats anti-fire safety due to concentration of $CO_2$ vapour in the space above fuel in the fuel tanks.

95. To determine in flight the changed range when the conditions of flight have changed it is necessary to use the nomogram and the chart shown in Figs 10 and 11.

## Directions for Use of Nomogram and Chart

### If Aircraft Aerodynamic Characteristics Have Not Changed

If the conditions of flight (altitude, airspeed, gross weight) have changed as compared to the prescribed values, but the aircraft aerodynamic characteristics have not changed, one should use the nomogram based on the chart of relative fuel consumption per kilometre in order to determine the range and endurance of flight on board the aircraft under these changed conditions.

The procedure for determining the fuel consumption per kilometre and the flying range is shown in Fig.10.

### If Aircraft Aerodynamic Characteristics Have Changed

If the aircraft aerodynamic characteristics have changed (the bomb bay doors have failed to close, the aircraft surfaces are damaged, etc.) the approximate calculation of range and endurance of flight should be made according to fuel consumption per hour. To this end, for the known conditions of flight (altitude, airspeed, and engines speed) it is necessary to determine fuel consumption per hour for two engines by means of the chart (See Fig.11).

By the fuel remaining $W_{level\ flight}$ and fuel consumption per hour Q determine endurance and range using the formulas:

$$t = \frac{W_{LF}}{Q},$$

$$L = Vt,$$

where V is true air speed in kilometres per hour.

It should be taken into account that the accuracy of this calculation will depend on the amount of deviation of the ambient temperature from the standard values. If deviation of the ambient temperature $\delta t^o = t^o_{standard} - t^o_{actual}$

is known, the corrected value of fuel consumption per hour can approximately be determined by the formula:

$$Q_{corrected} = Q\left(1 + \frac{2\ \delta t^{\circ}}{t^{\circ} + 273^{\circ}}\right),$$

where Q is fuel consumption per hour determined by means of the chart;

$t^{\circ}$ is the standard temperature of the ambient air at the altitude.

It is possible to consider approximately that in winter at medium and high altitudes the temperature of the ambient air is lower than the standard temperature by 3 - 4% (by 10°C). Consequently, in winter it is necessary to increase fuel consumption per hour by 6 - 8% at the same engines speed, and, on the contrary, in summer the temperature of the ambient air is higher than the standard temperature by approximately the same value. Consequently, fuel consumption per hour, obtained from the chart, should be decreased by 6 - 8%.

## High-Altitude Flights

96. While preparing for high-altitude flight it is necessary to thoroughly check serviceability of the high altitude and oxygen equipment.

The co-pilot and the radio-gunner will check:

- position of the АРД-54 function switch: the switch must be in the NORMAL position;

- position of the control handwheel of the ККД cabin combined pressure valve and the emergency pressure drop button: the handwheel must fully be turned counter-clockwise to the rest to the pressure differential in the cabin equal to 0.4 kg/cm$^2$, locked, and sealed, the emergency pressure drop buttons must be depressed completely;

- position of the low-altitude ventilation baffle plate in the front cabin and the cabin low-altitude ventilation cock in the rear cabin: the baffle plate of the front cabin ventilation and the cock in the rear cabin must be in the CLOSED position.

The aircraft commander and the gunner will check the position of the emergency pressure drop button on their control panels; the buttons must fully be pulled up.

97. Before taxiing out to the take-off position, on the aircraft commander's order: "Cabin supercharge ON", the following will be done:

- the co-pilot will open the shut-off valve of the air mains (the pressure read by the low pressure gauge must be equal to 3.8 - 4.5 kg/cm$^2$, open the shut-off valves of cabins pressurization from the starboard and port engines;

- the co-pilot and the radio-gunner will open the manual regulator of the air supply for cabins pressurization with a smooth motion of the control so that the air consumption at first should not exceed 6 - 7 units. During this the УВПД cabin altitude and pressure differential gauge must not read pressure drop both on the ground and up to an altitude of 2000 metres. Presence of pressure differential in the cabin on the ground and up to an altitude of 2000 metres indicates that the АРД-54 or АРД-50 automatic cabin-pressure regulators are unserviceable. The baffle plates of the by-pass valves of the turbo-coolers will be set to the COLD position if the temperature of the ambient air near the ground is high (in summer) and to the HOT position, if the ambient temperature near the ground is low, and hold them in this position for 30 - 45 seconds, after that release them and make sure that the selector switch has returned to its neutral position.

98. All the crew members, before taxiing out from the parking place, on the aircraft commander's order should:

- open the КВ-5 oxygen shut-off valve at the inlet to the КП-24М oxygen regulator;

- check adjustment of oxygen masks and proceed to breathe oxygen; check airtightness of adjustment by twisting the corrugated hose; if inhalation is impossible, the mask is adjusted properly;

- check the position of the air-dilution switches and the emergency oxygen supply cock of the КП-24М oxygen regulator and the position of the excessive pressure knob on the КП-24М oxygen regulator; during normal operation of the oxygen regulator (irrespective of flight altitude), the air-dilution switch must be in the 100% position, the emergency oxygen supply cock in the CLOSED position, and the excessive pressure knob must fully be turned to the right.

<u>WARNING</u>: If it is necessary to take the mask off the face on the ground or in the air when the oxygen shut-off valve is open, one must make a vigorous exhalation into the mask in order to stop oxygen outflow into the aircraft cabin through the mask.

99. After the take-off, at an altitude of 2000 metres, upon the aircraft commander's order: "Seal the cabins" it is necessary:

- for the co-pilot, to open the valve of air supply to the sealing rubber bladders of the hatches and check pressure in the air mains by means of the pressure gauge;

- for the co-pilot and the radio-gunner, to set the control selector switch of the turbo-cooler by-pass baffle plates to the AUTO position.

If by setting the selector switch to the AUTO position, the required temperature in the cabins is not provided, it is necessary to set the selector switch to the COLD or HOT position (depending on the required temperature) and keep it in this position for 3 - 5 seconds, after that release it and wait until the required temperature is reached; if necessary, this procedure should be repeated several times until the required temperature is attained.

If temperature in the cabins is high and does not drop when the turbo-cooler switch is set to the COLD position, it is allowed to reduce the amount of air supply into the cabins till the prescribed pressure differential remains stable (Tables 4 and 5).

Table 4

Pressure Differential and Pressure Cabin Altitude Versus Flight Altitude (under Normal Pressure Conditions)

| No. | Flight altitude, m. | Pressure differential (between ambient air and cabin), kg/cm² | Cabin altitude, m. | No. | Flight altitude, m. | Pressure differential (between ambient air and cabin), kg/cm² | Cabin altitude, m. |
|---|---|---|---|---|---|---|---|
| | by altimeter | by УВПД cabin altitude and pressure differential gauge | by УВПД gauge | | by altimeter | by УВПД cabin altitude and pressure differential gauge | by УВПД gauge |
| 1 | 1000 | 0 | 1000 | 9 | 9000 | 0.4 | 3000 |
| 2 | 2000 | 0 | 2000 | 10 | 10,000 | 0.4 | 3500 |
| 3 | 3000 | 0.0965 | 2000 | 11 | 11,000 | 0.4 | 4000 |
| 4 | 4000 | 0.1825 | 2000 | 12 | 12,000 | 0.4 | 4440 |
| 5 | 5000 | 0.253 | 2000 | 13 | 13,000 | 0.4 | 4840 |
| 6 | 6000 | 0.33 | 2000 | 14 | 14,000 | 0.4 | 5180 |
| 7 | 7000 | 0.393 | 2000 | 15 | 15,000 | 0.4 | 5440 |
| 8 | 8000 | 0.4 | 2480 | 16 | 16,000 | 0.4 | 5700 |

Table 5

Pressure Differential and Pressure Cabin Altitude Versus Flight Altitude (under combat pressure conditions)

| No. | Flight, altitude, m. | Pressure differential (between ambient air and cabin), kg/cm² | Cabin altitude, m. | No. | Flight altitude, m. | Pressure differential (between ambient air and cabin), kg/cm² | Cabin altitude, m. |
|---|---|---|---|---|---|---|---|
| | by altimeter | by УВПД cabin altitude and pressure differential gauge | by УВПД gauge | | by altimeter | by УВПД cabin altitude and pressure differential gauge | by УВПД gauge |
| 1 | 1000 | 0 | 1000 | 9 | 9000 | 0.2 | 5580 |
| 2 | 2000 | 0 | 2000 | 10 | 10,000 | 0.2 | 6200 |
| 3 | 3000 | 0.0965 | 2000 | 11 | 11,000 | 0.2 | 6820 |
| 4 | 4000 | 0.1825 | 2000 | 12 | 12,000 | 0.2 | 7400 |
| 5 | 5000 | 0.2 | 2560 | 13 | 13,000 | 0.2 | 7940 |
| 6 | 6000 | 0.2 | 3400 | 14 | 14,000 | 0.2 | 8420 |
| 7 | 7000 | 0.2 | 4140 | 15 | 15,000 | 0.2 | 8820 |
| 8 | 8000 | 0.2 | 4920 | 16 | 16,000 | 0.2 | 9200 |

Note: Permissible deviations of the pressure differential in the cabins from those mentioned in the Tables must not exceed ±0.02 kg/cm². Maximum permissible pressure differential in the cabins equals 0.43 kg/cm².

In flight the pressure in the cabin is maintained automatically depending upon the altitude of flight. Consumption of the air fed into the cabin must equal 5 - 10 units read by the flowmeter if the turbo-cooler baffle plate is in the HOT position, and 2 - 4 units if the baffle plate is in the COLD position.

100. The co-pilot and the radio-gunner will periodically check the readings of the cabin altitude and pressure differential gauge. If the pressure differential exceeds 0.43 kg/cm$^2$, they must act in accordance with the present Instructions.

The emergency pressure release can also be performed by the aircraft commander and the gunner by fully pushing the emergency pressure release buttons located at their working places.

Notes: 1. Pressure release from the pressurized cabins can be performed in the following ways:

- by unsealing the cabins (by bleeding the air from the rubber bladders which seal the hatches; in this case the excessive pressure will drop in both cabins);
- by opening the ККД cabin combined pressure valve (in this case the excessive pressure will drop only in that cabin where the ККД valve is opened);
- by closing the shut-off valves of the cabins pressurization from the engines compressors (in this case the pressure in the cabins will drop considerably slower than in the previous two cases);
- by closing the throttle of the cabin air supply regulator (the excessive pressure in the cabin will drop very slowly as compared to all previous ways of cabin pressure release);
- by emergency jettison of hatches covers before ejection (the excessive pressure will drop sharply in that cabin where the hatch cover was jettisoned); this method will be used upon the aircraft commander's order in case of extreme necessity only (when there is no time to use other methods), because sharp depressu-

rization may cause the crew members to feel pain and lead to formation of vapour in the cabin.

2. The method of excessive pressure release from the cabin will be selected by the aircraft commander depending on the concrete situation in flight.
3. The following members of the crew have the possibility to release excessive pressure in flight:

   - the left-seat and right-seat pilots, the radio-gunner, and the gunner by opening the ККД cabin combined pressure valves;
   - the right-seat pilot - by closing the shut-off valves of the system of cabins pressurization from the engines compressors;
   - the right-seat pilot and the radio-gunner by closing the throttles of the cabin manual air supply regulator.

101. Before air combat the co-pilot and the radio-gunner will reduce the excessive pressure to 0.2 kg/cm$^2$ by setting the selector switch of the АРД-54 automatic pressure regulator in their cabins to the COMBAT position in order to prevent the crew from harmful effect caused by quick change of pressure in case the cabin is hit by enemy fire. Emergency oxygen supply of the КП-24 devices should not be engaged.

102. In all cases the aircraft level flight is permitted at any rating of the engines but with the following restrictions:

- duration of flight at the maximum engine rating must not exceed 8 minutes, it is permitted to repeat the maximum rating only after 10 minutes of the engine operation at normal rating or 5 minutes of operation at the rating not exceeding 0.8 of the normal rating;

- flight at the normal engine rating must not last longer than 120 minutes; it is permitted to repeat the normal engine rating after 10 minutes of the engine operation at the rating equal to 0.8 of the normal rating;

- duration of flight at the rating equal to 0.8 of the normal rating is not limited;

- flight at the engines speed of 3600 - 3900 r.p.m. is not recommended;

- the readings of the engine instruments must not exceed the limits prescribed by the present Instructions;

<u>WARNING</u>: If the readings of the instruments exceed the limits in the course of flight, it is necessary to immediately reduce the engine speed and establish a new rating.

- the engine transfer from any intermediate rating to the maximum rating should be made for not less than 1 - 2 seconds; in this case the restrictions in relation to the r.p.m. increase and gas temperature increase after the turbine are the same as during the ground test of the engine acceleration; to avoid a possible spontaneous stopping of both engines at the same time, in all flights at 10,000 metres and higher, any change in the engines rating will be made in turn, the rating of one engine will be changed after the other engine rating has been changed;

- when flying at altitudes higher than 5000 metres at the maximum rating, the engine speed increase up to 4720 r.p.m. is permitted.

<u>WARNING</u>: 1. To prevent spontaneous stopping of both engines in flight due to possible appearance of surge, the engines speeds will separately be reduced by the engine-control levers.

When surge appears at altitudes lower than 3000 metres, the engine-control lever will immediately be shifted to the slow running position and then, after 4 - 5 seconds, transfer the engine to the required rating by slowly moving the control lever. During this action see that the engine speed increases smoothly, without stationary r.p.m. If surge continues, it is necessary to immediately shift the throttle lever to the STOP position and immediately start the engine again. (If surge appears on the ground, immediately shift the throttle lever to the STOP position).

If surge appears at altitudes higher than 3000 metres, immediately shift the throttle lever to the STOP position and re-start the engine at once.

The flight over, find out the cause of trouble and remove it.

2. If surge appears when the engine runs at maximum rating, reduce the engine speed by the throttle lever until surge discontinues and after the flight find out the cause of trouble and remove it.

3. While changing over to normal and maximum engine ratings after continuous operation of the engines at high altitude with the opened air blow-off band, carefully check the gas temperature, because in this case the blow-off band may fail to close due to freezing of condensate in its control mechanism. It is strictly forbidden to run the engines with the opened blow-off bands at the ratings higher than the normal rating.

103. Throttling down of the engines at high altitudes does not change the amount of pressure differential in the cabin, which is automatically maintained even if one of the engines stops.

104. The optimum average IAS of flight to descend from high altitudes equals 500 km/hr. At this speed the longest glide distance at the lowest fuel consumption is obtained.

105. At an altitude of 2000 metres upon the aircraft commander's order: "Remove oxygen masks, unseal the cabins" all members of the crew will take off oxygen masks and close the oxygen valves; the co-pilot will close the valve of the hatches sealing.

106. After landing and taxiing to the parking area, upon the aircraft commander's order: "Stop cabins supercharge" the co-pilot and the radio-gunner will close the manual air supply regulator in their cabins. Besides, the co-pilot closes the shut-off valves of the cabins supercharge from the port and starboard engines, opens the window to bleed air excessive pressure in the cabin and the radio-gunner pulls out the emergency pressure release button for this purpose.

WARNING: It is strictly forbidden to open the entry hatches of both cabins if there is even insignificant excessive pressure in them, as it may result in sharp opening of the hatch and injure people being at the hatch.

## Take-Off with Maximum Gross Weight

107. Before take-off the aircraft commander will calculate the length of the take-off run and the take-off distance for the given take-off conditions, as well as approximate points of the aircraft unsticking and the altitude for clearing the obstructions in the take-off heading.

108. Taxiing with the maximum gross weight will be performed at a speed of 10 - 15 km/hr without sharp braking.

109. The aircraft will be positioned for take-off not farther than 50 metres from the end of the runway. Before take-off (the centre-of-gravity location is 22 - 23% MAC), the elevator trim tab will be set by 1.5 - 2 divisions backward. Before the beginning of the take-off run, holding the aircraft by the brakes, allow the engines to develop the maximum possible rating at which the aircraft does not start moving. Make sure of normal operation of the engines by the instruments, release the brakes smoothly and simultaneously and begin the run. If the engines have not developed the take-off rating, the latter should be developed at the very beginning of the take-off run.

110. At a speed of 180 - 190 km/hr it is necessary to begin unloading the front wheel strut by smooth pulling of the control column with the subsequent placing of the aircraft at the take-off angle of attack (at a speed of 210 km/hr). The take-off angle of attack, equal to 8°, should be given to the aircraft at a speed of 240 km/hr and maintained until the aircraft quits the ground. The heading of the take-off run should be maintained as in usual flight.

111. Take-off of the aircraft at the normal take-off angle of attack takes place at a speed of 295 - 300 km/hr. The aircraft take-off at lower speed IS FORBIDDEN.

After unsticking, at an altitude of 5 - 10 metres, brake the wheels and order the co-pilot: "Undercarriage up". At an airspeed of 330 km/hr somewhat reduce the angle of attack.

112. Gain of airspeed up to 380 - 390 km/hr will be made with simultaneous climb at a vertical speed of 2 - 2.5 metres per second.

At an altitude of 100 - 150 metres order the co-pilot: "Flaps up" irrespective of the fact whether the undercarriage is fully retracted or not. The flaps will be retracted in two stages: by 5° and by 15°. In the course of flaps retraction it is necessary to prevent the aircraft from pitching and balance it for the increase of speed by turning the hand-wheel of the elevator trim tab forward.

When the airspeed of 380 - 390 km/hr is reached, the co-pilot makes sure that the undercarriage is retracted and then on the aircraft commander's order sets the engine speed at 4350 r.p.m. and begins to increase the airspeed for climb.

The service ceiling is equal approximately to 11,000 metres when taking off with the maximum gross weight.

The following take-off characteristics correspond to take-off from a concrete runway at maximum engines rating (Table 6).

Table 6

Take-Off Characteristics at Maximum Engines Rating

| Gross weight, t. | Position of flaps, deg. | Engines speed, r.p.m. | Take-off run length, m. | Time of take-off run, sec. | Unstick speed, km/hr | Length of take-off distance (before climb to 25 m.), m. |
|---|---|---|---|---|---|---|
| 55 | 20 | 4650 | 1000 | 25.0 | 250 | 1710 |
| 65 | 20 | 4650 | 1550 | 40.0 | 270 | 2660 |
| 75.8 | 20 | 4650 | 2200 | 51.0 | 295 - 300 | 3800 |

Notes: 1. Take-off characteristics are given for the standard atmospheric conditions in still air.

2. After take-off, not later than 8 minutes after maximum rating has been established, it is necessary to transfer the engines to the normal rating. When climbing at maximum rating avoid gas temperature rise after

the turbine above 720°C by decreasing the engines speed for this purpose, if necessary.

## Landing with Gross Weight of 55 tons

113. In urgent cases, when immediate landing is required and the aircraft gross weight is higher than the normal landing weight (50 tons), it is necessary to reduce the aircraft gross weight by emergency jettison of fuel and safe bomb drop.

As an exception, landing with gross weight of 55 tons on a concrete runway with utmost attention on the part of the pilot is allowed. When approaching for landing with the given gross weight, the speed of flight during descent (not less than 300 km/hr) will be maintained up to the outer homing radio marker beacon and 290 km/hr - up to the inner homing radio marker beacon, and 280 km/hr before the beginning of levelling-off. Touchdown will be made at the beginning of the runway, the drag chutes will be released, and the main brakes will be applied. If these means are not enough for efficient braking, use the emergency brakes.

## Flight at Maximum Speeds and Limit Mach Numbers

114. Pressure exerted by the elevator upon the control column greatly changes versus airspeed. Therefore, in the course of the airspeed increase until the maximum airspeed is reached, it is necessary to remove the pressure by means of the trim tab.

When balancing the aircraft with operational centre of gravity of 22 - 23% MAC at indicated Mach number = 0.75, the pressure exerted by the elevator grows gradually as the speed increases up to Mach 0.82 - 0.83, When balancing the aircraft at Mach 0.83, slight pulling efforts appear as the speed increases up to Mach 0.87 - 0.88. At further increase of Mach number the pressing efforts begin to grow rapidly.

Maximum Mach number 0.89 - 0.90 achieved, the behaviouv of the aircraft is normal, jolting and vibration are not observed, efforts exterted by the elevator are of pressing nature and great in value.

115. At Mach 0.87 - 0.90 opposite reaction of the rudder to the bank appears, but it is feebly marked and does not reduce the combat efficiency of the aircraft within the permissible limits of Mach number (up to 0.9).

When flying at speeds, corresponding to Mach 0.87 - 0.90, the opposite reaction is expressed in the change of aircraft behaviour when the rudder is deflected. When the left pedal is applied the aircraft at these speeds banks to the right, when the right pedal is pushed the aircraft banks to the left.

116. Execution of turns and banked turns at speeds corresponding to Mach 0.87 -0.90, requires utmost attention and great care on the part of the pilot in the aircraft control. Entering and rolling out the aircraft of the turns (or banked turns) will be made by coordinated deflection of the ailerons and rudder. If the aircraft is banking spontaneously against the bank at a speed corresponding to Mach 0.87 - 0.88 and higher, at accelerations nearing 1, deflection of the rudder only may result in bank increase and may lead to sharp increase of pressure exerted on the control column by the ailerons.

117. In some cases a banking moment increases and the pressure exerted on the control column by the ailerons grows as the speed of flight increases. In this case it is necessary to remove pressure by means of the ailerons trim tabs and check, after landing, whether the trailing edge of the ailerons and the rudder (ground adjustable trim tabs) are not bent and the wing fences are not twisted.

## Ty-16 Aircraft Behaviour at Mach 0.90 - 0.95

Never increase the speed of flight above Mach 0.9 at the altitudes below 10,000 metres.

Flying at Mach numbers from 0.90 to 0.95 has a number of peculiarities in the lateral and longitudinal stability and controllability of the aircraft.

The Mach numbers exceeding 0.9 can be obtained during the descent at full thrust of the engines. To get Mach 0.94 - 0.95 it is necessary to descend at a vertical speed of 45 - 50 metres per second at the maximum thrust of the engines, and the aircraft must be balanced for Mach 0.91. Descent at a vertical speed of up to 60 metres per second at the engines speed reduced completely increases the Mach number only up to 0.93. The efforts, exerted by the elevator during this, considerably change in their value and direction.

When balancing the aircraft at a speed corresponding to the Mach numbers less than 0.90, the pressing efforts of both pilots are not sufficient for controlling the aircraft during continuous descent at Mach numbers exceeding 0.925.

The aircraft recovers from descent to level flight rather slowly. Loss of altitude during this reaches 500 - 700 metres. Depending on balancing, the roll-out is performed by means of the reduction of pressing efforts on the control column and by its slight pulling back. A sharp pulling of the control column results, as a rule, in creation of G force in excess of the permissible one, and in bringing the aircraft to jolting conditions.

Decrease in the engines speed increases the aircraft deceleration, creates a slight diving moment, and makes the roll-out more smooth. Great increase of the aircraft pitch angle by a vigorous pulling of the control column back at all speeds of flight may lead to the fact that with the beginning of jolting the aircraft will spontaneously increase the G force even in that case if with the start of jolting the control column is sharply and completely pushed forward. Such wrong actions may result in the aircraft stall and complete loss of control.

As a result of the created G force and intensive jolting, one of the undercarriage legs may slip out. The leg and the half-opened doors create a great banking moment in the opposite direction. The efforts of both pilots in this case are not sufficient for recovering the aircraft from the bank at IAS higher than 430 km/hr. In this case it is necessary to set the undercarriage cock for the retraction of the leg, or, if the leg does not retract, to extend the undercarriage.

At Mach numbers exceeding 0.9 the opposite reaction of the rudder to the bank displays itself much more sharply, the aircraft banks energetically (willingly) in the direction opposite to the rudder deflection.

If up to Mach numbers equal to 0.90 the aircraft reaction to the deflection of ailerons is more or less calm, the picture sharply changes at Mach numbers exceeding 0.9, when the ailerons are deflected, the aircraft at first begins banking unwillingly, but with the start of banking the speed around the longitudinal axis increases progressively. In order to stop this more and more increasing banking, it is necessary to deflect the ailerons in the opposite direction energetically. The aircraft stops banking with a marked delay, then with acceleration it begins to recover from the bank and, as a rule, begins banking in the opposite direction. When flying at the speeds corresponding to Mach 0.90 - 0.95, the aircraft swings relative to its longitudinal axis and it is difficult for the pilot to proportionate the motion of the control column because at these speeds the aircraft lateral stability is poor. At Mach numbers higher than 0.90 the pressure exerted on the control column by the ailerons is insignificant which in turn makes the aircraft control more complicated. These difficulties still more redouble on the aircraft where the pressure exerted on the control column by the ailerons is lower than on other aircraft.

Because of high effectiveness of the ailerons and the difficulty to maintain the prescribed bank, it is somewhat difficult to perform a turn by means of the ailerons only. Therefore, the turns up to Mach 0.93 can be easier performed in a coordinated manner (the pedal corresponding to the direction of bank should be pushed).

At Mach 0.93 - 0.95 this method also does not allow to perform smooth correction turns, because with the great pressure on the pedals it is very difficult to proportionate their coordinated deflection.

Switching on of the rudder part of the automatic pilot at Mach numbers up to 0.93, when the turns are performed at the bank of up to 15$^{\circ}$ makes the aircraft control somewhat easier, because the automatic pilot stabilizes its bank more accurately.

Switching on of the elevator servo unit at Mach numbers higher than 0.91 does not provide the possibility to control the aircraft by means of the formation stick.

Beginning with Mach 0.89 - 0.91 a specific noise can be heard, which is similar to the noise which appears when the cabin window or canopy is opened in usual flight. Sometimes the appearance of this noise is accompanied with slight vibration or the cabin "jittering". At Mach number higher than 0.92 this vibration disappears.

## Aircraft Behaviour at Minimum Permissible Speed of Flight and Its Control under Stall Conditions

118. It is not recommended to reduce the speed of flight below the speed corresponding to the maximum endurance of flight for the gross weights:

45 - 50 tons - 350 km/hr;
55 - 60 tons - 370 km/hr;
65 - 70 tons - 400 km/hr.

IT IS FORBIDDEN to reduce IAS below the minimum permissible speed under any conditions of flight.

Note: To approximately determine a minimum permissible speed in flight (without a chart) it is necessary to remember the minimum permissible IAS, taken from the chart, for the definite altitude and gross weight, (for example, at an altitude of 10,000 m. for the aircraft gross weight of 55 tons the minimum permissible IAS of the flight with the undercarriage and flaps up is equal to 320 km/hr).

To determine a minimum permissible speed for other altitudes and gross weights it is necessary to remember the following:

- the change of aircraft gross weight by 5 tons results in the change of the minimum permissible speed by 15 km/hr on an average (increase of gross weight results in the increase of speed);
- the change of altitude by 2000 m. results in the change of the minimum permissible speed by 10 km/hr on an average (increase of altitude results in the increase of speed).

When the aircraft is approaching the minimum permissible speed, preceding its stall, the loads to the control column by the elevator gradually decrease but their direction remains the same.

The Ty-16 aircraft flying at a minimum speed with the undercarriage and flaps up does not display enough signs to warn the pilot of approaching stall.

At cruising altitudes of 9000 - 12,500 metres, before the aircraft is going to stall at a minimum speed, the aircraft usually pitches up sharply, though the elevator does not move, with the following appearance of periodic jolting and banking.

At lower altitudes stalling is accompanied with the prevalence of banking at a high angular velocity, which is the higher the lower is the flight altitude.

119. The Ty-16 aircraft returns to its initial cruising conditions without the pilot's interference (the elevator being immovable), unless the limit of permissible lift coefficient has been exceeded during manoeuvre or 1.2 of the permissible lift coefficient has been exceeded due to the effect of vertical gust of air masses.

When manoeuvring at speeds higher than the minimum speed, it is forbidden to exceed the limit beyond which stalling vibration appears (beyond the limit of the permissible lift coefficient) and exceed the operational values of G force.

If the aircraft begins jolting, pitching, or banking, the pilot must immediately push the control column energetically forward to position the aircraft at the operational angles of attack in order to prevent it from stalling. If the pilot interferes in time, the aircraft decreases the pitch angle practically without delay and jolting stops.

120. Delay in the pilot's reaction during the increase of the permissible values of the lift coefficient ($C_L$) during a manoeuvre or the effect of powerful vertical gusts may result in the aircraft stalling, which is characterized by:

- sharp pitching at stalling vibration with the following increase of the pitch angle up to 35 - 40° (because the aircraft is unstable when manoeuvring with an overload at the lift coefficient higher than the permissible one, or at the lift coefficient higher than 1.2 of the permissible one when affected by the gust);
- the aircraft banking from side to side up to ±30° with yawing up to 8 - 12°;
- drop of speed.

To recover from stalling it is necessary to fully push the control column forward and keep it in this position until the aircraft returns to the operational angles of attack, which are determined by the moment the stalling vibration stops (sometimes it takes up to 10 - 12 seconds). The ailerons and rudder must be kept in the neutral position.

If the aircraft recovers from stall slowly with the control column fully pushed forward, to increase the elevator deflection down it is recommended to use the elevator trim tab, which should be returned to its initial position immediately after the vibration is stopped.

If there is stalling vibration, it is strictly forbidden to parry the aircraft rushes to bank by means of the ailerons and rudder.

The aircraft return to the operational angles of attack may take place in the steep bank attitude (up to 90° and more).

To recover from a bank it is necessary to energetically eflect the ailerons immediately after stalling vibration is stopped.

After the vibration is stopped it is necessary to return the elevator to the position near to the balancing one (to avoid negative overload), with a smooth transfer of the aircraft to level flight as the speed is growing.

Sharp pulling of the control column backward to reduce the diving angle after the jolting has stopped may result in a repeated stalling.

When recovering from the banks within the whole range of speeds, no marked slips appear, therefore slight deflections of the rudder (within 3 - 5°) are required to parry the slip. It is not recommended to deflect the rudder at Mach numbers higher than 0.8, because the opposite reaction of the rudder appears at Mach numbers over 0.87.

To recover from stalling at a minimum speed at altitudes below 8000 metres, at which there is no warning jolting, it is necessary to immediately and fully push the control column forward, thus preventing the aircraft from sharp banking by the ailerons and rudder.

To bring the aircraft from descent after stall at minimum speed, pull the control column smoothly backward after IAS of 340 - 360 km/hr is reached, prevent the aircraft from repeated arrival to the jolting conditions (without overpulling the control column backward beyond its neutral position).

121. The aircraft can get into inverted position when stalling at a considerable deflection of the ailerons and rudder at high altitudes, or at a delayed deflection of the controls to recover from sharp banking at the moment of stall at medium altitudes.

TO RECOVER FROM INVERTED ATTITUDE DO THE FOLLOWING:

- after jolting has stopped, immediately deflect the ailerons to arrive at the maximum possible angle towards the smallest correction turn to return the aircraft to the normal attitude;

- after jolting has stopped, delay the control column return from the extreme pulled back position to the balancing position until a bank of 60 - 70° is reached to avoid rapid increase of the diving angle;

- after the bank of 60 - 70° has been established, move the control column from its extreme pulled back position to the balancing position and, while continuing to roll-out of the bank, smoothly place the aircraft to level flight by pulling the control column back, avoiding the aircraft arrival to the jolting conditions again.

122. After the aircraft has been transferred to level flight, check the operation of the engines. If they happen to stop spontaneously, shift the throttle lever of the stopped engine to the STOP position and re-start the engine at altitudes not exceeding 7500 metres.

123. The aircraft control at the moment of recovery from stalling should be checked by means of the sky-line. In instrument flight and at night this should be done by means of the turn and slip indicator, stable artificial horizon, airspeed indicator, and rate-of-climb indicator.

124. If after stalling at high altitudes the aircraft has entered normal stable spin, it is necessary:

- to determine the direction of spinning and fully deflect the controls in the direction of the spin to regulate the aircraft spinning and to get greater travel of the controls when deflecting them for recovery. (The rudder will be deflected to the right during the right-hand spin, to the left - during the left-hand spin, the elevator will be deflected up, the ailerons will exactly be set in the neutral position);

- to wait for 0.5 - 1 revolution (4 - 6 seconds), after that fully deflect the controls to recover from the spin in a standard way (the rudder will be deflected to the left during the right-hand spin, to the right - during the left-hand spin, 0.5 - 1 revolution after the rudder has been deflected, deflect the elevator down, and keep the ailerons strictly in the neutral position);

- to wait for the spin to stop for not less than two revolutions.

If rotation of the aircraft stops at any stage of recovery from the spin, immediately set all the controls in the neutral position and bring the aircraft out of the dive into level flight without exceeding the prescribed vibration and IAS limits.

If after the aircraft recovery from stall it enters the dive or spin, the engines will be transferred to the slow running.

If up to an altitude of 5000 m. the pilots have failed to stop the aircraft rotation, the aircraft commander must order the crew to bail out.

In those cases when the aircraft enters the stable spin at an altitude below 5000 m., the aircraft commander will order the crew to bail out immediately.

## Aircraft Control by Means of АП-5-2М Automatic Pilot

125. Before taxiing out to the take-off position, make sure that the centering and sensitivity knobs on the autopilot control panel are turned to the POINTERS-UP position, the ratio and turn compensation knobs are set to the fixed marks, the control transfer knob is at PILOT, the shutters of the tell-tale lights are opened, the formation stick selector switch is at OFF and the stick itself freely without jamming travels forward, backward, to the right and to the left.

The navigator will switch on the stabilizer switch (marked STAB.) of the autopilot directional stabilizer before taxiing out, for the period of taxiing and take-off, as well as 10 minutes prior to landing.

## Switching On of Automatic Pilot in Flight

126. The automatic pilot will be switched on by the aircraft commander himself at an altitude not lower than 2000 m., and in overcast - only above the clouds.

The automatic pilot will also be switched off at the altitudes not below 2000 m.

The automatic pilot will be put into operation in the following sequence:

- switch on the automatic pilot master switch;

Note: The automatic pilot will not be switched on until the switches of the RUDDER, AILERON, and ELEVATOR servo units are on.

- after 8 - 10 minutes, in the case when the autopilot is switched on with the STAB. switch of the autopilot directional stabilizer off, or after one minute when the STAB. switch is on, switch on the SERVO.- P.D.I. (pilot director indicator) switch, and after that trim the aircraft for a stable straight-and-level flight without slip. The check of the aircraft balancing by the trim tabs will be made by means of the sensitivity has bad effect on the control system as it results in frequent vibrations of the control system.

To adjust sensitivity it is necessary to rotate the sensitivity knob clockwise until the control system (control wheel, column, and pedals) begins to vibrate. After that it is necessary to rotate the sensitivity knob back until continuous vibration of the controls discontinues.

## Adjustment of Turn Compensation

131. To ensure turn compensation while using the turn control knobs and the autopilot clutch it is necessary to select the correct relation between the motion of the rudder and ailerons.

In the АП-5-2М automatic pilot the setting of the lower row of the knobs (turn compensation knobs) by the fixed marks already provides, as a rule, turn compensation by the aircraft navigator, and with minimum time spent on correction turn for aiming in azimuth.

Therefore, the turn compensation adjustment should be made only in case of necessity.

### (a) Turn Compensation Adjustment by Navigator

132. To adjust, proceed as follows:

- make sure of the aircraft straight-and-level flight by PDI, artificial horizon, altimeter or rate-of-climb indicator, if necessary the pilot must balance the position of the aircraft by means of the centring knobs;
- have navigator disengage the automatic pilot clutch.

For this purpose he turns the clutch arm counter-clockwise, deflects the autopilot clutch by the bombardier knob to the extreme left or right position (depending upon the desirable direction of turn) and keeps it in this position;

- have pilot adjust the coordinated turn by the knobs of the lower row on the control panel so that the bank should equal 18$^{o}$ (by the AILERON compensation knob), the ball of the turn and slip indicator is in the centre (by the RUDDER compensation knob) and that there should be no altitude loss during turn (by means of the ELEVATOR compensation knob);

- have navigator engage the autopilot clutch upon the pilot's order: "Engage autopilot clutch", during this the aircraft must recover from the bank and return to straight-and-level flight.

After turn compensation adjustment, it is necessary to check the time of turn execution from the autopilot clutch.

For this purpose, with the clutch engaged, the navigator, pressing the autopilot clutch engaging knob, quickly shifts the autopilot clutch to one of the extreme positions and releases it. The time of turn by 4 - 6$^{o}$ must not exceed 18 seconds.

If the correction turn is performed slowly, it is necessary to increase the AILERON ratio. The speed of the correction turn being too high (the needle of the PDI travels across the centre position) it is necessary to decrease the AILERON ratio. If the aircraft recovers from the correction turn with vibrations, it is necessary to decrease the RUDDER ratio.

If it does not help, it is necessary in this case to discontinue the autopilot adjustment and use.

### (b) Compensation Turn Adjustment by Pilot

133. Adjustment of the turn by means of the turn control knobs should be made after turn compensation adjustment by means of the autopilot clutch in the following sequence.

Make sure of the aircraft straight-and-level flight by the directional gyro, artificial horizon, altimeter and rate-of-climb indicator. If necessary, adjust the attitude of the aircraft by means of the centring knobs.

Set the turn control knob at the beginning of the shaded portion of the scale, having delayed it for a short time in the zero position.

By means of a screw-driver adjust the position of the AILERON rheostat on the control panel so that the bank should equal 25 - 30°.

Adjust the position of the RUDDER rheostat in such a way that there should be no slip (the AILERON and RUDDER rheostats are located on the control panel between the sensitivity knob and ratio knob).

If the altitude decreases during the turn performed by means of the turn compensation knob, it is necessary to use the formation stick to maintain the altitude.

When recovering the aircraft from the turn, it is necessary to check the turn control knob in the zero position. The knob should be left in this position until the aircraft surfaces are in level position.

The aircraft surfaces level, the knob should be set to the CENTRE position.

WARNING: It is allowed to use the lower limit of the shaded portion of the scale in still air only. Setting of the knob to this limit creates a bank over 30°, which may increase spontaneously in "bumpy" air and cause striking of the vertical flight gyro unit against the limit stop.

The adjustment of the turn performed by means of the pilot's turn compensation knob remains effective when the formation stick is used.

## Use of Formation Stick in Flight

134. The formation stick function switch should be set to the ON position. It is recommended to use this position of the control switch when the aircraft is the leader of the formation or when sharp manoeuvres are not necessary.

Procedure of the formation stick use in the ON operating conditions is as follows:

- in straight-and-level flight leave the stick in the neutral position, the automatic pilot will maintain straight and level flight;

- for descent or climb deflect the stick forward or backward by the angle sufficient for the desirable change of the aircraft attitude and keep the stick in this position until it is necessary to proceed to straight-and-level flight again; when the stick is returned to the neutral position or released, the aircraft returns to straight-and-level flight;

- to perform a turn it is necessary to deflect the stick to the right or left by the angle required to attain necessary bank (maximum angle of bank is reached during complete deflection of the stick to the limit stop, and equals 15 - 18°); the stick should be kept in the deflected position to the end of turn, after that it should be released, or returned to the neutral position.

The direction of the aircraft turn coincides with the direction of the stick deflection.

135. The function switch should be set in the "Only altitude is ON" position.

The switch being in this position, it is possible by means of the stick to control the aircraft altitude only.

It is recommended to use this position of the switch to compensate for the loss of altitude during a turn, especially during bombing, when the aircraft is controlled by the navigator.

136. Set the function switch to the OFF position. In this case the stick will be completely disconnected from the automatic pilot.

## Use of Automatic Pilot during Bombing

137. Climb to an altitude prescribed for bombing. Balance the aircraft by means of the trim tabs for straight-and-level

flight. Check the aircraft attitude by means of the artificial horizon, turn and slip indicator, altimeter, and rate-of-climb indicator.

Switch on the switches of all the servo units on the control panel.

Set the prescribed speed of flight, open the bomb-bay doors. Make sure of the autopilot maintaining the aircraft at the prescribed altitude. The altitude is maintained by the formation stick with the function switch set to the "Only altitude is ON" position.

Note: To compensate for pitching moment, which appears during opening of the bomb-bay doors, the autopilot set includes a special pitching moment compensator adjusted by the factory for 450 km/hr IAS. The speed of bombing being different, the compensator is adjusted on the ground in a way described in the АП-5-2М autopilot Description by a technician competent in autopilots.

138. During bombing the clutches of the directional stabilizer must be in the following positions:

(a) The Aircraft Is Controlled by the Navigator

If while controlling the aircraft the navigator performs an evasive manoeuvre or makes a correction turn towards the target, he must disengage both clutches and turn the aircraft in the required direction by turning the bombsight or shifting the autopilot clutch arm.

WARNING: When it is necessary to set the bombsight on the retainer during landing, take-off or in other cases, switch off the autopilot and disengage the bombsight and autopilot clutches and the drift gears.

(b) The Aircraft is Controlled by Means of the Bombsight (lateral correction turn)

The bombsight and drift gear clutches must be engaged and the autopilot clutch must be disengaged. If the bombsight and drift gear clutches are engaged the directional stabilizer stabilizes the bombsight in azimuth. By means of the bombsight knobs DRIFT and CORRECTION TURN the navigator controls the aircraft through the bombsight and autopilot thus performing a lateral correction turn.

(c) The Aircraft is Controlled by the Pilot

The autopilot clutch is engaged and the bombsight and drift gear clutches are disengaged. Each time, when the pilot takes control of the autopilot, the navigator must engage the autopilot clutch before disengaging the bombsight and drift gear clutches (if they have been engaged).

## Flight for Aerial Gunnery

139. The armament is prepared for gunnery by the aerial gunner, the navigator-radar operator, and the radio-gunner. The preparation includes: inspection of cabins equipment, check of proper condition of sight sighting stations and gun mounts, stowage of ammunition, and gun loading.

140. During inspection of the equipment of the cabins and sighting stations special attention should be paid to:

- correct initial position of the switches of the gun armament units and the ПРС-1 fire-control radar.

141. During the test of proper condition of the sighting stations and gun mounts switch on the aircraft electric mains and check:

- the optical sights of the ПС-53 sighting stations and the ПКИ collimator sight;
- the ПРС-1 fire-control radar;
- the system of gun mounts remote control (through the main and auxiliary channels) by the optical and radar sighting stations;
- the control of the front fixed gun mount;
- the operation of the camera gun.

WARNING: 1. Before checking proper condition of the sighting stations and gun mounts make sure that all the circuit breakers are on.
2. IT IS FORBIDDEN to check the remote control of more than two gun mounts at a time. The sequence of check is determined by the aerial gunner.
3. IT IS STRICTLY FORBIDDEN TO CHECK THE GUN MOUNTS CONTROL IF THE GUNS ARE LOADED AND THERE ARE ROUNDS IN THE FEED BELT.

## Actions of Crew during Air-to-Ground Gunnery

142. While approaching the range those detailed for gunnery, upon the aircraft commander's permission and in the prescribed sequence, check proper condition of the gun sights and the gun mounts control.

WARNING: If the gun sight or the remote control system is out of order, IT IS FORBIDDEN to perform shooting.

Having checked the gun sights and gun mounts those detailed for gunnery report to the aircraft commander: "Second navigator (or radio operator, or gunner), guns checked, ready to fire".

143. When over the range, the aircraft commander gives a command: "Get ready to fire". Upon this command the radio-gunner and the gunner switch on the gun mounts control system, reload the guns, and report the aircraft commander that they are ready to open fire.

During each run for gunnery the radio-gunner corrects the setting of airspeed, altitude of flight, and ambient temperature on the ДСП-53 airspeed-and-density transmitter.

During target approach the aircraft commander gives a command: "Clear for shooting".

Upon this command the members of the crew, detailed for gunnery, switch on the FIRE switch and open fire as soon as the targets appear in their sectors.

144. After each run the members of the crew performing air-to-ground shooting report to the aircraft commander: "Radio operator (or gunner) firing stopped, guns switched off" (switch off the FIRE switch).

Having made sure by the rounds counter and check reloading that all the rounds have been used, each member of the crew, who was shooting, should set the gun mount and the sighting station to the inoperative position, fully switch off the remote control system, and report to the aircraft commander: "Radio operator (or gunner) firing completed, ammunition used, guns inoperative".

145. Having made sure by the warning lights that the gun mounts are in the non-operative position the aircraft commander reports to the range CP that the gunnery is over and then leaves the range.

## Actions of Crew during Air-to-Air Gunnery

### Actions of Crew when Flying to Air-to-Air Gunnery Range

146. The towing aircraft takes off first and releases the target. The aircraft, detailed for air-to-air gunnery, takes off after it. After take-off all the crew members

should watch the air situation. The air situation being complicated, the gunner, besides visual observation, should use the ПРС-1 fire-control radar to observe the rear hemisphere.

147. The commander of the aircraft detailed for gunnery should establish a two-way radio communication with the commander of the towing aircraft.

148. The aircraft assemble according to the procedure determined by an appropriate authority.

149. While flying to the air-to-air gunnery area the crew members of the aircraft detailed for gunnery continuously report the position of the towing aircraft to their commander. At the same time on the aircraft commander's permission they check proper condition of the sighting stations and gun mount control. The results of the check should be reported to the aircraft commander.

## Actions of Crew in Air-to-Air Gunnery Area

150. In the air-to-air gunnery area the pilot of the aircraft detailed for gunnery at the prescribed altitude brings the aircraft to the prescribed heading and in level flight transmits his altitude and heading to the commander of the towing aircraft.

On receiving these data the towing aircraft assumes the initial position for run in accordance with the exercise conditions and the prescribed direction of shooting in the area. During this it is necessary to take into account the fact that the target is lower than the towing aircraft.

151. Upon entering the sector of fire the navigator should report to the aircraft commander: "Entered the sector of fire".

The aircraft commander gives a command: "Shooting cleared". Upon this command the members of the crew detailed for shooting fully switch on the remote control system, reload the guns, aim in their sectors of fire, and open fire.

152. If the ПРС-1 fire-control radar is used for gunnery, the gunner is allowed to open fire only after he has made sure that it is the target which is being tracked by the radar antenna and the towing aircraft is out of the sector of fire of the rear gun mount.

153. When leaving the sector of fire the navigator will report to the aircraft commander: "Leaving sector of fire". The aircraft commander must give a command: "Stop firing".

Upon this order the crew members will stop firing immediately.

154. IT IS STRICTLY FORBIDDEN to fire if a two-way radio communication between the aircraft is broken, and also during the aircraft turn. The crew of the towing aircraft performs a manoeuvre to take a reverse heading only after they have been warned by the commander of the shooting aircraft.

Shooting over, each member of the firing crew, having made sure by the rounds counters and check reloading that all the rounds have been used set the gun mount and the sighting station sight to the inoperative position, fully switch off the remote control system, and report the completion of firing to the aircraft commander.

155. The aircraft commander transmits to the pilot of the towing aircraft that the exercise has been completed and then will a descent leaves for the outer side of the gunnery area without crossing the heading of the towing aircraft. The aircraft with then proceed with further execution of its task or to the landing airfield.

156. After landing the members of the crew who were shooting, supervised by the armament specialists, perform a post-flight inspection of the armament and:

- unload and inspect the guns;

- inspect the gun mounts;
- inspect the ammunition boxes and feed belts for absence of ammunition;
- remove the magazines from the camera guns.

The results of the inspection will be reported to the aircraft commander by the gunner.

## V. FLIGHTS IN ADVERSE WEATHER CONDITIONS

### General

157. The following flight technique methods will be used during instrument flight.

Deviations of the aircraft will be corrected by means of a double motion of the controls. There must be a pause between the main motion of the control to change the attitude of the aircraft and the auxiliary motion to stop its movement due to inertia. Violation of this rule results in the aircraft swinging. The amount of pause between the motions of the controls somewhat increases with the increase of altitude (at the expense of decrease of damping moments of the aircraft).

158. Transition from one mode of flight to another one will be performed:

- from climb to level flight by bringing the aircraft to horizontal attitude by means of the artificial horizon and rate-of-climb indicator; after increasing the airspeed by 10 km/hr change the engines rating in accordance with the airspeed at which the flights will be made;
- from level flight to climb (after the engines rating required for climb has been established) by bringing the aircraft to climb attitude by means of the artificial horizon (with a check of forward and vertical speeds);
- from level flight to descent by bringing the aircraft to descent by means of the artificial horizon and rate-of-climb indicator with the subsequent throttling down the engines to the rating which provides a descent at the prescribed airspeed.

159. During instrument flight the turns will be performed with a bank not over 15° at all altitudes irrespective of the aircraft gross weight except for turn to final approach. The bank of up to 20° is allowed during final turn.

When flying a rectangular course in clouds the turns to downwind leg, base leg and final will be performed in level flight at an altitude of 400 m.

160. During instrument flight by means of the autopilot the aircraft commander himself must check the flight by means of the instruments or entrust the co-pilot with it.

IT IS FORBIDDEN TO LEAVE THE FLIGHT INSTRUMENTS UNOBSERVED DURING INSTRUMENT FLIGHT BY MEANS OF THE AUTOPILOT.

161. In flights, during which ice formation is possible, it is necessary to switch on the de-icing system of the engines and the aircraft, the heating of the pitot-static tubes, the pilots' windscreens and the navigator windscreen.

The wing de-icing system can also be used periodically by switching it on during ice formation on the wing and switching it off as soon as ice disappears.

WARNING: 1. During switching on of the de-icing systems the gas temperature after the turbine increases by 10 - 15°C.

2. IT IS FORBIDDEN to switch on the aircraft de-icing systems if the engines run at the maximum rating.

3. If the gas temperature after the engine turbine becomes higher than the permissible one, when the engine de-icing system is switched on, it is necessary to reduce the engine speed until the gas temperature becomes normal.

4. If the signs of freezing of the static line of the pitot-static tube of the left-seat pilot are detected, it is necessary to immediately switch on the emergency line.

162. Before flights under adverse weather conditions the pilots must:

- make sure of reliable operation of the artificial horizons, ДГМК-7 remote reading gyromagnetic compass, РВ-2 radio altimeter, АРК-5 automatic radio compass and of the instruments of the СП-50 instrument landing system;
- switch on the artificial horizons for not less than 6 minutes before take-off to prevent the aircraft flight with unserviceable artificial horizons;
- check operation of the wings de-icing system with the engines running.

When checking the operation of the wings de-icing system on the ground, do not let the temperature of the air coming to the leading edge rise above +100°C.

163. At a flying speed above 600 km/hr IAS and the ambient temperature up to minus 4°C, there is no ice formation; the ice formed during the flight at lower speeds melts as the airspeed increases above 600 km/hr IAS.

If there are layers with ice formation in the atmosphere there should be no flying in these layers. If necessary, these layers will be penetrated through energetically and within the shortest time.

## Flights in Clouds

164. Before entering the clouds compare the indications of the artificial horizon with the actual attitude of the aircraft relative to the sky-line and switch on the engines de-icing system; before entering the clouds proceed to instrument flight, keeping the prescribed IAS.

WARNING: IT IS FORBIDDEN TO SWITCH ON THE WING DE-ICING SYSTEM IF THE ENGINES RUN AT MAXIMUM RATING.

165. After the clouds have been penetrated through or the prescribed altitude has been gained, approach the radio homing beacon, assumed to be the initial point of route, and fly for execution of further mission from it.

The main methods of penetration through the clouds, judgement and landing approach for the Ty-16 aircraft are "rectangular landing pattern" and "straight-in approach".

## Aircraft Control in "Bumpy" Air

166. At medium and high altitudes the "bumpy" areas may be encountered both in cloudy and cloudless weather.

If the aircraft suddenly gets into the area with intensive "bumping" at altitudes above 8500 m., climb will immediately be stopped (if the aircraft was in climb), then switch off the autopilot (if it was on), set IAS corresponding to M = 0.73 - 0.75 (with the undercarriage and flaps up), estimate the situation, and determine the route for coming out of the "bumpy" area. If it is impossible to control the aircraft because of strong rushes, change the altitude of flight.

It is recommended to decrease the altitude of flight by 2500 m. relative to the altitude of the service ceiling.

At altitudes lower than the service ceiling by 2500 m. and more the IAS, read by the wide needle, should not exceed the values given below:

Weight: 70 tons - 510 km/hr;
60 tons - 510 km/hr;
50 tons - 480 km/hr

and should not be lower than the above speeds by more than 30 km/hr. UNDER "BUMPY" AIR CONDITIONS IT IS FORBIDDEN TO REDUCE AND INCREASE THE SPEED AGAINST THE RECOMMENDED ONE AND TO PERFORM MANOEUVRES AT G NUMBER HIGHER THAN ONE, BECAUSE IT INCREASES THE DANGER OF STALL.

167. It is allowed to pilot the aircraft under adverse weather conditions (in clouds) by means of the autopilot, if "bumping" is moderate.

Under these conditions the autopilot operates satisfactorily, maintains the prescribed conditions of flight and makes the pilots' work easier to a considerable extent.

The aircraft commander must attentively watch the aircraft attitude and, if necessary, interfere with the control immediately.

WARNING: It is forbidden to pilot the aircraft by means of the autopilot if the aircraft gets into the area with intensive "bumping" at all altitudes.

168. Complexity in piloting the aircraft under the conditions of intensive "bumping" lies in the fact that to maintain the prescribed condition of flight the pilot has to move the controls only to prevent the aircraft from considerable deviations from the prescribed conditions without compensating for feeble rushes to avoid swinging of the aircraft.

IT IS STRICTLY FORBIDDEN TO MOVE THE CONTROL COLUMN SHARPLY, ESPECIALLY BACKWARDS, IN ORDER TO CORRECT THE LONGITUDINAL ATTITUDE OF THE AIRCRAFT.

169. The main instrument which checks the aircraft position in space during "bumping" is the artificial horizon, the auxiliary instruments are the turn and slip indicator and the airspeed indicator.

Getting of the aircraft into the area of thunderstorm activity and intensive "bumping" is sometimes accompanied, with trouble in operation of the instruments of the speed group (altimeters, rate-of-climb indicators, and airspeed indicators).

It is possible to maintain the prescribed conditions of flight under these weather conditions by keeping the engines speed and pitch angle constant.

170. If a progressing bank is formed, caused by strong and irregular motion of the air, the pilot must immediately eliminate the bank by means of the ailerons if the aircraft has no stalling vibration. If the aircraft gets into vibration at great angles of attack, it is necessary to keep the ailerons in the neutral position until vibration stops and after that energetically eliminate the bank by means of the ailerons. The prescribed heading will be maintained by the directional gyro.

new heading should be taken at the moment of "bumping" ...ccessive, short coordinat...

## VI. FLIGHTS WITH USE OF ILS EQUIPMENT

### Pattern Flying with Landing Approach and Judgement for Rectangular Landing Pattern

174. After take-off it is necessary to retract the flaps, establish the prescribed conditions of flight, and gain the required altitude in the same sequence as in visual flight. The undercarriage should not be retracted during pattern flying with landing approach by the rectangular landing pattern method.

### Turn to Crosswind Leg

175. After the time assigned by the flight control officer has elapsed, it is necessary to turn to crosswind leg at an altitude of not lower than 200 m. until the directional gyro reads 270° for the left-hand circuit (90° for the right-hand circuit) and continue climbing with the heading perpendicular to the landing one.

At an altitude of 400 m. it is necessary to bring the aircraft to level flight conditions.

### Turn to Downwind Leg

176. When the APK radio compass needle reads the radio station relative bearing (Rad Sta RB) equal to 240° for the left-hand circuit (120° for the right-hand circuit) it is necessary to turn to downwind leg by 90° (until the directional gyro reading equals 180° ± drift angle).

### Downwind Leg

177. After turn to downwind it is necessary to check correctness of coming to the heading reverse to the landing one through the readings of the ДГМК-7 compass and directional gyro.

The homing radio station being abeam (radio station relative bearing = 270° ± drift angle for the left-hand circuit, radio station relative bearing = 90° ± drift angle for the right-hand circuit), report to the flight control officer that the outer homing radio marker has been passed.

## Turn to Base Leg

When the APK radio compass needle reads the radio station relative bearing equal to 240° ± drift angle for the left-hand circuit (120° ± drift angle for the right-hand circuit) turn to base leg by 90° until the directional gyro reads 90° for the left-hand circuit (270° for the right-hand circuit). Being on base leg, check the aircraft heading.

## Final Turn

179. As soon as the APK radio compass needle reads the radio station relative bearing equal to 290° ± drift angle for the left-hand circuit (70° ± drift angle for the right-hand circuit) begin turning to final.

During the left-hand circuit flying with the right-hand drift on final, begin turning to final earlier, as soon as the radio compass reads the radio station relative bearing equal to 290° + drift angle on final; there being the left-hand drift on final, begin turning to final later when the radio compass reads 290° minus drift angle on final.

During the right-hand circuit flying with the right-hand drift on final, begin turning to final later when the radio compass reads the radio station relative bearing equal to 70° + drift angle on final; there being the left-hand drift on final, begin turning to final earlier, as soon as the radio compass reads 70° minus drift angle on final.

While turning to final the aircraft commander must:

- watch the readings of the directional gyro and the radio compass having started the turn with a 15° bank;

- in the course of a turn beyond 60°, before coming to final, begin to compare the readings of the radio compass and the directional gyro (they must be equal to: directional gyro - 60° and radio compass - 310° for the left-hand circuit flying, or directional gyro - 300° and radio compass - 50° for the right-hand circuit flying).

If the remaining number of degrees of the correction turn up to zero, read by the radio compass, is smaller than that, read by the directional gyro, decrease the bank; if the radio compass reads more than the directional gyro, increase the bank (but not in excess of 20°) and maintain it until the residual angles of the correction turn are equalized up to zero as read by the radio compass and the directional gyro, after that set a bank of 15°.

180. Having recovered from final turn and knowing the drift value on final, it is necessary to set a lead into the heading following the readings of the instruments.

## Descending on Final

181. After the aircraft has been brought to final, set the engines speed of 3400 - 3600 r.p.m. and extend the flaps by 35° according to the procedure described in Item 55. Speed should gradually decrease during the flaps extension and after the flaps extension by 35°. It must equal 300 km/hr over the outer homing radio marker, 290 - 280 km/hr over the inner homing radio marker, and 280 - 270 km/hr before the beginning of levelling-off.

182. The heading should be corrected after final turn as follows:

- if after coming out of final turn the radio compass reads 0° and the aircraft heading is greater than that for landing, it is necessary to make a correction turn by means of the directional gyro to the right by the magnitude of error, fly with this heading until the radio compass reads 2 - 3° less than the directional gyro deviation from 0°, and by a correction turn to the left direct the aircraft to the outer homing radio marker by means of the radio compass;

- if after coming out of final turn the radio compass reads 0° and the aircraft heading is less than that for landing, it is necessary to make a correction turn by means of the directional gyro to the left by the magnitude of error, fly with this heading until the radio compass reads 2 - 3° less than the directional gyro deviation from 0°, and by a correction turn to the left direct the aircraft to the outer homing radio marker by means of the radio compass.

## Passing Over Outer Homing Radio Marker

183. The outer homing radio marker is approached at an altitude of not lower than 200 m. When reaching an altitude of 200 m. before flying over the outer homing radio marker, it is necessary to bring the aircraft to level flight at an IAS of 300 km/hr and proceed flying to the outer homing radio marker.

As soon as the warning light and bell of the marker receiver indicate that the aircraft is flying over the outer homing radio marker, and the radio compass needle begins deviating from 0° by 10 - 15°, the navigator will change over the radio compass to the inner homing radio marker frequency.

After passing over the outer homing radio marker, it is necessary to correct the heading to the inner homing radio marker by the radio compass and bring the aircraft to descent at a vertical speed of 3 - 4 m. per second.

## Passing Over Inner Homing Radio Marker

184. The aircraft being out of the clouds (or the cabin windscreen covers being removed), continue to fly the aircraft

by means of the instruments until it is over the inner homing radio marker and the runway comes in sight.

Having passed the inner homing radio marker at an altitude of 80 - 70 m., correct the judgement and proceed to smoothly reduce the engines speed so that IAS should be equal to 270 - 280 km/hr by the beginning of levelling-off. As the speed is being reduced and the altitude of levelling-off decreases it is necessary to smoothly pull the control column backward up to touchdown.

185. The aircraft navigator continuously watches the correct execution of manoeuvre by the aircraft commander with regard to judgement and landing approach and in case of some deviations from the prescribed values, he will immediately report it to the aircraft commander.

The navigator must:

- accurately tune the АРК-5 radio compass to the homing radio stations of the landing airfield;

- timely report the beginning of turns to the aircraft commander, watch the readings of the instruments and the operation of the outer homing radio marker;

- calculate the relative bearing of final turn, the lead to the aircraft heading, and the outer homing radio marker relative bearing after the turn, report the data to the aircraft commander; systematically watch the readings of the instruments and the operation of the markers;

- watch the beginning of final turn when the aircraft has approached the estimated relative bearing of the outer homing radio marker, and in the course of turn and after it check proper readings of the АРК radio compass and ДГМК-7 compass; if the readings are inaccurate or have some other deviations, he must report it to the aircraft commander, watch the readings of the airspeed indicator and the altimeter, and the operation of radio facilities of the markers;

- report the passing over the outer homing radio marker to the aircraft commander and change over the radio compass to the frequency of the inner homing radio marker;

- watch the moment the ground comes into sight (the aircraft comes out of the clouds); watch the altitude and the speed of flight; report them to the aircraft commander;
- report the passing over the inner homing radio marker to the aircraft commander;
- report the aircraft commander that the runway is clear.

## Action of Navigator when Radio Station of Outer Homing Radio Marker Fails

186. If the radio station of the outer homing radio marker fails, when forming the route by means of the rectangular landing pattern method the navigator on the commander's permission, should change over the radio compass to the radio station of the inner homing radio marker.

In this case he should report the beginning of turns to downwind and base leg as soon as the aircraft is brought to the radio station relative bearing of the inner homing radio marker which equals $235^{o} \pm$ drift angle, and report the beginning of final turn to the radio station relative bearing equal to $285^{o} \pm$ drift angle.

If the radio station of the outer homing radio marker fails on final he should change over the radio compass to the radio station of the inner homing radio marker and report it to the aircraft commander.

Passing over the outer homing radio marker will be determined by the ringing of the bell of the aircraft marker receiver.

## Rectangular Landing Pattern after Returning from Cross-Country Flight

187. 10 - 15 minutes before approaching the landing airfield the aircraft commander will request the flight control

officer's clearance for approach and altitude separation, and landing instructions. Approach cleared and altitude separation prescribed, approach the outer homing radio station of the airfield.

Upon entering the airfield area the aircraft commander should change over to communication with the flight control officer.

188. When passing over the outer homing radio station it is necessary to bring the aircraft to the heading parallel to the landing one by means of the left-hand turn (if the left-hand circuit is used for flights). The right-hand turn in this case is allowed only if the difference between the approach heading and the landing one does not exceed 15°.

If the right-hand circuit is used for flights, it is necessary to bring the aircraft to the heading parallel to the landing one by means of the right-hand turn. The left-hand turn is allowed in this case only if the difference between the approach heading and the landing one does not exceed 15°.

Upon entering the heading parallel to the landing one set the directional gyro at 0°. Having noted the passage over the inner homing radio marker start the stop-watch and follow the heading parallel to the landing one for 75 seconds. After that turn to crosswind leg with the flight control officer's permission. Descent to the pattern flying altitude will be performed upon the flight control officer's order.

189. Vertical speed of descent up to an altitude of 1000 m. will not be maintained in excess of 10 m. per second, and below 1000 m. it should not be more than 5 m. per second.

190. The undercarriage will be extended at the pattern flying altitude when the aircraft is approaching the outer homing radio marker traverse. Further flight will be performed in the usual manner.

## Judgement and Straight-In Approach

(Fig.15)

### Action of Crew above Clouds when Approaching Airfield

191. When flying above clouds, 10 - 15 min. before approaching the airfield the aircraft commander will request clearance for approach, altitude separation, and landing instructions from the flight control officer.

Having received the clearance for approach and the landing instructions, the aircraft commander will order the navigator to calculate the drift angle on final, the time, lead angle $\alpha$ and the course of flight from the radio station to the point of turn for penetrating the clouds down to an altitude of 200 m. (the altitude of flight over the outer homing radio marker).

Time of flight above the clouds "t" from the radio station to the point of turn is calculated by means of the formula

$$t = \frac{(H_{flt} - 200)\ V_1}{V_{vert}\ \ V_2} + 1 \text{ min.},$$

where: $H_{flt}$ - altitude of flight above the clouds in metres;

$V_{vert}$ - vertical speed of descent in metres per second;

$V_1$ - speed of flight when penetrating the clouds down in km/hr (read by the narrow needle);

$V_2$ - speed of flight above the clouds from the radio station to the point of turn in km/hr (read by the narrow needle).

If there is no wind, airspeeds $V_1$ and $V_2$ are practically considered to be equal to IAS of flight; if there is wind, $V_1$ and $V_2$ must be equal to the average ground speeds during penetration of the clouds down and the flight above the clouds respectively.

Lead angle $\alpha$ is calculated by means of the formula

$$tg \ \alpha = \frac{2R}{S},$$

where: R - radius of turn in km.;

S - the aircraft path from the radio station to the beginning of $180^{\circ}$ turn ($S = V_2 t$) in km.

The results of calculation: the time of flight from the radio station to the point of $180^{\circ}$ turn, the lead angle and the drift angle on the heading of penetration of the clouds down must be recorded in the aircraft log by the navigator and reported to the aircraft commander.

## Action of Crew above Clouds in Airfield Area

192. Approach of the landing airfield will be performed by a passive method of flying to the outer homing radio station of the airfield by means of the radio compass at the altitude prescribed by the flight control officer.

## Run for Penetration of Clouds Down

193. After passing over the homing radio station take the heading reverse to the landing one plus the lead angle and a minute prior to turning to the landing heading extend the undercarriage.

After the estimated time has elapsed, perform a turn by $180^{\circ}$ to the left (if the left-hand circuit is used for flights) or to the right by $180^{\circ}$ (if the right-hand circuit is used) with the following coming to the landing heading until the radio compass and the directional gyro read $0^{\circ}$.

## Descent on Landing Heading

194. Having completed the turn, extend the flaps by 20° and transmit the following to the flight control officer: "This is Air 2, on final, undercarriage down, request landing clearance". Then switch on the engines de-icing system on (the aircraft de-icing system should be switched on if necessary) and bring the aircraft to descent at a vertical speed of up to 10 m. per sec. IAS will be maintained at 400 km/hr during descent.

Having proceeded to descent, it is necessary to correct the residual error of turn for accurate approach to the runway.

Correction of error after the turn and introduction of lead for drift at crosswind should be made in the same way as during landing approach by means of the rectangular landing pattern. At an altitude of 400 m. and an airspeed of 340 km/hr extend the flaps by 35°. The further action of the crew is the same as during judgement and landing approach by means of the rectangular landing pattern.

# VII. FLIGHT AT NIGHT

195. When preparing for a night flight, in addition to the aircraft inspection performed before a day-time flight, it is necessary:

- to check intactness and cleanness of glass of the taxi lights, landing lights, navigation lights, and formation lights during outside inspection of the aircraft;
- to check illumination of the instrument panels and control panels after taking the seat in the cabin. For this purpose switch on the lamps of ultraviolet light, turn the caps of fittings to the right, adjust brilliance by means of the rheostats and set the fittings in such a way that all the instruments are well illuminated when the control column is in the neutral position; check the fitting for fixing in the operating position;
- to check proper condition of the cabin light lamps. For this purpose switch them on by pushing the button on the fitting body;
- to check illumination of the КИ-12 compass;
- to switch on the navigation lights and get the senior aircraft technician's report on their serviceability;
- to check good condition of the taxi lights by switching them on; after the check the lights should be switched off;
- to check good condition of the landing lights by switching them on for a short time; during this the lights must come out, the beam of light must be directed along the aircraft longitudinal axis and the brightest illumination of the ground must be at a distance of 40 - 50 m. in front of the aircraft; after the check the lights should be switched off;
- to dim all the warning lights by turning the caps of light filters to the extreme right-hand position, except for fire warning lights, "speed too high" lights," fuel remaining for 15 and 30 minutes" lights, and the pressure drop warning lights of the main and emergency brake systems;

- to check proper condition of formation lights.

Starting and testing of the engines should be performed in the usual manner.

WARNING: If the flight begins at day light and ends in darkness, it is necessary to dim out the undercarriage warning lights before the flight, and the rest of the lights subject to be dimmed out will be dimmed out in flight as it is getting dark.

If the flight begins in darkness and ends at daylight, all the lights subject to be dimmed out, except for the green lights of the undercarriage extended position, will be dimmed out before the flight and at dawn the caps of their light filters will be set for full brilliance. The green lights of the undercarriage extended position will not be dimmed out in this case.

196. The taxi clearance received from the flight control officer, switch on the taxi lights and begin taxiing.

197. Taxi only along the taxiways with the taxi lights and navigation lights ON. If it is necessary to inspect the taxiway, use the landing lights.

During taxiing out to the take-off position the co-pilot must keep the control column in the neutral position for normal illumination of all the instruments on the pilots' instrument panels by the ultraviolet lights.

During dark night and poor visibility even during moonlit night taxi with the formation lights switched ON.

When in the pre-take-off checks position, besides the usual day flight procedure, check illumination of the flight instruments.

The aircraft gross weight being 72 tons and more, it is necessary to take off with the landing and taxi lights ON.
If switching on of the lights creates glaring "screen" which makes piloting difficult, the take-off will be performed with

the lights OFF. The aircraft gross weight being less than 72 tons, the take-off will be performed with the landing lights OFF and the taxi lights ON . After the take-off the landing and taxi lights will be switched OFF at an altitude of 50 m.

198. Take-off is performed at night in the same way as in the day-time. The direction of take-off run will be maintained by the relative displacement of the line of the runway landing lights. The nosewheel will be lifted at the same speed as during the take-off in the day-time.

199. Do not make the aircraft holdout over the ground but continue flying with a gradual climb and increase of speed up to 370 - 380 km/hr with the undercarriage down and the flaps extended by 20°, and up to the prescribed speed of climb with the retracted undercarriage and flaps.

200. The aircraft being airborne, pilot it by referring to the artificial horizon, runway lights airspeed indicator, and rate-of-climb indicator; before passing over the runway boundary lights it is necessary to begin to pilot the aircraft by means of the instruments only.

201. After the aircraft unsticking the co-pilot will assist in piloting the aircraft by paying main attention to the absence of banks, maintenance of speed and direction of take-off. If there are some deviations from the normal readings, he will immediately report it to the aircraft commander.

## Methods of Pilotage at Night

202. Pattern flying at night will be performed along the same route and at the same speeds and altitudes as during a day-time flight. Banks during turns must be equal to 15°. It is allowed to increase the bank up to 20° during final turn for accurate alignment with the runway.

Banked turns in the zone will be performed with 15° and 30° banks, if one of the engines is throttled down, the bank during the turns should not exceed 15°.

203. As a rule, all flights at night will be performed according to IFR. It is not recommended to use the sky-line (even if it is visible).

Cross-country flight at night requires utmost attention on the part of the crew and greater accuracy in their job than the flight during the day-time.

204. Landing approach will be performed in the same way as in the day-time. Points for the beginning of turns will be determined by means of the APK-5 radio compass.

In order to align with the runway, final turn will be performed without descent at an altitude of 400 m. in such a way that the bank by the end of the turn is decreased but not increased.

205. The aircraft being on the landing course, the flaps will be extended and the taxi lights switched on.

206. While descending on final the aircraft commander should pay special attention to the maintenance of the prescribed speeds and altitudes over the outer and inner homing radio markers. In the course of the flaps extension and after their extension by 35° the airspeed must be decreased gradually and be equal to 300 - 290 km/hr over the outer homing radio marker, 290 - 280 km/hr over the inner homing radio marker, and 280 - 270 km/hr before the beginning of levelling-off. The altitude of flight over the outer homing radio marker must be equal to 200 - 220 m., and 80 - 70 m. over the inner homing radio marker. The vertical speed of descent on final must be equal to 2 - 4 m. per sec.

207. If the air is transparent, the landing lights will be switched on during landing approach at an altitude of 100 - 150 m. IF IT IS RAINING OR THERE ARE DUST AND HAZE IT IS FORBIDDEN TO USE THE LANDING LIGHTS.

208. The aircraft will be levelled-off for landing only in the runway area lit by searchlights. It should be remembered that the first searchlight is positioned at a distance

of 200 - 300 m. from the beginning of the runway. LANDING ON THE GROUND IN FRONT OF THE RUNWAY IS STRICTLY FORBIDDEN.

Landing on the runway illuminated by the searchlights will be carried out in the same way as in the day-time. After the touchdown, switch off the landing lights. The landing run will be carried out with the taxi lights on.

Landing with the switched on landing lights on the runway which is not illuminated by the searchlights is more complicated and requires a certain skill and utmost attention on the part of the pilot.

209. The direction of the landing run will be maintained by the relative displacement of the runway lights. Braking during the landing run will be performed in the same way as in the day-time.

210. Under adverse weather conditions the landing approach at night both by the method of straight-in approach and rectangular landing pattern is performed with the aid of instrument landing facilities in the same way as in the day-time.

211. Prior to entering the clouds it is necessary to switch on the pitot-static tubes heating, the engines de-icers, pilots' cabin windows heating and, if necessary, the wing and tail unit de-icers.

212. If visibility through the windscreens is poor, the aircraft commander should open the side sliding window and observe the ground through it, the co-pilot in this case should check the altitude and the speed of flight, he should check the absence of banks and accurately maintain the landing course by means of the directional gyro; he will immediately report all the deviations to the aircraft commander.

# VIII. SPECIAL CASES IN FLIGHT

## Engine Failure during Take-Off

213. If during take-off one of the engines does not develop the maximum speed (less than 4600 r.p.m.) the aircraft commander should:

(a) In the first half of the take-off run discontinue the take-off immediately, apply the brakes, release the drag chutes, extend the flaps by 35° and cut out the engines. If the length of the runway is not sufficient in this case, it is necessary to taxi onto the grass in the safe direction with the help of brakes. Report to the flight control officer over the radio that the take-off is discontinued.

(b) In the second half of the take-off run, when the engine speed of one of the engines has decreased (but is not less than 4100 r.p.m.), continue the take-off, preventing the aircraft from turning at the same time.

(c) In the second half of the take-off run, when the speed of one of the engines has become less than 4100 r.p.m. and the aircraft take-off weight exceeds 68 tons, discontinue the take-off, cut out the engines, close the fuel shut-off valves, release the drag chutes, extend the flaps by 35°, apply the brakes and, if threatened with the head-on collision with obstacles, turn onto the grass in the safe direction, deenergize the aircraft and retract the undercarriage, if necessary.

(d) After the aircraft becomes airborne and the engine speed drops or one of the engines fails completely, continue the take-off at the maximum rating of the operative engine, maintaining straight flight with a bank of not more than 2 - 3° in the direction of the operative engine; open the fuel jettison cock (if the aircraft gross weight exceeds 55 tons).

If the ground relief allows, accelerate the aircraft in level flight up to the speed of 320 - 330 km/hr and go into climb preventing the speed decrease below 300 km/hr during the climb. In the presence of obstructions climb will be performed without acceleration at the speed at which the engine has failed. The optimum speed of climb with one operating engine at the maximum rating, extended undercarriage and 20° flaps is equal to 300 - 310 km/hr. The speed decrease below 300 - 310 km/hr will lead to the minimum permissible speeds of flight; the speed increase considerably decreases the rate of climb.

At an altitude of 40 - 50 m. over the obstructions, begin to retract the undercarriage and flaps (flaps will be retracted up to 10° by 5° impulses), maintaining the speed of flight of 300 - 310 km/hr at the same time. After complete retraction of the undercarriage (maintaining the vertical speed of climb) upon reaching the speed of 340 km/hr, retract the flaps completely and continue climbing with the speed increase up to 380 km/hr.

The turn to crosswind and rectangular landing pattern flight will be performed at a speed of not less than 380 km/hr.

After the undercarriage and flaps have been retracted and the speed of 380 - 390 km/hr has been reached, but not later than 8 min. after the maximum rating has been established, transfer the engine to the normal or lower rating required to maintain the speed of pattern flying.

## Flight with One Engine Operating

214. When one of the engines stops in flight, the aircraft is very slow to turn in the direction of the failed engine. During this the load on the pedal is small and it is eliminated by an insignificant deflection of the rudder trim tab.

The Ty-16 aircraft practically with all gross weights can fly level with one stopped engine (with smaller gross weights at the altitudes of up to 7000 m.).

The indicated airspeeds (IAS) which practically depend on the altitude only correspond to the maximum level flight range conditions with one operating engine (See Tablo 7).

Table 7

| Altitude, m. | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 |
|---|---|---|---|---|---|---|---|
| IAS, km/hr | 560 | 540 | 520 | 500 | 480 | 460 | 430 |

In order to achieve the maximum range , when flying with one operating engine,it is necessary to fly at the maximum possible altitude of flight, which depends on the aircraft gross weight.

During this the operating engine speed should be set within the limits of 4300 - 4350 r.p.m. and IAS should correspond to the values indicated in Table 7.

The maximum endurance of flight is achieved at all altitudes at the indicated airspeeds of 370 - 380 km/hr.

When the engine fails at high altitude, it is necessary to set the speed of the operating engine within the limits of 4300 - 4350 r.p.m. and descend with the operating engine, maintaining the IAS versus the altitude (See Table 8).

Table 8

| Altitude, m. | 11,000 | 9000 | 7000 |
|---|---|---|---|
| IAS, km/hr | 410 | 420 | 430 |

At lower altitudes the speed will be maintained in accordance with Table 7 up to the altitude at which the aircraft will fly without descent.

The turns and banked turns both in the direction of the operative engine and in the direction of the inoperative engine are performed at 400 - 450 km/hr IAS with a bank not exceeding 20°.

With the undercarriage down and the flaps extended by 35° and the aircraft gross weight of up to 46 tons, the aircraft with one operating engine may make a go-around from the altitude of 150 - 200 m.

## Actions of Crew in the Event of Engine Failure in Flight

215. If one of the engines fails in flight, the aircraft commander should:

- shift the throttle lever of the failed engine to the STOP position and set the speed of the operating engine within the limits of 4300 - 4350 r.p.m.;
- remove loads from the pedals by the rudder trim tab;
- switch OFF the master power supply selector switch and close the fuel shut-off cock of the failed engine.

In case of a long duration flight with one of the engines failed, open the fuel cross-feed cock and watch by the fuel quantity gauge that the fuel is being consumed evenly.

WARNING: 1. If at the moment of the engine failure the tanks of the first groups are filled completely, it is necessary (with the cross-feed cock opened) to watch the even consumption of fuel from these groups by the readings of the fuel quantity gauges. If the fuel is being consumed unevenly, change over to the manual control of fuel consumption.

If at the moment of the engine failure the aircraft fuel capacity has not exceeded 30,000 lit. of fuel and the tanks of the first groups are empty, then unevenness of fuel consumption will not cause displacement of the aircraft centre of gravity beyond the permissible limits.

2. Never open the cross-feed cock when there is fuel leakage from the groups of tanks of one of the engines (for example, the tank is punctured, the pipeline is broken or disconnected, etc.), because due to this damage the fuel from the groups of tanks of the other engine may be forced out into the atmosphere which will result in stopping of both engines.

Fuel leakage may be detected by means of the fuel quantity gauges (during leakage the actual fuel consumption will exceed the estimated one), or visually by the trail of atomized fuel after the aircraft, or by the fuel runs on the aircraft parts.

Approach to the airfield will be made at an altitude not lower than 600 m. The undercarriage will be extended prior to the turn to base leg. The pattern flying speed and the speed during turns will be equal to 400 km/hr without allowing its decrease below 360 km/hr.

The final turn will be performed at a conventional distance from the runway. Judgement will be made for a slight additional power.

After the final turn extend the flaps by 35°.

The speed of the operating engine during descent will not be decreased below 3500 r.p.m. in order to decrease the time of the engine acceleration up to high revolutions with a view to correcting the judgement, or making a go-around.

After the landing is performed, taxi to the parking area. The aircraft is taxied well with one operating engine.

## Failure of Automatic Fuel Consumption System

216. If the successive group has failed to switch on,(the blue and green lights have failed to go on),and the engine fuel supply is provided from the fourth (stand-by) group, it is necessary to change over to the manual control of fuel consumption without switching off the stand-by pumps, but switching on the groups in the same sequence as during the automatic control of fuel consumption.

When 300 - 500 lit. of fuel remain in the switched on groups of tanks, switch on the pumps of the successive groups. In order to consume this fuel remainder after switching on the pumps of the successive groups of tanks approximately one hour of flight is required. After the above mentioned time has elapsed, switch off the pumps of the preceding groups.

When the sequence of the blue lights burning is broken, it is also necessary to change over to the manual control of fuel consumption without switching off the stand-by pumps.

If the lights of the 30-or 15-minute fuel remainder burn with the automatic fuel consumption system functioning normally and there is fuel in other groups (check by the fuel quantity gauge, fuel flowmeter, and calculations), continue the automatically controlled fuel consumption, and accurately check its remainder. Such a case is possible, when the fuel has been consumed ahead of time (when a tank leaks, when fuel flows from one tank to another one, when the rating of the stand-by pumps is higher than normal) from the fourth or fifth groups of tanks.

If the blue lamp has come on and the green lamp of one of the pumps of this group of tanks does not light up it is necessary to make sure by the fuel quantity gauge that fuel is consumed from this group. If the fuel is being consumed, it means that the pump is in good condition and the pressure warning unit is out of order or the green lamp has burnt out; in this case continue to use the automatic fuel consumption system.

But if the fuel is not being consumed, it means that the pump is out of order, and it is necessary to change over to the manual fuel consumption control without switching off the stand-by pumps and consume fuel from all the groups in the prescribed sequence.

WARNING: 1. If the fuel booster pumps of the first or second group of one of the engines fail, IT IS FORBIDDEN to consume fuel from the corresponding group of the other engine in order to maintain the location of the aircraft centre of gravity within the permissible limits.

2. If the fuel booster pump of the third or fourth group of tanks, located in the port or starboard wing, fails, it is allowed to consume fuel from the tanks symmetrically located in the other wing.

3. If all the warning lights on the automatic fuel consumption panel go out in flight (during the automatic fuel consumption), immediately change over to the manual control of the pumps, having switched on the АЗС-5 circuit breaker of the manual control of all the fuel booster pumps.

217. If after the take-off with full fuel capacity both green lights of one of the first groups went out, it is necessary:

- to make sure by the fuel quantity gauge whether the fuel is being consumed from this group;

- if fuel is being consumed, continue to use the automatically controlled fuel consumption; if fuel is not consumed, change over to the manual control without switching off the stand-by pumps and switch on the booster pumps of both first groups; if after this the green lights, which were not on during the automatically controlled fuel consumption, do not come on and the fuel is not being consumed, immediately switch off the booster pumps of both first groups and switch on the booster pumps of the second groups;

- report the case to the flight control officer and act according to his directions.

If landing is ordered it is necessary:

- to drop bombs (if they were suspended) on the flight control officer's instructions;

- to jettison fuel from the third and fourth groups.

Before jettisoning fuel BE SURE TO SWITCH OFF the circuit breakers of the emergency fuel jettison on the co-pilot's circuit breakers panel, because otherwise fuel jettison will also take place from the first groups, where only the serviceable booster pumps will be on, and this may result in the dangerous derangement of the aircraft centre of gravity.

By the fuel consumption from the second groups ensure the aircraft landing weight not in excess of 55 tons and perform landing.

218. If during the flight the green lights of all previously consumed groups do not go out or come on, this indicates failure of one of the units of the automatic fuel consumption system (amplifier). In this case it is necessary to detect the failed unit by switching off by turns and continue the automatically controlled fuel consumption with the help of the serviceable unit.

The navigator should replace the СП-1 A.C. fuse of the failed unit of the automatic fuel consumption system on the panel of A.C. fuses. After the replacement of the fuse, switch on the failed unit and if the trouble is not eliminated continue the flight with one serviceable unit (amplifier).

219. If the fuel has been consumed before all four blue lights and the lights of the 30-and 15-minute fuel remainder come on and the flight should be continued, one should:

- change flight conditions to ensure the minimum fuel consumption per hour or kilometre depending on the particular situation (the 15-minute fuel remainder is designed for 15 minutes of flight at an altitude of 5000 m. at the normal engine rating);

- change over to the manual control of the pumps and at the same time switch on the pumps of all the groups (to consume the fuel remainder).

220. The Ty-16 aircraft may have spontaneous stopping of the engines when flying with the non-operating booster pumps (e.g., the flight in the deenergized aircraft, or the flight with the automatic fuel consumption system switched off, if the successive group is not switched on in time and fuel from the fourth groups is already consumed, or the stand-by pumps were not switched on), when the fuel supply of the engines is performed by gravity. The flight with the switched off booster pumps, and with the sufficient fuel supply, may be performed only at altitudes of 7000 m. and lower in the absence of "bumping" without any danger of the engines spontaneous stopping. Therefore when the fuel booster pumps are switched off in flight at altitudes of 7000 m. and lower, it is necessary to switch on the neutral gas and continue flying at this altitude at the maximum range rating to the nearest airfield. During this it is forbidden to perform evolutions at the engines rating above 4000 r.p.m. and it is also forbidden to sharply shift the engines control levers.

During pattern flying and landing take into account the fact that the engines, at the ratings higher than 4100 r.p.m.

and while changing their operational ratings towards the increase of engine speed, function very unsteady (the engines stopping is possible).

221. During flights at altitudes higher than 7000 m. as well as during descent from high altitudes to 7000 m. when the fuel booster pumps are off, the engines stopping is possible. That is why, when the booster pumps are off at altitudes higher than 7000 m. it is necessary to descend to the altitude of 7000 m. and after that continue the flight. If the engines stopped spontaneously while descending to the altitude of 7000 m. or during the flight at various altitudes because of "bumping", perform their starting in the sequence described in Section "Spontaneous Stopping of Both Engines in Flight".

## Crew Actions when Trouble in Undercarriage Extension and Retraction System Is Detected

### Incomplete Retraction of Undercarriage

222. If during the undercarriage retraction (when the pressure in the system has reached 146 - 157 kg/cm$^2$ and the system has been under this pressure for 15 seconds) one or several warning lights have failed to come on or all the lights indicating the undercarriage retracted position have come on, but after the cock button has returned to the initial position one or several lights of the undercarriage retracted position go out, it indicates that the undercarriage legs (the retraction of which is indicated by these lights) have not reached the extreme retracted position. In this case it is necessary to make sure that the buttons EXTENSION are in the initial upper position and after that decrease the speed of flight down to 360 - 380 km/hr,

then extend the undercarriage using the main system and repeat the undercarriage retraction.

If during the second attempt to retract the undercarriage the red warning lights fail to come on again or after they are on they will go out, report to the flight control officer that there is trouble in the undercarriage retraction system and then act according to his directions.

WARNING: IT IS FORBIDDEN:

1. To perform flights with the depressed button.

2. To continue execution of the mission when the undercarriage is not locked and is held in the retracted position by the pressure in the hydraulic system, even if the warning lights of the undercarriage retracted position burn during the retraction, but go out when the undercarriage cock button is returned to its initial position.

3. To use the emergency hydraulic system for the undercarriage retraction, except for the case when the aircraft commander has decided due to some reason to perform a belly landing.

## Incomplete Extension of Undercarriage

223. If during the undercarriage extension one or several warning lights of the undercarriage extended position fail to come on, it is necessary:

- to make sure that the pressure in the main hydraulic system is 146 - 157 kg/cm$^2$ and the button RETRACTION is in its initial upper position and a locking clip is inserted under it;

Note: If the pressure in the system is below 146 $kg/cm^2$, the additional extension of the undercarriage will be performed using the emergency system.

- to make sure that the larger button of the undercarriage extension on the main cock is fixed in the depressed position, and the smaller button of the counterpressure is in its initial upper position;
- to decrease the speed of flight down to 360 km/hr and wait for 10 - 15 seconds;
- to check the position of the undercarriage main legs by the tell-tale rods if the warning light fails to come on and the condition of the nosewheel leg lock strut through the inspection port situated in the hydraulic equipment compartment;
- to replace the non-burning lamp or to change places with an adjacent lamp if according to these signs there is no doubt in full extension of the undercarriage;
- to retract and extend the undercarriage once more using the main hydraulic system if the above-mentioned actions have not resulted in the coming on of the warning lamp.

## Additional Extension of Undercarriage with the Help of Emergency Hydraulic System

224. If the undercarriage is not locked by the main hydraulic system at a speed of flight equal to 360 km/hr and one or several green warning lights have failed to come on and the visual check confirms that a leg (or legs) is incompletely extended, it is necessary to make the additional extention of the undercarriage with the help of the emergency hydraulic system.

For this purpose maintaining a speed of 360 km/hr, make sure that all the three buttons of the undercarriage retraction and extension main cock are in the initial pulled up position and the locking clips are put under the larger button RETRACTION and the smaller button of extension, then open the cap of the undercarriage emergency retraction and extension cock and press the larger button of extension (without pressing the smaller button and withdrawing the locking clip from under it) and lock it in the pressed position. Put on the switch BOOST mounted on the central panel of the pilots and raise pressure in the main braking system up to 160 - 165 kg/cm$^2$.

If the warning light does not come on, check the position of the main undercarriage legs.

Report the position of the undercarriage to the flight control officer and get his directions and permission for landing.

Notes: 1. Landing, landing run, and taxiing in all cases will be performed with the larger button EXTENSION locked in the pressed position. The smaller button should be in its upper position and the locking clip should be put under it. The larger button will be released only by the permission of the squadron engineer or by the permission of the senior aircraft technician after the ground crew have taken measures against spontaneous folding of the undercarriage legs.

2. In order to provide full pressure in the hydraulic system after the landing it is necessary that one of the engines should work till the measures against the undercarriage spontaneous folding are taken.

## Undercarriage Extension with the Help of Emergency (or Main Braking) Hydraulic System

225. Extension of the undercarriage with the help of the emergency system is performed in those cases when the main hydraulic system fails. In order to extend the undercarriage with the help of the emergency hydraulic system it is necessary to make sure that:

- the buttons of the main cock of the undercarriage extension and retraction are in the initial upper position and the locking clips are put under the larger button of retraction and smaller button of extension of the undercarriage;

- the pressure in the main braking system is equal to 148 - 155 kg/cm$^2$. If the pressure is less than 148 kg/cm$^2$, it is necessary to increase it up to 150 kg/cm$^2$ by pressing the selector switch BOOST mounted on the central panel of the pilots.

The sequence of handling the emergency undercarriage extension cock buttons is the same as during the extension of the undercarriage assisted by the main hydraulic system.

Notes: 1. The time of the undercarriage extension in this case is equal to 2.5 - 3 minutes.

2. In order to ensure braking after the undercarriage extension before landing, make sure that the pressure in the main and emergency braking systems is normal. If the pressure is lower than the normal one, increase it up to the normal level. During this one should take into account that during the pressure drop below 30 kg/cm$^2$ the 465K pump is automatically switched off. In this case the pump will be switched on manually by pressing the selector switch BOOST mounted on the pilot's central panel.

## Failure of Main and Emergency Systems of Undercarriage Extension

226. If during the flight the main and emergency systems of the undercarriage extension fail, the undercarriage extension should be performed by the manual pump (the time of the undercarriage extension is 15 - 20 minutes), for this purpose:

- make sure that all the buttons of the main and emergency cocks of the undercarriage retraction and extension are in the initial upper position and the locking clips are put under the larger buttons RETRACTION and smaller buttons of the undercarriage extension;
- insert the handle into the pump mounted between the pilots' seats;
- press the button of extension of the main cock of the undercarriage retraction and extension and lock it in the pressed position;
- actuate the pump by means of the handle till the undercarriage is completely extended.

## Landing When Nosewheel Leg Fails to Extend

227. When landing with retracted nosewheel it is necessary:

- to report the malfunction of the undercarriage to the flight control officer, get landing clearance and the flight control officer's directions;
- to switch on the neutral gas system;
- to decrease the aircraft gross weight. For this purpose jettison fuel and drop bombs "safe" in such a way so as not to inflict damage to the people and buildings;
- to create the maximum possible aft location of the centre of gravity by consuming fuel in flight;

- navigator, take his position behind the armoured back of the aircraft commander's or co-pilot's seat;

- extend the flaps by 35° after the final turn;

- all the members of the crew, who remained in their seats tighten and lock the harness; switch off the electric consumers except for those which ensure the landing and normal functioning of the engines;

- immediately after touchdown the co-pilot will jettison the upper hatch cover above his seat and the gunner will open the emergency exit hatch; the navigator-radar operation will switch off the ПО-4500 inverter;

- at the moment of touchdown cut out the engines, the co-pilot will close the fuel shut-off valves;

- after touchdown by the main wheels of the undercarriage, begin braking, holding the aircraft nose from lowering by the control column. As the speed decreases during the landing run, smoothly lower the aircraft nose. When the aircraft nose touches the runway, release the drag chutes and continue braking till the complete stop of the aircraft.

## Landing on One Main Undercarriage Leg and Nosewheel Leg

228. The whole preliminary preparation for landing will be made in the same way as for the landing with the retracted nosewheel leg. Besides, it is necessary:

- to level-off and float with a slight bank in the direction of the extended main leg;

- to land on the extended main leg;

- to cut out the engines at the moment of touchdown; the co-pilot, close the fuel shut-off valves;

- to lower the aircraft onto the nosewheel leg and release the drag chutes after the touchdown; during the landing run maintain bank in the direction of the extended main leg; in order to maintain direction use ailerons as long as possible (until they lose their effect) and use brakes;

- to be ready for a sudden aircraft turn in the direction of the main leg, which failed to extend;

- to vigorously brake the wheels of the extended main leg by the emergency brakes prior to the moment the aircraft falls on its wing towards the retracted main leg, the navigator-radar operator, switch off the aircraft storage battery.

## Landing when Undercarriage Bogie Overturning Mechanism Fails

229. If after take-off, prior to the undercarriage retraction (or in the process of undercarriage retraction), or during the flight with the undercarriage down it is detected that one of the bogies of the undercarriage strut is in the position near to the vertical (at an angle of 85° to the aircraft longitudinal axis) the aircraft commander will:

- not retract the undercarriage (or discontinue its retraction, if retraction was under way. For this purpose the RETRACTION cock will be returned to its initial upper position and the undercarriage will be extended in the usual manner);

- ascertain the position of the failed undercarriage strut by the gunner's reports and report the malfunction to the flight control officer and get his directions;

- decrease the aircraft gross weight down to 48 tons by fuel jettison or by fuel consumption and get the landing clearance from the flight control officer.

All the members of the crew, remaining in their seats, will tighten and lock their harness.

Approach, judgement, and landing will be performed in the same way as during landing with operative undercarriage, avoiding banks and the aircraft touchdown at a small angle of attack and higher speed.

After touchdown commence braking and release the drag chutes.

## Belly Landing

230. Depending on the situation the aircraft commander will take a decision to land with all members of the crew or with some members of the crew abandoning the aircraft.

Prior to the belly landing it is necessary:

- the aircraft commander, warn the crew by the order: "Crew, prepare for belly landing";
- to switch on the neutral gas system;
- to jettison fuel and drop bombs "safe" (if they are suspended). The bombs will be dropped in such a way that not to inflict damage to people and buildings;
- to make landing on the ground according to the directions of the flight control officer;
- the members of the crew who remained in their seats, tighten and lock the harness;
- to take into account the reduced drag due to the retracted undercarriage while making the judgement to avoid overshoot when landing;
- to extend the flaps by 35° after the final turn; descent after the final turn will be performed with a gradual decrease of flying speed with a view to achieving the speed of 260 - 270 km/hr before levelling-off judgement will be made with inconsiderable additional power;
- the co-pilot, jettison the upper hatch cover above his seat by the aircraft commander's order prior to the touchdown; the gunner, open the emergency exit hatch;

- to cut out the engines before touchdown. The co-pilot, close the fuel shut-off valves; the navigator-radar operator, deenergize the aircraft by means of the master bar;

- the crew, leave the aircraft through the emergency exit hatches without the aircraft commander's order after the aircraft has stopped;

- to take all possible measures to localize fire and to rescue the crew members in the event of fire in the aircraft and if the crew members are wounded.

## Landing Flaps Fail to Extend

231. If the flaps fail to extend, when they are controlled from the co-pilot's control panel, extend them from the aircraft commander's control panel.

If the flaps still fail to extend, the navigator in this case will switch off by turns the circuit breakers Nos 1 and 2 of the flaps extension mechanism (on the commander's circuit breaker panel, the bottom row) and the pilots will try to extend the flaps from their control panels, with one of the circuit breakers being off.

When the landing flaps fail to extend, the approach, judgement, and landing will be made in the following way:

(1) If the flaps are not fully extended the outer homing radio marker will be passed at an altitude of 150 m. and at a speed of 330 km/hr, the inner homing radio marker will be passed at an altitude of 50 m. and at a speed of 300 km/hr, the levelling-off will be commenced at a speed of 300 km/hr at a distance of 500 m. from the beginning of the runway. The touchdown will occur at the speed of 270 - 280 km/hr.

After the touchdown (2 - 3 seconds later) commence braking and release the brake chutes. If it is necessary to reduce the length of the landing run, apply the emergency brakes and cut out the engines. In emergency cases open the bomb bay doors (in the absence of bombs).

(2) When the flaps are extended by 20-25°, the outer homing radio marker will be passed at an altitude of 180-200 m. and at a speed of 310-315 km/hr, the inner homing radio marker will be passed at an altitude of 60-70 m. and at a speed of 300-310 km/hr, the levelling-off will be commenced at a speed of 300 km/hr at a distance of 300 - 400 m. from the beginning of the runway. The touchdown will take place at the speed of 250 - 260 km/hr.

After the touchdown ( 2 - 3 seconds later) begin braking, release the braking chutes and if necessary apply the emergency brakes and cut out the engines. In emergency cases open the bomb bay doors (in the absence of bombs).

Note: When the flaps are extended by means of one МПЗ-3М flaps actuating motor, the time of their extension is increased by two times. This fact should be taken into account when performing the landing approach.

## Urgent Landing and Fuel Jettison

232. When it is necessary to perform urgent landing and if the aircraft gross weight exceeds 55 tons, it is necessary to jettison fuel via the fuel jettison system, For this purpose bring the aircraft to level flight, set the speed of not more than 500 km/hr IAS and open the cock mounted on the commander's panel. While doing this remember that when the

aircraft gross weight is 70 - 71 tons the permissible landing weight of 55 tons will be obtained after 8 - 9 minutes if the fuel jettison system is used. The fuel jettison will be checked by the readings of the fuel quantity gauges total scales.

The landing with the aircraft gross weight equal to 55 tons will be performed onto the concrete runway with the pilot's utmost attention. The location of the aircraft centre of gravity during the fuel jettison practically does not change (at the end of the fuel jettison from the first groups of tanks the location of the centre of gravity will shift by 2 per cent aft). At the same time take measures (if possible) to drop the outer bombs "safe".

## Spontaneous Stopping of Both Engines in Flight

233. If both engines spontaneously stop in flight the aircraft commander should:

(1) immediately shift the throttle levers to the STOP position and bring the aircraft to descent conditions;

(2) immediately connect the emergency instruments to the aircraft storage battery supply. For this purpose lift the red cap mounted on the left engine control panel, and place the twin selector switches EMERGENCY INSTRUMENTS BATTERY SUPPLY to the ON position (towards the aircraft side).;

<u>Note:</u> The emergency instruments can also be connected to the aircraft storage battery supply by the navigator-radar operator upon the commander's order: "Connect emergency instruments to battery supply".

(3) as soon as the aircraft reaches an altitude of 7500 m. at the IAS within 400 - 500 km /hr and the autorotation speed of not less than 900 r.p.m. set to start the engine.

<u>Note:</u> When both engines are cut out, the aircraft IAS of 400 - 500 km/hr corresponds to the vertical speed of about 20 - 30 m. per sec.;

(4) after the engine has been started, come to the normal rating within one minute, stop descending, return the selector switch EMERGENCY INSTRUMENTS BATTERY SUPPLY to the OFF position, and proceed to start the other engine.

WARNING: 1. If the aircraft was lower than 7500 m. at the moment the engines stopped , it is necessary to proceed to the engines starting immediately after the preliminary operations have been carried out and the airspeed of 400 - 500 km/hr and the speed of the engines autorotation above 900 r.p.m. have been reached.

2. If starting of one engine was a failure, immediately proceed to starting the other engine. Before the second attempt to start the first engine it is necessary to bleed it at the autorotation rating for not less than 2 - 3 minutes but in such a way so as to prevent fuel jettison from the jet nozzle.

3. The engine must be started before an altitude of not lower than 1000 m. over the ground relief is reached. If the engines have not been started while descending to this altitude, discontinue their starting, reduce the vertical speed of descent and, depending upon the situation, decide whether to bail out or land with the dead engines. The crew members(except for the pilots)should completely get ready for ejection (without jettisoning the hatches covers) before an altitude of 1000 m. is reached irrespective of the fact whether they will bail out or not.

4. If the engines have stopped at the altitudes lower than 1000 m., do not start them and, depending upon the situation, decide whether to bail out or land with the dead engines.

## Cabins Depressurization at High Altitudes

234. If a cabin is depressurized at altitudes above 7000 m. and the excessive pressure drops below 0.2 kg/cm$^2$ with the air supply to the cabin from the engines being available and the oxygen equipment being in good condition, it is necessary:

- to descend to 7000 m. and continue flying, taking into account the fact that fuel consumption increases. If the fuel supply available on the aircraft is not sufficient for the execution of mission at this altitude, get back to your airfield or to the nearest one;
- to report the case to the flight control officer;
- all the crew members, check the state of health of each other continuously and report their good or bad condition and the functioning of oxygen equipment to the aircraft commander every 5 minutes.

235. If the cabins are depressurized at any altitude because the air supply to the cabins from the engines is stopped (consumption according to flowmeters equals zero) and the oxygen equipment is in good condition, the co-pilot, on the commander's order, should check the availability of the air pressure by the low pressure gauge, mounted on the hatches sealing panel. If the pressure is dropped to zero, it is necessary to close the HATCHES SEALING valve, mounted on the hatches sealing panel, and to check whether the pressure read by the low pressure gauge increases or not. If the pressure has increased up to 3.8 - 4.5 kg/cm$^2$, it is necessary to

check by means of the flowmeter whether the air is fed to the cabins from the engines or not. If the air is being fed, continue flying at the altitudes mentioned in Item 234.

If the pressure read by the low pressure gauge has not increased after the HATCHES SEALING valve had been closed, it is necessary to open the HATCHES SEALING valve, close the cocks of the cabins supercharge from both engines and check whether the pressure increases or not.

If the pressure has increased up to 3.8 - 4.5 kg/cm$^2$, open the cock of the cabins supercharge of one of the engines. If the air pressure read by the pressure gauge remains the same, leave this cock open, make sure that the air for the cabins pressurization is being fed, seal the cabins, and proceed with your mission. If the air pressure indicated by the pressure gauge is not maintained, close the cabins pressurization cock of this engine and open the cabins pressurization cock of the other engine. If the air pressure read by the pressure gauge is maintained, leave this cock open, make sure that the air for the cabins pressurization is being supplied, seal the cabins, and continue to fulfil the mission.

If the air for the cabin pressurization is not supplied even from the other engine, or when closing both cabin pressurization cocks, the air pressure indicated by the low pressure gauge does not increase up to the value of 3.8 - 4.5 kg/cm$^2$, report the case to the flight control officer.

Discontinue the mission and return to your base or to the nearest airfield. During this the co-pilot and the radio-gunner in order to prevent high concentration of oxygen in the cabin (which is dangerous in fire respect) will switch on the cabins ventilation by the atmospheric air (from the low altitude ventilation system) and will keep the cabin combined pressure valve open in the position of the emergency pressure release. The co-pilot will make sure that the manual air supply regulator is open. In order to prevent freezing of the window panes in the cabins, switch on the electric heaters (unit 107). Also switch on the electric heating of the pilots' windows and the navigator's windscreen in the front cabin.

In flight the aircraft commander will periodically ask the members of the crew about their state of health especially while flying in the depressurized cabins at altitudes higher than 4000 m.

236. When the cabins air supply from the engines is discontinued at altitudes higher than 12,000 m. immediately descend to an altitude of 12,000 m. and act in accordance with Item 235.

## Troubles in Oxygen System

237. When the normal oxygen supply is disturbed (the reaction of the oxygen-flow indicator blinkers to breathing is weak or is absent) it is necessary to open the emergency oxygen supply cock of the oxygen regulator, check whether the oxygen hoses are not jammed; check the fitting of the oxygen mask. If the oxygen supply is not recovered, descend to an altitude of 4000 m.

Note: When the emergency oxygen supply cock is opened, the blinkers of the oxygen-flow indicator should be open too.

When the oxygen pressure in the oxygen mains drops down to 6 kg/cm$^2$, or when oxygen is spent up to 4 kg per each КПЖ-30 liquid oxygen converter, it is necessary to descend to an altitude of 4000 m., report the case to the flight control officer and get his directions on the further execution of the task.

If oxygen pressure in the mains sharply drops, oxygen supply at altitudes above 4000 m. in the depressurized cabins is stopped, it is necessary to change over to the КП-23 parachute oxygen breathing apparatus supply. For this purpose, upon the commander's order pull the chain connected to the aircraft side and withdraw the safety pin of the connector. Descend to 4000 m. and report the case to the flight control officer and act according to his directions.

WARNING: The amount of oxygen in the КП-23 parachute oxygen apparatus is sufficient for 13 - 15 minutes.

## Fire in Aircraft Cabins and Compartments

### Fire in Front Pressurized Cabin

238. When fire appears in the front pressurized cabin of the aircraft, the member of the crew, who detected the fire first will report its nature and place to the aircraft commander via the intercom and take all possible measures to put out the fire.

The commander gives a command: "Put out the fire". Upon this order all the crew members of the front pressurized cabin will make sure that the air-dilution switch on the oxygen regulator is in the 100% OXYGEN position.

The co-pilot depressurizes the cabin by means of the emergency pressure release valve, closes the cabins pressurization cocks of both engines, and closes the hatches sealing cocks.

The navigator-radar operator deenergizes the aircraft mains when the ammeters needles are off the scale steadily which indicates short circuit of the aircraft electric mains. After that he switches on the emergency instruments for supply from the aircraft storage batteries, takes the portable fire extinguisher and starts to put out the fire.

If fire occurred in the area of the pilots' or navigator's seats, the navigator-radar operator hands over the portable fire extinguisher to one of the above-mentioned persons.

While using the portable fire-extinguisher it is necessary:

- to take the fire-extinguisher handle with the right hand;

- to turn the sprayer tube in the direction of the fire centre with the left hand, so as to approach the sprayer to the surface of the object on fire as close as possible;

- to vigorously press the trigger and direct the $CO_2$ jet to the centre of fire;

- to release the trigger after the fire has been extinguished.

Note: When extinguishing the flammable liquid begin to put out fire from the edge of the flammable liquid surface in order to avoid its splashing on the walls of the cabin.

After the fire has been extinguished, the aircraft commander should open the slide windows to ventilate the cabin and take measures to continue the flight to the nearest airfield.

If the aircraft has been deenergized, then, prior to landing on the airfield, the navigator-radar operator will switch on the electric supply for the normal circuit and switch it off after the end of the landing run.

If it is impossible to extinguish fire with all available means, the aircraft commander will take a decision whether to continue the flight or the crew members must abandon the aircraft depending on the particular situation (altitude, nature of fire, possibility of piloting the aircraft, landing performance, state of health).

## Fire in the First Technical Compartment after fr. 12

239. It fire appears in the first technical compartment the navigator-radar operator will report the fire to the aircraft commander and, by his order, will deenergize the normal circuit, if there is short circuit in the aircraft mains and then connect the emergency instruments to the aircraft storage battery supply. In case the fire gets into the pressurized cabin, he will take the portable extinguisher and use it to suppress fire.

The co-pilot will depressurize the cabin by the emergency pressure release valve.

If it is impossible to eliminate the fire by the measures taken and the fire starts in the front pressurized cabin, the aircraft commander, proceeding from the concrete situation, will decide either to continue the flight to the nearest airfield or to abandon the aircraft by the part of the crew or by the whole crew.

## Fire in the Rear Pressurized Cabin

240. In the event of fire in the rear pressurized cabin, the member of the crew, who was the first to detect the fire, immediately reports the place and nature of fire to the aircraft commander via the intercom and takes measures to extinguish the fire at once.

On the commander's order: "Put out fire" the radio-gunner and the gunner will make sure that the air-dilution switch on the oxygen regulator is in the 100% OXYGEN position.

The navigator-radar operator will deenergize the aircraft electric mains in case the ammeters needles jump off the scale (which indicates that the aircraft electric mains are short-circuited) and will connect the emergency instruments to the aircraft battery supply.

The radio-gunner will depressurize the cabin by means of the emergency pressure release valve, then close the cabin air supply manual regulator and with the help of the portable fire-extinguisher will start to eliminate fire (the emergency pressure release may be also performed by the gunner).

If the fire centre is in the area of the gunner's seat, the radio-gunner hands over the fire-extinguisher to him for suppressing the fire. After the fire has been extinguished, the radio-gunner will air the cabin (by means of the cabin low altitude ventilation).

If it is impossible to extinguish the fire by all the means available, the members of the crew of the rear pressurized cabin report to the aircraft commander : "Fire is not extinguished" and by the commander's order (or if further stay in the cabin threatens their lives, without the order) abandon the aircraft.

Depending on the concrete situation, the aircraft commander decides to abandon the aircraft by other members of the crew or to continue the flight for landing on the nearest airfield.

## Fire in Fuel Compartments and Engines

241. When the fire-extinguishing system operates normally, in the event of fire in the fuel compartments or in the engines, release of $CO_2$ from the first couple of the bottles to the fire centre is made automatically and simultaneously with coming on of the red warning light on the panel "Fire alarm".

When this light comes on, the pilot should switch on the neutral gas system, reduce the speed of flight and, if necessary (if the fire continues), switch on the second couple of the bottles by pressing the additional button, on the panel "Fire alarm".

In the event of fire in the engine and in order to prevent penetration of smoke or smell of burning into the pressurized cabin the co-pilot closes the cabin pressurization cock belonging to the engine in which the fire has occurred, and all the crew members change over to the pure oxygen supply. On the commander's order the co-pilot and the radio-gunner ventilate the cabins by increasing the air consumption.

After the system has functioned and the fire has been extinguished, especially when using one couple of the bottles, the system should be returned to its initial position. For this purpose the switch on the "Fire alarm" panel should be put to the OFF position, at this the red light should go out. After that the switch should be returned to the ON position again.

Notes:

1. When closing the cabin pressurization cock of one of the engines, pay attention to the provision of normal pressure differential in the cabins by the other engine. If the pressure differential decreases, the rating of the engine should be increased.
2. The switch of the system should be positioned at OFF not earlier than 20 seconds after the light has come on, otherwise the pressure appearing in the pipeline when the system is being switched off makes the repeated opening of the electromagnetic valves impossible.

If one couple of the bottles was used and the system is returned to the initial position, it will not work automatically if the fire appears again. In this case it is necessary to switch on the couple of the bottles which was not used by pushing the additional button as soon as the red light on the "Fire alarm" panel comes on.

If the aircraft "Fire alarm" panel is fitted with the switch, intended for the use of neutral gas bottles for fire-extinguishing, it is necessary to put this switch on after the bottles of the fire-extinguishing system have been used.

242. If the fire has been detected visually and the red warning light does not come on, it is necessary to switch on the fire-extinguishing system manually. For this purpose:

- switch on the neutral gas selector switch;
- push the lamp-button of the compartment (where fire has been detected) on the "Fire alarm" panel; shining of the red warning lamp-button indicates the opening of the corresponding electromagnetic valve and, at the same time, it indicates the switching on of the first couple of the $CO_2$ bottles; during this the carbon dioxide gas will be delivered through the corresponding pipelines to the compartment in which the fire has occurred;
- if the first couple of the bottles is already discharged, after pressing the lamp-button of the compartment, in which the fire has occurred, it is necessary to press the button of the second couple of the bottles.

243. In the event of fire in the engine compartment it is necessary to sharply shift the throttle lever of this engine to the STOP position, the co-pilot should hold the throttle lever of the engine on fire pressed in this position and should close the fuel shut-off valve of this engine, while the commander should reduce the speed of flight. Transition of the engine throttle lever to the STOP position provides the closing of the blow- off band and the shutters

in the lower section of the nacelle, which reduces ventilation of the engine compartment and facilitates quick forming of the required concentration of $CO_2$ in order to suppress the fire.

WARNING: 1. Transition of the throttle lever to the STOP position by a sharp movement is obligatory, because during smooth transition of the throttle lever to this position the blow-off band will open and the air escaping from the compressor will increase the fire.

2. After the fire has been extinguished the starting of the engine in which the fire has occurred IS STRICTLY FORBIDDEN.

## Fire in the Area of Oxygen Regulator

244. In the event of fire in the area of some oxygen regulator the member of the crew, who is supplied by this oxygen regulator, should immediately close the KB-5 oxygen valve and change over to the oxygen supply from the КП-23 parachute oxygen apparatus and take measures to suppress fire.

The aircraft commander will descend to an altitude of 4000 m. report the case to the flight control officer and act according to his directions.

If it was impossible to extinguish the fire, the commander, depending on the concrete situation, decides either to continue the flight or to abandon the aircraft.

IT IS STRICTLY FORBIDDEN TO SMOKE IN THE AIRCRAFT BOTH ON THE GROUND AND IN THE AIR, AS WELL AS TO USE OPEN FIRE.

## Failure of Braking System

245. When landing or taxiing the blue light of the automatic brake control unit is burning continuously (does not blink)

In this case it is necessary to:

- switch off the automatic brake control unit;
- report the case to the flight control officer.

If the defect is detected during the landing run and the pressure in the main braking hydraulic system is normal, release the drag chutes and brake the aircraft with the help of the main braking (if necessary, emergency) system. At the end of the landing run clear the runway and act according to the flight control officer's directions.

<u>WARNING:</u> When the automatic brake control unit is switched off, the sharp braking actuated by the main hydraulic system, may lead to erasing and tearing off of the wheel tyres.
If the defect is detected while taxiing, switch off the automatic brake control unit, discontinue taxiing, brake the aircraft up to the complete stop with the help of the main (if necessary, emergency) system not allowing erasing and tearing off of the tyres.

246. During landing or taxiing the blue light of the automatic brake control unit does not burn and blink.

In this case it is necessary to:

- leave the automatic brake control unit in the ON position;
- act in the same way as described in Item 245.

247. The pressure in the main braking hydraulic system has dropped to zero.

In this case it is necessary to report the case to the flight control officer.

If the defect is detected during landing, release the drag chutes and brake the aircraft with the help of the emergency braking system, in the emergency cases open the bomb bay doors (in the absence of bombs).

<u>WARNING:</u> The sharp braking, when using the emergency system, leads to the destruction of the tyres.

If the defect is detected while taxiing, immediately discontinue taxiing, change over to the emergency braking, bring the aircraft to the complete stop, and cut out the engines.

248. While landing or taxiing the main and emergency braking systems fail.

In this case it is necessary to report it to the flight control officer.

If the defect is detected during landing, release the drag chutes and open the bomb bay doors (in the absence of bombs) and, if the length of the runway is not sufficient, switch on the nosewheel steering mechanism taxi onto the ground in the safe direction, cut out the engines. When threatened with head-on collision, retract the undercarriage. In this case the navigator will go to the working place of the navigator-radar operator.

If the defect is detected while taxiing, immediately discontinue taxiing, turn into the direction free of obstacles with the help of the nosewheel steering mechanism and cut out the engines.

249. In flight the pressure in the main braking system periodically drops to 120 $kg/cm^2$ and then increases up to 148 - 155 $kg/cm^2$ again.

In this case it is necessary:

- to check whether one of the pilots presses the braking pedals;

- to switch off the circuit breaker of the 465K pump mounted on the circuit breaker panel of the aircraft commander, if the periodic pressure drop occurs not because of pressing the braking pedals;

WARNING: The untimely switching off of the pump may lead to overheating of its motor and to fire.

- to switch on the pump circuit breaker again prior to landing and, if the pressure increases up to the normal value, perform landing. The braking will be made in the conventional manner. If the pressure does not increase, perform landing, while taxiing release the drag chutes and change over to the emergency braking to prevent sharp braking and tearing off of the wheel tyres.

## Operation of Units in Emergency Cases

### Short Circuit of Electric Mains

250. The short circuit of the aircraft electric mains is detected by the ammeters needles continuous jumping off the scale and by sharp voltage drop. When such signs appear, the navigator-radar operator reports it to the commander and changes over to the emergency supply. For this purpose it is necessary:

- to deenergize the aircraft, having switched off the generators and the aircraft battery by the master bar;

WARNING: In all cases, when the aircraft is deenergized, the pilot should remember that when the aircraft is deenergized the fuel booster pumps will not function.

- to change over to the aircraft battery supply of the emergency instruments by positioning the twin selector switches (under the red-coloured hinged cover of the electric panel) to the upper position;
- to set the aircraft battery selector switch to the OFF position (in the intermediate position) and switch off the ПО-4500 inverter;
- to remind the aircraft commander of the necessity to switch off the СЭТС-60М electric fuel quantity gauge (set the selector switch AUTO-MANUAL to the MANUAL position) and also the powerful electric consumers;
- to set the voltmeter selector switch to the EMERGENCY NETWORK position;
- to switch on the EMERGENCY NETWORK switch and make sure that the ammeters of the generator and the voltmeter indicate

normal readings; if generator No.2 is unserviceable, switch on generator No.3;

- to connect the aircraft battery to the emergency network;
- to switch off the twin selector switch of the emergency instruments battery supply and put the red cover down;
- to switch on the stand-by inverter ПО-4500 and report the possibility of the second switching on of the СЭТС-60М electric fuel quantity gauge and other consumers to the aircraft commander.

When being supplied from the emergency network, the consumers, connected to the normal electric supply bus ,are to be disconnected; the electric supply is received only by those consumers, which are connected to the double feed bus and to the emergency instruments battery supply bus.

Notes: 1. Prior to the second switching on of the automatic fuel consumption system it is necessary to manually switch on the booster pumps of the last consumed or non-filled group of tanks.

2. During the period when the aircraft is de - energized, the blow-off bands of both engines are opened; the work of the ЭМИ-3р electric engine-gauge unit and of the ЭДМУ-3 remote-reading fuel pressure gauge is disturbed. In this case it is necessary to carefully watch the gas temperature and the engines speed adjusting them by the engine throttle levers.

The functioning of the instruments becomes normal after the generator is switched on, and at the engine speed of 3900 r.p.m. the blow-off bands close.

3. When the electric supply is provided by the emergency network,the 465K pump does not work.

251. If the signs of the stable short circuit do not disappear when generator No.2 or No.3 is connected to the emergency network, this indicates the presence of short circuit in the double-feed bus before the inertia-type group protection safeguards or in the emergency network. In this case the navigator-radar operator should deenergize the network, connect the emergency instruments to the aircraft battery, and report the case to the aircraft commander.

It is necessary to bear in mind that when the emergency instruments are supplied by the aircraft battery with the network deenergized:

(1) only the following units may be energized:

- the АГБ-2 main artificial horizon on the commander's panel (accuracy of the readings of the artificial horizon will be checked by the rate-of-climb indicator, turn and slip indicator, altimeter, airspeed indicator, and the КИ-12 magnetic compass;
- the commander's turn indicator;
- the heating of the ТП-156 Pitot tube;
- the СПУ-10 aircraft intercommunication system No.1;
- five ultraviolet lamps of the front cabin (two lamps with the aircraft commander, two with the co-pilot, and one with the navigator);
- the portable lamp in the front cabin;
- the electric control of the fire extinguishing system;
- the remote control of the fuel shut-off valves and shut-off cocks;
- the control of the airstart of the engines, the control of the drag chutes and the automatic brake control units;
- the РСИУ-3 V.H.F. communication radio set.

<u>WARNING:</u> It is allowed to connect the radio set to the aircraft storage battery for not more than 5 minutes.

Besides, the IFF transponder destruction circuit, the extra-emergency bomb drop circuit, and the units of the airstart of the engines are directly connected to the aircraft storage battery;

(2) the fuel quantity gauges, flowmeters, and booster pumps do not work;

(3) the charged and operative 12САМ-55 aircraft storage battery ensures the operation of all the above-mentioned consumers during 2 hours of flight;

(4) the flight is continued when the blow-off bands are opened and there are no readings of the ЭМИ-3р electric engine-gauge unit and the ЭДМУ-3 fuel pressure gauge. The input pressure of the ПН-28-15 plunger pump is created only by the ЦН-1А centrifugal pumps of the engines;

(5) the undercarriage position warning lights do not burn. The extension of the main undercarriage legs will be determined by the tell-tale rods and through the report of the radio-gunner and the extension of the nosewheel leg will be determined by the position of the lock of the undercarriage extended position (to be checked through the inspection port).

During the landing approach remember that the flaps will fail to extend.

## Overvoltage in the Aircraft Electric Mains

252. When there is overvoltage in the aircraft electric mains, the needles of the voltmeter and ammeter of one of the generators are deflected to the right up to the rest, the ammeters of other generators indicate the decrease of load (possibly down to zero), and the ammeter of the aircraft storage battery indicates high value of the charge current (the needle is deflected to the left up to the rest) the heating of the warning and illumination lamps sharply increases and damage of the lamps is possible.

When there is overvoltage in the aircraft electric mains it is necessary:

(1) If it is detected by the ammeter readings which of the generators is under the load, the navigator-radar operator immediately switches off this generator, makes sure that the overvoltage is eliminated, and reports to the aircraft commander that the flight is continued with three operative generators.

(2) If it has not been detected in which of the generators overvoltage had taken place, the navigator-radar operator should:

-immediately deenergize the aircraft by switching off the generators and the aircraft storage battery using the master bar;

- switch off the ПО-4500 inverter;

- connect the emergency instruments to the aircraft storage battery and report the case to the aircraft commander;

- find out the generator (or generators ) with overvoltage by switching the voltmeter to each generator by turns;

- switch the operative generators to the normal network; then the aircraft storage battery and the ПО-4500 inverter; report the number of the operative generators connected to the normal network to the aircraft commander.

Note: On obtaining the navigator-radar operator's report about the overvoltage in the aircraft electric mains, the commander orders all the crew members to switch off all the consumers, and after the overvoltage is eliminated, he should order to switch on the required consumers depending on the number of operative generators connected to the aircraft mains.

### Break in Winding of Any One of Five Double-Feed Bus Bar Changeover Contacts

### (КП-200Д or КП-400Д )

253. In this case the group of consumers connected to the double-feed bus bar, which was supplied by the normal network

via the failed contactor, is automatically changed over to the emergency network which is deenergized during the normal flight.

In order to restore the supply of the disconnected group of consumers the navigator-radar operator should deliver the supply to the emergency network without deenergizing the normal one. For this purpose:

- disconnect the generators No.2 or No. 3 from the normal network and turn on the emergency network switch;
- set the selector switch of the voltmeter to the EMERGENCY NETWORK position and make sure of the presence of voltage in the emergency network and that the function of the failed group of consumers is recovered;
- report to the aircraft commander that the flight is continued with a combined electric supply (the normal and emergency networks are energized).

<u>Notes:</u> Depending on the fact which of the contactors has failed, external manifestation of the failure will be different:

(1) When the КП-200Д changeover contactors, placed in the aircraft commander's double-feed junction box (at fr.6), fail, all three АГБ-2 artificial horizons, the СПУ-10 intercom system, the automatic and manual control of the booster pumps and other consumers, controlled from the front cabin and fed by the double-feed bus bar and by the bus bar of the aircraft battery emergency instruments supply, are disconnected from the normal network and deenergized.

(2) When the КП-200Д contactors, placed in the junction box of the fuel pumps (at fr.49), fail, the work of the first group pumps of the starboard engine and the second group pumps of the port engine is disturbed.

(3) When the КП-400Д contactors of the port engine panel fail, the work of the booster pumps of the first, third, fourth, and fifth tank groups of the port engine is disturbed.

(4) When the КП-400Д contactors, of the starboard engine panel fail, the work of the booster pumps of the second, third, fourth, and fifth groups of the starboard engine is disturbed.

(5) Failure of the КП-400Д contactor, placed in the double-feed junction box (at fr.17), leads to the reserve ПО-4500 inverter changeover to the emergency network and if it was switched on before the contactor failure then also to the discontinuance of normal operation of the automatic fuel consumption system and other A.C. consumers, fed by the ПО-4500 inverter.

## Sticking of Contactors or Electric Heater Fan (unit 107) Failure in Front or Rear Pressurized Cabins

254. When the contactors are stuck after switching off the electric heater its housing begins to overheat and the smell of burning appears in the cabin.

In this case the co-pilot or the radio-gunner (depending on the fact whose heater gets overheated when being switched on) should immediately switch on the fan of the heater and make sure of the fact that the first and second heating elements of the heater are switched off. If the fan works and the overheating is stopped, the heater should not be switched off until the aircraft is taxied to the parking place.

If the fan fails to operate, and the electric heater gets overheated, the aircraft commander orders the navigator-radar operator to change over to the emergency supply and continues the flight with the deenergized normal network.

After the changeover to the emergency supply the electric heaters will be deenergized.

## Crew Actions during Spontaneous or Erroneous Deflection of the Ailerons Trim Tabs at the Angles which do not Correspond to the Aircraft Balanced Attitudes

255. When the electric wiring is short-circuited or the 2ПН-20 selector switch is faulty, spontaneous deflection of one or both ailerons trim tabs at full angle is possible. This leads to the creation of considerable banking forces on the control column of the aileron control in flight.

If spontaneous sharp banking of the aircraft occurs, when the ailerons trim tabs control selector switches are neutral on both panels, it is necessary:

- to prevent the increase of bank by the efforts of both pilots;
- to reduce the speed of flight down to the minimum permissible speed for the given altitude and the aircraft gross weight by decreasing the engines speed;
- to attempt to remove the loads on the control column by deflection of the ailerons trim tabs control switches by turns from both pilots' panels.

If during this the tendency of the aircraft to bank is decreased, when the handle of one of the 2ПН-20 selector switches is deflected, and after its release this tendency grows again, which may occur when the circuit of deflection of one of the trim tabs is short-circuited, then it is necessary:

- by holding the switch handle deflected for the bank decrease to order the navigator: "Prepare to switch off the A3C-5 circuit breakers of the ailerons trim tabs control";

- at the moment of compensation for the bank order the navigator: "Switch off the circuit breakers of the ailerons trim tabs control".

Upon this order the navigator switches off both A3C-5 circuit breakers with the inscription "Ailerons" (the top row on the circuit breakers panel of the aircraft commander);

- to continue the flight without using the ailerons trim tabs.

If it was impossible to remove the banking forces by the ailerons trim tabs control switches operated in direct and reverse sequence, continue the flight at a reduced speed with a side slip in the direction of the bank. The landing airfield will be selected and the decision to land will by taken according to the instructions of the flight control officer.

## Failure of Pitot-Static Systems

256. Failure of the pitot-static pressure systems (failure of airtightness, clogging of the pipelines) leads to wrong readings of the airspeed indicators, altimeters, rate-of-climb indicators, Machmeter, the cabin altitude and pressure differential gauges as well as of some engine instruments (oil and fuel pressure indicators, fuel-pressure warning units).

The malfunction of the pitot-static systems may be accompanied both by the increase and by the decrease in the readings of the above-mentioned instruments.

The increase in the readings occurs during the aircraft descent with the clogged static pressure lines (the rate-of-climb indicator does not react to the change of flight altitude).

The decrease in the readings (absence of the readings of separate instruments) is possible when the Pitot pressure lines are clogged or their airtightness is disturbed.

Pressure from various vents with self-contained systems is delivered to flight instruments and engine instruments on the aircraft. That is why, if the accuracy of the instruments readings is doubted, it is necessary to compare them with the readings of the indentical instruments, mounted on the instrument panels of other members of the crew. The readings of the ВД-20 altimeters are also compared with those of the radio altimeters.

Such readings are considered to be accurate, which coincide in two instruments, connected to the different Pitot-static tubes or static vents.

One of the reasons of the instruments wrong readings may be clogging of the pipelines with the frozen condensate. In this case the instruments readings may recover during the aircraft descent to altitudes at which the temperature of the ambient air is above zero.

If the signs of freezing (or clogging)of the static pressure system are detected by the aircraft commander's instruments readings, the aircraft commander should change over the instruments to the emergency static pressure line by positioning the selector switch of the static pressure lines on the left-hand panel at EMERGENCY. After 15 - 20 seconds the instruments readings should recover.

## Failure of Long-Range Radio Set

257. If the transmitter of the communication radio set fails, the radio operator has the possibility to transmit by telegraph via the transmitter of the short-wave command radio set using the receiver of the communication radio set for reception. For this purpose the radio operator reports the

failure of the communication radio set transmitter to the aircraft commander, and the co-pilot is ordered by the commander to switch on the transmitter of the short-wave command radio set (the selector switch FUNCTION on the transmitter remote control panel is set to the TELEGRAPH position and the channel selector switch is set at the required channel).

During the changeover to the short-wave command radio set the range of communication decreases.

## Failure of Aircraft Intercommunication System

258. In the absence of intercommunication between the members of the crew, who work in the network No.1, it is necessary to re-position the network selector switches on the interphone sets from the NETWORK No.1 position to the NETWORK No.2 position (or vice versa).

If failure has occurred simultaneously in both networks, use the РСИУ-3М VHF communication radio set for intercommunication. For this purpose the members of the crew should set the selector switches of their interphone sets to the V.H.F. RADIO position.

Afterwards, the intercommunication should be limited, because the talks between the members of the crew will be transmitted into the air, if the VHF radio set is used for the intercom.

## Actions of Crew when Bombing Equipment Fails

259. If the doors of the main bomb bay have not been actuated by the bombsight, it is necessary:

- to open the doors by means of the bomb-bay door control push-button switch;

- to open the doors by the stand-by control switch mounted on the bomb-bay door control panel;

- to open the doors by the aircraft commander's switch (the switch for the bomb-bay doors opening on the ground, when the aircraft electric mains are deenergized).

260. If the aerial bombs fail to disconnect from the bomb racks actuated by the bombsight, it is necessary:

- to check the bomb-bay doors opening by the warning lights;

- to check whether the master switch, the switches of the bomb release variation box, and the SALVO switch are switched on in the proper way;

- to check correct preparation of the ЭСБР-49А electric bomb release (intervalometer) for the selected method of bomb drop, which may be IN TRAIN or SELECTIVE;

- to check reliability of fastening the plugs connectors of the BOMBSIGHT and STAB. to the autopilot directional stabilizer;

- to perform repeated bomb release by means of the bomb sight;

- if the bombs have failed to drop again release them by means of the navigator's КСБ-49 bomb release button;

- to order the navigator-radar operator to drop the bombs by means of his КСБ-49 bomb release button;

- to drop the bombs by means of the EMERGENCY BOMB RELEASE switch, having preliminarily set the selector switch ARMED EMERGENCY RELEASE to the ARMED position, if the anued bomb release is intended;

- to drop the bombs from the aircraft commander's seat by means of the handle mounted on the storage battery actuated bomb release panel.

261. If the bombs do not slip from the bomb racks after all possible measures have been taken, it is necessary:

- to close the bomb-bay doors;

- to cut off all the switches on the navigator's control panels;

- to switch off all the circuit breakers of the bombing equipment, mounted on the navigator's right-hand and left-hand circuit breakers panels;

- to warn the flight control officer that the bombs are not dropped;

- to avoid rough landing and sharp braking during taxiing;

- after landing, to taxi the aircraft to the special sector of the airfield to remove the bombs.

262. If the main bomb-bay doors do not close by means of the main bomb-bay door control switch, it is necessary:

- to check whether the EMERGENCY RELEASE switches mounted on the navigator's and the aircraft commander's panels are cut off, if the bombs have been released in emergency;

- to close the bomb-bay doors by means of the bomb-bay door control switch of the navigator or the aircraft commander.

## Actions of Crew when Guns Fail

263. In case of spontaneous shooting it is necessary:

- to turn the gun mount to the safe direction;

- without releasing the actuating lever, first of all cut off the FIRE switch on the control panel and then cut off the rest of the switches strictly keeping to the following sequence: "Drive", "Inverter", "Auxiliary".

264. If the belly or tail gun mount does not turn to the inoperative position, but the warning lights of the gun mount inoperative position burn on the aircraft commander's panel, it is necessary, with the DRIVE switch on, to press the EMERGENCY switch upward for 4 - 5 seconds on the counters

panel of the corresponding gun mount in order to set it in the inoperative position.

265. If the ammunition was not used completely because the mission was discontinued or there was a stoppage in shooting, it is necessary:

- to turn the guns to the safe direction;
- to warn the flight control officer that the ammunition has not been completely used or that a stoppage has taken place;
- to avoid rough landing and sharp braking;
- to take the required precaution measures while the guns are being unloaded or the stoppage is being removed.

## IX. ORGANIZATION OF OBSERVATION BY CREW MEMBERS

266. In order to develop the habits of circumspection and to prevent collisions with obstacles all the members of the crew should conduct continuous and unremitting observation of the situation on the ground and in the air and timely report everything noticed to the aircraft commander.

The observation should be conducted continuously from the moment the members of the crew take their seats in the aircraft prior to taxiing out and it should be ended after the aircraft has been taxied to the parking place.

267. The sectors of observation are distributed among the members of the crew as shown in Fig.16.

The aircraft commander conducts observation in the left front sector of the upper hemisphere.

The co-pilot conducts observation in the front sector and the right front sector of the upper hemisphere.

The aircraft navigator conducts observation in the front sector (140° in horizontal plane) of the lower and upper hemispheres (50° in the lower hemisphere and 30° in the upper one).

The navigator-radar operator conducts observation throughout the whole upper hemisphere.

The radio-gunner conducts observation in the left-hand and right-hand rear sectors of the lower and upper hemispheres (70° in the lower hemisphere and 20° in the upper one).

The aerial gunner conducts observation throughout the whole rear hemisphere.

268. The objects of observation are:

- when taxiing out from the parking place - the taxiing aircraft, passing motor vehicles,people, and other obstructions;

- at the moment of taxiing onto the runway - obstacles on the runway, aircraft in the air, and especially the aircraft on the landing approach after the final turn;

- in flight - all the aircraft in the air, the aircraft joining the formation and being in immediate proximity, especially the aircraft flying at the same altitude at crossing courses.

All the members of the crew should immediately report all the noticed aircraft and obstacles to the aircraft commander. In the report the following should be mentioned: the sector in which the aircraft is detected ,the type of aircraft, distance in kilometres, altitude, and direction of flight.

269. During the flights under adverse weather conditions use the ПРС-1 and РБП-4 radar sights for watching the air situation and report the target appearance within the radar swept area and the target range to the aircraft commander.

270. In order to avoid collision with other aircraft it

is necessary to strictly keep to the prescribed routes by time, altitude, and speed.

271. The aircraft commander is responsible for training and forming of good skills in observation and circumspection of all the members of the crew both on the ground and in the air.

## X. BAIL OUT

272. The procedure for the hatch cover jettison mentioned in the present section is given as a variant when each member of the crew in the front cabin has his individual hatch cover air jettison control,and in the rear cabin air jettison is absent.

In case the aircraft has another variant of the pneumatic jettison the hatch covers are jettisoned with the help of the pneumatic system, and if it fails, each member of the crew jettisons his hatch cover with the help of the mechanical system. During this in all the cases of the hatch cover jettison it is necessary to remember that, when the pilots' hatch covers are jettisoned ahead of time, the hatch covers of the aircraft navigator and the navigator-radar operator may fail to be jettisoned due to the appearance of great aerodynamic loads onto the hatches.

The aircraft is abandoned by the members of the crew on the aircraft commander's order only.

In exceptional cases,for example, in the absence of intercommunication under the conditions when further stay in the cabin directly threatens the life of any one of the crew members, the abandoning of the aircraft by this member of the crew is performed without the aircraft commander's order.

Upon the order: "Prepare for ejection" the whole crew, except for the aircraft commander assume the initial position for ejection without jettisoning the hatch covers.

On this order the co-pilot and the radio-gunner depressurize the cabins either in emergency or gradually with the help of the cabin combined pressure valve handwheel, depending on the situation and on the aircraft commander's directions.

<u>Notes:</u> 1. The aircraft commander and the gunner may depressurize the cabins only with the help of the emergency pressure release by depressing the button which is located on the left-hand side at the aircraft commander's seat and on the right-hand side at the gunner's seat.

2. At the moment of cabins depressurization a short time vapour formation occurs due to sharp differential between the cabin air temperature and the ambient air temperature.

After the cabins have been depressurized, the aircraft commander gives a command: "Jettison the hatch covers". On this order the members of the crew, who eject downwards, jettison their hatch covers.

The radio-gunner and the co-pilot report jettisoning of the hatch covers in their cabins to the aircraft commander.

Upon the order: "Abandon the aircraft" the members of the crew perform ejection. On this order, the co-pilot first of all jettisons the cover of the canopy and immediately ejects.

273. The aircraft will be abandoned by the crew in the following order:

(1) the gunner;

(2) the radio-gunner;

(3) the navigator-radar operator;

(4) the aircraft navigator;

(5) the co-pilot;

(6) the aircraft commander.

274. In extra-emergency cases all the members of the crew adandon the aircraft without the preliminary commands on the aircraft commander's order: "Abandon the aircraft", after all the operations required for ejection have been completed.

275. When abandoning the aircraft the pilots should:

- disengage the control column from the aircraft control;

- set the seat to the ejection position. For this purpose move it to the extreme rear position manually or with the help of the pneumatic system (in the presence of G force) by shifting the lever of the emergency seat back movement; to ensure complete back movement of the seat and fixing of the top and bottom locks, hold the lever in the rear position for 1 or 2 seconds (determining the time by counting: "twenty one", "twenty two");

<u>Note:</u> In the Ty-16 aircraft the safety blocking system is used, which does not allow to perform ejection if the seat is not in the extreme rear position.

- jettison the canopy cover by the air control cock mounted on the side; if the control column has not been disconnected mechanically prior to the seat back movement, it is now disconnected automatically;

- if the pneumatic system fails, the canopy cover should be jettisoned mechanically by shifting the hatch cover jettison lever downwards;

- tighten and lock the harness;

- assume the posture for ejection. For this purpose place your feet on the foot-rests, press your back to the back of the seat, press your head against the head-rest, grip the face blind handle with both hands, clench your jaws, close your eyes and mouth, and strain your muscles;

- perform ejection by quick movement of the face curtain, fully pulling it down.

276. When abandoning the aircraft the navigator-radar operator upon the command: "Prepare for ejection" should:

- place his feet on the foot-rests and lower the seat to the extreme downward position;

- turn his back in the direction of flight and lock the seat on the locking pin;

- tighten and lock the harness (pay attention to the position of the head-rest);

- by forward movement remove the safety guards located on the left and right arm-rests of the seat.

On the order: "Jettison hatch covers" the navigator-radar operator should jettison the hatch cover. For this purpose move up the safety guard of the hatch cover mechanical jettison handle and by a quick movement pull the jettison handle backwards.

If the hatch cover fails to be jettisoned, the navigator-radar operator should immediately report it to the aircraft commander who will jettison the hatch cover by the pneumatic control cock mounted on the pilots' central panel.

On the order: "Abandon the aircraft" the navigator-radar operator should assume the posture for ejection. For this purpose he should press his back to the back of the seat and the head against the head-rest. Then grip the arm-rests with the hands, press the pelvis to the parachute pack and the pan of the seat, strain the muscles, close the eyes and mouth, and press the ejection levers mounted on the arm-rests. Quickly and fully press the levers mounted on the left and right arm-rests.

277. When abandoning the aircraft the navigator, upon the command: "Prepare for ejection", should:

- fully lower the pan of the seat downwards;
- turn the seat till it aligns with the aircraft axis, roll it to the rear position and check locking of the seat in the extreme rear position, having made an attempt to move forward without unlocking the seat;
- tighten and lock the harness, lock the folding back of the seat;
- throw the safety lever forward and place the feed on the foot-rest.

On the order: "Jettison hatch covers" the aircraft navigator should turn downward the hatch cover pneumatic jettison control cock mounted on the right side.

If the pneumatic system fails, quickly pull the hatch cover mechanical jettison lever.

On the order: "Abandon the aircraft" the navigator should assume the posture for ejection. For this purpose it is necessary to press the back to the back of the seat, press the head against the head-rest, grip the arm-rests with the hands and, pressing the pelvis to the parachute pack and the pan of the seat, strain the muscles, close the eyes and mouth and by a quick movement press the ejection levers.

278. When abandoning the aircraft the gunner, upon the command: "Prepare for ejection", should:

- set the cradle of the seat to the extreme rear position and lock the seat;
- tighten and lock the harness, lock the folding back of the seat;
- throw the safety lever forward (during this the foot-rest will slide out) and place the feet on the foot-rests.

On the order: "Jettison hatch covers" quickly pull the hatch cover jettison lever.

Upon the command: "Abandon the aircraft", assume the posture for ejection. For this purpose it is necessary to press the back to the back of the seat, press the head against the head-rest, grip the arm-rests with the hands and, pressing the pelvis to the parachute pack and the pan of the seat, close the eyes and mouth, strain the muscles, and by a quick movement press the ejection lever.

279. When abandoning the aircraft, the radio-gunner on the order: "Prepare for ejection" should:

- set the cradle of the seat to the central position;
- depressurize the cabin;
- tighten and lock the harness, lock the folding back of the seat;
- remove the safety guard from the hatch cover jettison lever;
- throw the safety lever of the ejection gun forward (during this the foot-rest will slide out) and place the feet on the foot-rests.

On the command: "Jettison hatch covers" he should:

- quickly pull the hatch cover jettison lever located on the left side of the aircraft cabin (under the right hand);
- report the jettison of hatch covers to the aircraft commander.

On the order: "Abandon the aircraft" assume the posture for ejection. For this purpose it is necessary to press the back to the back of the seat, press the head against the head-rest, grip the arm-rests with the hands and, pressing the pelvis to the parachute pack and the pan of the seat, close the eyes and mouth, strain the muscles and by a quick movement press the ejection lever.

280. During the forced landing outside the airfield or while landing with faulty undercarriage on the airfield the aircraft commander decides on the forced abandoning of the aircraft by the members of the crew; upon his permission a part of the crew may abandon the aircraft by the ejection method.

281. When ditching the aircraft commander orders:

"Prepare for ditching". On this order all the members of the crew should stay in their places, lock the harness and the movable pans of the seats.

The co-pilot should open the air cock on his panel for inflation of the entry hatches bladders with air; the gunner should open the emergency exit hatch. After ditching the navigator-radar operator should release the front dinghy boat by fully pulling the dinghy boat release handle while the gunner should release the rear dinghy boat. The co-pilot jettisons the canopy hood prior to ditching.

The priority of abandoning the aircraft after ditching is as follows:

- from the front cabin: the co-pilot, the aircraft navigator, the navigator-radar operator, the aircraft commander;
- from the rear cabin: the gunner, the radio-gunner.

The АВРА-45 emergency radio set is brought from the aircraft into the dinghy boat by the navigator-radar operator through the upper hatch.

## XI. PECULIARITIES OF OPERATION OF Ту-16 AIRCRAFT WITH TWO РД-3М ENGINES

282. In the process of engine operation the following limitations will be introduced:

(a) In flight:

| Engine rating | Engine speed, r.p.m. | Gas temperature after turbine (not above), t°C | Oil pressure, kg/cm² | Oil temperature at engine intake, t°C | Time of continuous operation (not above), min. |
|---|---|---|---|---|---|
| Maximum | 4700±50 | 720 | 4.0 to 5.0 | -40 to +80 | 8 |
| Normal | 4425±25 | 610 and not more than 620 when the air is delivered to de-icer | 4.0 to 5.0 | -40 to +80 | Not limited |
| 0.8 of normal thrust | 4175±25 | 500 | 4.0 to 5.0 | -40 to +80 | Same |

Notes: 1. The engine acceleration up to 4770 r.p.m. in flight is permitted.

2. If the surge occurs when the engine runs at the maximum rating, reduce the engine speed by the engine control lever till the surge disappears and after the flight find out and eliminate the trouble.

(b) On the ground:

| Engine rating | Engine speed, r.p.m. | Gas temperature after turbine (not above), t°C | Oil | | Time of continuous operation (not above), min. |
|---|---|---|---|---|---|
| | | | pressure, $kg/cm^2$ | temperature at engine intake, t°C | |
| Maximum | 4700±50 | 660 | 4.0 to 5.0 | From -40 to +80 | Not more than 20 seconds during testing |
| Normal | 4425±25 | 590 | 4.0 to 5.0 | From -40 to +80 | 120 |
| 0.8 of normal thrust | 4175±25 | 500 | 4.0 to 5.0 | From -40 to +80 | Not limited |
| Slow running | 1750±50 | 500 | Not less than 2 | From -40 to +80 | |

Notes: 1. Decrease of the engine slow running rating by 150 r.p.m. is permitted when the aircraft units are switched on.

2. At the stable engine operational ratings the fluctuation of the engine speed are permitted:

- not more than ±15 r.p.m. at the ratings above 3800 r.p.m.;
- not more than ±25 r.p.m. at the ratings of up to 3800r.p.m.;
- up to ±50 r.p.m. at the ratings of 3300 - 3500 r.p.m. (the beginning of the automatic regulation of fuel delivery).

In case fluctuations of the engine speed occur within this range, it is recommended to somewhat shift the engine-control lever to eliminate them.

283. In order to avoid possible spontaneous stopping of both engines, when their operational ratings are being changed at any altitude, any change of the engine rating should be made at first with one engine and then with the other one.

284. The flight at the engine speeds of 3600 - 3900 r.p.m. is not recommended, this range of r.p.m. must be solely used as a transient one.

Revolutions for opening the air blow-off band of the РД-3М engines must be 3800+50 r.p.m. and the difference in the revolutions corresponding to the closing and opening of the blow-off band must not exceed 50 r.p.m.

P a r t T w o

## MAINTENANCE OF UNITS AND EQUIPMENT

### Check of Trim Tabs Electric Control System

To check proceed as follows:

- make sure that the АЗС-5 circuit breakers of the ailerons, elevator, and rudder trim tabs control circuits on the aircraft commander's circuit breakers panel are switched ON;
- put on the В-45 switch intended for emergency cutting of the elevator trim tabs control circuit;
- open the lock of the ПН-45М selector switch for switching on the elevator trim tabs mounted on the aircraft commander's control column and pressing the knob of the selector switch move the elevator trim tabs in both directions up to the extreme positions; make sure that when the selector switch is pressed forward the elevator trim tabs are deflected upward, and when it is pulled backward they are deflected downward; when the trim tabs are repositioned with the help of the electric mechanism, the handwheel of the manual (cable) control of the elevator trim tabs should rotate;
- switch on the electric mechanism of the elevator trim tabs and put off the В-45 emergency trim tabs disconnection switch. During this the electric mechanism should discontinue its operation and begin it again only after the В-45 emergency trim tabs disconnection switch is put on;
- set the elevator trim tabs to the neutral position, which can be determined by the scale on the handwheel of the manual trim tabs control and by the actual position of the trim tabs on the elevator;
- close the lock of the ПН-45М selector switch of the elevator trim tab and make sure that the electric mechanism of

the trim tab does not operate when the switch is slightly pulled backward and pushed forward;

- put the rudder trim tab mechanism into operation by the ПН-45М selector switch mounted on the aircraft commander's trim tabs control panel. Move the trim tab in both directions up to its extreme positions and then set it to the neutral position, which can be determined through burning of the right-hand warning light indicating the neutral position, which is mounted on the aircraft commander's instrument panel, and by the actual position of the trim tab on the rudder.
During the check it is necessary to make sure that the rudder trim tab deflects to the left when the switch is pushed to the right, and the trim tab deflects to the right when the switch is pushed to the left;

- put the ailerons trim tabs mechanisms into operation by the 2ПН-20 ailerons trim tabs selector switch located on the aircraft commander's trim tabs control panel. Move them to both extreme positions and then set them to the neutral position (setting of the trim tabs to the neutral position should be discontinued after the left-hand warning light on the aircraft commander's panel has started to burn. During the check it is necessary to make sure that the right-hand aileron trim tab deflects downward and the left-hand aileron trim tab deflects upward when the selector switch is pushed to the right. When the selector switch is pushed to the left the right trim tab deflects upward and the left trim tab downward;

- check the operation of the elevator, rudder, and ailerons trim tabs control system from the co-pilot's seat in the same order;

- check that the left aileron trim tab is in the neutral position by its actual position. Open the cover of the ailerons synchronization panel and make sure that the warning light indicating the neutral position is burning; the КВ-6 synchronization blocking switch being pushed, the warning light should go out.

If one of the warning lights indicating the ailerons trim tabs neutral position (on the aircraft commander's instrument panel or the synchronization panel) does not burn, it is necessary to synchronize the operation of the ailerons trim tabs electric mechanisms. For this purpose it is necessary:

(a) to make the warning light indicating the ailerons trim tabs neutral position (mounted on the aircraft commander's instrument panel) burn by turning on the selector switch of the ailerons trim tabs control on one of the pilots' panels;

(b) to make the warning light (mounted on the panel) burn by turning on the ПН-45М selector switch on the ailerons trim tabs synchronization panel. This selector switch being turned on, only the left-hand aileron trim tab electric mechanism should operate.

The synchronization is considered to be attained when the warning lights simultaneously burn on both the aircraft commander's instrument panel and the synchronization panel. Correctness of the synchronization should also be checked by the actual position of the trim tabs on the ailerons.

WARNING: 1. The aircraft commander and the co-pilot MUST NOT simultaneously switch on the trim tabs selector switches to avoid damage of the trim tabs electric mechanism.

2. After the trim tabs operation has been checked all the trim tabs must be set to the neutral position. Make sure of it through the indication and actual position of the trim tabs. The trim tabs selector switches on the control columns must be locked and the synchronization panel must be covered.

3. It is permitted to use the elevator trim tabs electric control only when flying at altitudes above 1000 m.

## Flaps Extension and Retraction Control

The position of the flaps is determined by the УЗП-47 flaps position indicator. Wrong position of the flaps extended for take-off, (less than 19° and more than 23°) is indicated by a long buzz of the warninghorn when shifting the engine-control lever.

When the flaps are controlled from the aircraft commander's seat, the co-pilot's selector switch is switched OFF and does not affect the operation of the flaps mechanism.

The aircraft commander controls the flaps by the toggle switch and the co-pilot by the push-button.

## Bomb Bay and ЦОСАБ Compartment Doors Control

The normal bomb-bay doors control (opening and closing) is realized by the main hydraulic system (if pressure in it is created by the running engines or by the manual pump) with the help of the selector switch on the aircraft navigator's right panel.

The emergency closing of the bomb-bay doors is performed by means of the hydraulic braking system with the help of the switch mounted on the pilots' central panel.

During the normal bomb release the bomb-bay doors are automatically opened by the main hydraulic system through the operation of the contacts of the ОПБ-11р optical bombsight.

During the emergency bomb release by means of the emergency bomb release switches, located on the aircraft navigator's control panel and the aircraft commander's instrument panel, as well as by means of the extreme emergency bomb release handle, located on the aircraft commander's panel (when the circuit is deenergized), the bomb-bay doors are opened by two springs and the electrical release unit which controls the lock of the hydraulic cylinder of the doors mechanism.

In this case, after the emergency (extreme emergency) bomb release switch has been pushed, first of all the doors are opened and after that the bombs are released.

After the emergency bomb release (opening of the doors) the doors can be closed by the aircraft navigator or the pilot, who should preliminarily set the emergency bomb release switch to the OFF position. After the extreme emergency bomb release if the main system of the aircraft is deenergized and the main hydraulic system does not work, the bomb-bay doors should not be closed.

The ЦОСАБ compartment doors are controlled from the ЦОСАБ panel in the navigator's cockpit. Opening and closing of the doors is performed by compressed air.

## Switching On and Checking the Operation of Automatic Fuel Consumption System

Before switching on the automatic fuel consumption system it is necessary to determine the actual amount of fuel in each group of tanks, because the sequence of switching on the fuel pumps depends on the amount of fuel in each separate group of tanks.

To switch on the automatic fuel consumption system when the ПО-4500 inverter operates, it is necessary:

- to make sure that all the switches on the fuel supply panel are OFF and the circuit breakers of the fuel consumption control, the stand-by pumps, and the fuel pumps warning system on the co-pilot's circuit breakers panel are ON;
- to turn on the switch of the stand-by pumps control on the fuel supply panel;
- to set the AUTO-MANUAL selector switch at MANUAL;
- to turn on the switches of the automatic fuel consumption control of the port and starboard engines;

- 2 or 3 minutes later, after the above-mentioned operation has been completed, switch on the circuit breakers of the manual control of the last empty group of tanks; after that, in 30 - 40 seconds set the AUTO-MANUAL selector switch at AUTO; if all the groups of tanks are filled, the AUTO-MANUAL selector switch should be set at AUTO immediately after the stand-by pumps have been switched on;

- to switch off the circuit breakers of the manual control and make sure through burning of the blue and green warning lights that the fuel pumps have been switched on correctly for the given version of fuelling;

WARNING: To prevent all the fuel booster pumps from being deenergized in case of failure of the ИП-75 group fuse, it is necessary to keep the АЗС-5 circuit breakers of the manual control of the pumps of the third groups of tanks switched on in all the flights. In this case if the ИП-75 fuse fails, the pumps of the third groups of tanks are automatically put into operation irrespective of the position of the AUTO-MANUAL selector switch.

- to turn off and then to turn on the switch of the port engine automatic fuel consumption control and make sure by the stable burning of the worning lights that the automatic control system of the starboard engine is in good condition and "takes" the control of the fuel pumps of the port engine. The same should be done with the switch of the automatic system of the starboard engine. Stable burning of the warning lights indicates that the automatic control system of the port engine is in good condition and it "has taken" the control of the pumps of the starboard engine.

The fuel consumption system of the aircraft ensures also the manual control of the fuel pumps from the electric fuel supply panel.

The manual control of the pumps should be performed in the following way:

(a) turn on the switch of the stand-by pumps control;

(b) set the AUTO-MANUAL selector switch at MANUAL;

(c) set the fuel consumption control switches to the ON position;

(d) with the help of the A3C-5 circuit breakers on the fuel supply panel, which are marked 1; 1; 2; 3; 4, switch on the pumps manually in succession.

The switches of the fuel consumption control being switched ON, the blue warning lights work as usual and coming on of every successive blue light indicates the necessity of switching on this group.

When the switches of the fuel consumption control are switched off or if the units of the automatic fuel consumption system fail, the blue lights do not burn and the necessity of switching on the successive group should be determined through the readings of the fuel quantity gauge of the corresponding group of tanks. The fuel remainder in the operating groups of tanks being equal to 300 - 500 litres, switch on the pumps of the next successive groups. It will take about an hour of flight to consume this fuel remainder after the successive groups of tanks have been switched on. The mentioned time being over, the pumps of the preceding groups should be switched off.

Note: The two A3C-5 circuit breakers marked "1" should be switched on simultaneously (pumps of tanks Nos 2 and 5). Separate switching on is allowed only in case it is necessary to change the C.G. location.

## Operation Test of Manual Fuel Pumps Control System on Ground

The test is performed in the following order:

- make sure that the circuit breakers of the fuel pumps indication and the stand-by pumps control of the fourth and fifth groups of tanks are switched on on the co-pilot's circuit breakers panel;

- set the fuel consumption control switch on the fuel supply panel to the MANUAL position , switch on the A3C-5 circuit breakers of the manual fuel consumption control of the first group of the front tanks and make sure that the green lights of this group of tanks have come on;

- turn on the switch of the manual control of the pumps of the first group of the rear tanks and make sure that the green lights of this group of tanks have come on; the circuit breakers of the first group of tanks being switched on, the warning lights of both front and rear tanks must burn continuously without blinking;

- turn on the switch of the manual control of the pumps of the second group of tanks. During this the green warning lights of the second groups must come on and the pumps of the first groups of tanks must change over from normal operating conditions to forced operating conditions;

- turn off the pumps control switches of the first group of the rear and front tanks and make sure that the green warning lights of the front and rear tanks of the first group have gone out and the lights of the second groups continue to burn;

- turn on the switch of the third group of tanks. During this the green warning lights of the third groups must come on, and the pumps of the second groups of tanks must change over from normal operating conditions to forced operating conditions;

- turn off the switch of the second group of tanks and make sure that the green warning lights of these groups have gone out;

- turn on the 2В-45 switch of the stand-by pumps and make sure that the warning lights of the pumps of the fourth groups of tanks have come on;

- switch on the АЗС-5 circuit breaker marked "4" on the fuel panel. During this the warning lights of the pumps of the fifth groups, operating under the stand-by conditions, must come on, the pumps of the third group must change over from the normal operating conditions to the forced operating conditions, and the pumps of the fourth group of tanks must change over from the stand-by operating conditions to the normal operating conditions;

- turn off the switch marked "4" and the switch of the stand-by pumps.

## Operation Test of Aircraft Fuel Metering System

Before the test make sure that the "Fuel metering" circuit breakers of the port and starboard engine groups of tanks, mounted on the co-pilot's circuit breakers panel, are switched on.

**Note:** With the power supply switched off, the fuel quantity gauge needle may be in any place of the scale because the instrument has no spring to return the needle to zero position, when the instrument is deenergized.

The test procedure is as follows:

- turn on two switches of the 2ПП-250 type on the co-pilot's instrument panel to energize the fuel quantity gauges of the port and starboard engines;

- set the handle of the ПГ-7 switch of the port engine fuel quantity gauge to position "1" and make sure that the indicator needle of the left fuel quantity gauge has moved to the inner scale mark corresponding to the amount of fuel filled into the first group of tanks ( permissible deviation is ± 320 litres);

- push the button on the indicator case and make sure that the needle has moved to the zero mark of the scale (permissible deviation is ±160 litres); the button released, the needle of the instrument must return to its initial position, that is, to the mark corresponding to the amount of fuel in the first left group of tanks; in the same way check the readings of the instrument by setting the handle of the ПГ-7 selector switch at 2; 3; 4; 5 and compare the readings of the instrument with the actual amount of fuel filled into the corresponding groups of tanks;

- set the handle of the left-hand fuel quantity gauge selector switch to the TOTAL position and make sure that the needle of the instrument has moved to the outer scale mark corresponding to the total amount of fuel filled into all five groups of tanks (permissible deviation is ± 960 litres);

- push the button on the indicator case and make sure that the needle has moved to the zero mark of the scale with an allowance of ±480 litres; the button released, the needle of the instrument must return to its initial position, that is, it must indicate the total amount of fuel in all five groups of tanks.

The operation test of the starboard engine fuel quantity gauge is performed in the same order.

## Fire-Extinguishing System

To check the fire-extinguishing system on the ground it is necessary:

- to switch off the АЗС-10 circuit breaker "$CO_2$ bottles control" mounted on the co-pilot's circuit breakers panel;

- to turn on the system control switch;

- to push all the lamp-buttons in turn and make sure that they have come on;

- to turn off the system control switch and turn it on again; during this the lamp-buttons must go out and be out.

Note: The A3C-10 circuit breaker "$CO_2$ bottles control", mounted on the co-pilot's circuit breakers panel, should be switched on before starting the engines and should be switched off after the engines have been cut out on the ground.

## Pre-Flight Inspection of Autopilot and Its Check by Crew Members

Before checking the autopilot for operation it is necessary to perform a visual inspection of its units located at the seats of the pilots, the aircraft navigator, and the navigator-radar operator in order to make sure that there are no external defects of the units.
Unlock the aircraft control units.

THE NAVIGATOR must check relative tension of the autopilot and bombsight clutches. The check should be performed without a dynamometer in the following way:

- engage the bombsight and autopilot clutches;
- turn the bombsight in such a way that the lever of the autopilot clutch should reach the limit stop and the autopilot clutch should begin to skid on its drum; the bombsight clutch must not skid during this;
- check tension of the drift gear clutch. For this purpose engage the drift gear clutch and, with the autopilot clutch engaged, turn the drift gear by means of the sight drift knob; the drift gear clutch must skid earlier than the autopilot clutch;
- check the clutches of the bombsight, autopilot, and drift gear for free movement when they are disengaged; the

clutches must turn on their drums without jamming and turning them.

After that switch on the STAB. switch (the rest of the switches on the directional stabilizer must be switched off) and make sure that the gyromotors of the directional stabilizer and the vertical flight gyro work. Switch off the STAB. switch, disengage the bomb-sight clutch and the drift gear clutch, and engage the autopilot clutch.

THE AIRCRAFT COMMANDER must make sure that:

- the turn compensation knob on the control panel is in its neutral position (at index "▽ ");
- the control transfer knob is at PILOT;
- the shutters of tell-tale lights are opened;
- the pointers of the control panel knobs are fixed.

After that it is necessary:

- to set the centering and sensitivity knobs to the "pointers-up" position, and the ratio and turn compensation knobs are set at the fixed indexes on the control panel;
- to turn on the autopilot master switch on the control panel;
- 5 or 8 minutes later, after the master switch has been put on, turn on the SERVO (torque motor) - P.D.I. switch.

Further check of the autopilot should be performed in the following order:

1. THE NAVIGATOR will disengage the autopilot clutch on the directional stabilizer, centre the P.D.I. potentiometer, and then engage the autopilot clutch again.

2. THE AIRCRAFT COMMANDER will shift the control surfaces by means of the control column and pedals from one extreme position to another one. Repeat this action several times.

When the control surfaces are in their neutral position, the tell-tale lights on the control panel must not burn. The control surfaces being in any other position, one of the tell-tale lights in each of the three channels must burn without blinking.

Blinking of the tell-tale lights, when the control surfaces are neutral, indicates that the potentiometers of the servo units are dirty.

During the check it is necessary to make sure that all the control units move freely without jamming. After this turn the centering knob to the right or left (displace the electric centre of the potentiometer) and repeat the check.

Set the centering knobs again in the "pointers-up" position and turn on the AILERON, RUDDER, EVEVATOR·SWITCHES mounted on the control panel.

If during the switching on of any of the above-mentioned switches one of the tell-tale lights of the corresponding stabilization comes on, it should go out after some time, because the control surfaces will assume the neutral attitude due to the operation of the servo unit.

Turn the centering knobs slowly to the right and to the left up to the limit stops.

While turning the AILERON centering knob clockwise, the starboard aileron must go up (the control wheel turns to the right), and while turning the same knob counterclockwise, the port aileron must go up (the control wheel turns to the left).

While turning the RUDDER centering knob clockwise, the rudder must deflect to the position corresponding to the right turn (the right pedal should move forward) and vice versa.

When turning the ELEVATOR centering knob clockwise, the elevator must deflect upward (the control column should move backward), and when the same knob is turned counterclockwise, the elevator must go down (the control column should move forward).

When executing the above-mentioned check, the control surfaces should be deflected evenly by small portions; simultaneously with each portion of deflection the corresponding tell-tale light on the control panel should flicker.

3. THE NAVIGATOR will disengage the autopilot clutch on the directional stabilizer, and will turn its arm to the extreme left position. The control column should deflect to the right and the right pedal should move forward. At this moment the aircraft commander will check the deflection of the P.D.I. needle; the Pilot Director Indicator needle should deflect to the right. After this, position the autopilot clutch arm to the extreme right position. The control column should deflect to the left, the left pedal should move forward. At the same time the P.D.I. needle should deflect to the left. When this check is finished the navigator should return the clutch arm to the centre position (the wiper of the P.D.I. potentiometer is at zero) and engage the autopilot clutch.

4. THE AIRCRAFT COMMANDER will turn the turn compensation knob on the control panel to the right so that its indicator should be at the beginning of the shaded sector of the scale. During this the control column should turn to the right and the right pedal should move forward. Then turn the turn compensation knob to the left to the same position. The control column should turn to the left and the left pedal should move forward.

Set the knob to the right and to the left at zero and make sure that the solenoid of the locking device of the directional stabilizer is switched on and clamps the autopilot clutch arm. Move the knob to the neutral position (at index " ∇ ") and make sure that the solenoid of the locking device has been disconnected and has released the autopilot clutch arm.

5. THE NAVIGATOR-RADAR OPERATOR will make sure by rotating the turn compensation remote control knob to the right and to the left that its position does not influence the position of the aircraft control surfaces.

6. THE AIRCRAFT COMMANDER will set the control transfer knob at NAVIGATOR and order the navigator-radar operator to check deflection of the aircraft control surfaces from the turn compensation remote control knob; after that he will take the control again.

Set the function switch of the control handle (formation stick) to the ON position. Fully turn the control handle to the right. During this the control column should turn clockwise and the right pedal should move forward; the solenoid of the locking device of the directional stabilizer should get switched on and reliably clamp the autopilot clutch arm.

Release the control handle and make sure that it returns to the center position. The control column and the pedals should also return to the initial position, and the locking device, when the handle returns to the center position, should get disconnected.

Move the control handle to the extreme left position. During this the control column should turn counter-clockwise, while the left pedal should move forward.

Release the control handle and make sure that the handle and the control units return to the center position.

Fully move the control handle forward. During this the control column should also move forward.

Fully move the control handle backward. During this the control column should also move backward.

Release the control handle and make sure that the handle and the control column return to the center position.

Set the function switch to the ALTITUDE ONLY ON position and move the control handle forward and backward. During this only the control column should move. When the handle is deflected to the right and to the left, there should be no displacement of the control column and the pedals.

Press the button of the autopilot emergency disconnection mounted on the aircraft commander's control column and, by moving the steering wheel, the column, and the pedals make sure that the servo units of the autopilot are disconnected and the control units move freely.

Set the master switch on the autopilot control panel to the OFF position and then immediately set it to the ON position, and turn ON the AILERON, RUDDER, and ELEVATOR switches.

Move the formation stick forward and then backward and make sure that it again affects the control units. After that press the button of emergency disconnection mounted on the control column of the right-seat pilot and repeat the check.

Set the function switch of the control handle to the OFF position.

Check operation of the pitching moment compensator. For this purpose set the control column to the neutral position relative to the elevator and after that open the bomb bays. When opening the bomb bays the control column should move forward, and when they are closed, the column should resume its neutral position again.

If operation of the autopilot meets the above-mentioned requirements, switch off the autopilot, by setting the master switch to the OFF position.

## Checking Readiness of Oxygen Equipment for Flight

The oxygen equipment readiness for flight will be checked in the following order:

1. Determine the required amount of oxygen for the flight.

The approximate calculation of the required amount of oxygen for flight is made by the formula:

$$G_{req} = G_{res} + tq$$

where $G_{req}$ is the required amount of liquid oxygen in kilograms;

$G_{res}$ is the reserve of oxygen in kilograms not accounted for (6 kg per each liquid oxygen converter);

$q$ is the oxygen consumption rate for the whole crew in kg/hr (5 kg/hr for 6 members of the crew);

$t$ is the time of flight in hours.

The accurate calculation of the amount of liquid oxygen is made by the engineer in charge of the aircraft equipment in cooperation with the navigator while composing the engineer-navigator flight chart for a certain mission.

Measure the actual amount of oxygen on the aircraft by adding the readings of the oxygen level indicators together. For this purpose first turn on their supply switch with the ПО-4500 inverter operating. If the measured amount of oxygen is less than the designed one, order to make an additional charge of the liquid oxygen converters.

WARNING: IT IS FORBIDDEN to fly an aircraft when the amount of oxygen on the aircraft is less than the designed one.

2. Order the senior aircraft technician to report on the preparation of both КПЖ-30 liquid oxygen converters for work.

Oxygen pressure in the oxygen converters and in the aircraft oxygen mains 10 minutes later, after the automatic pressure units valves have been opened, should be within the limits of 8 - 10 kg/cm$^2$.

Pressure in the oxygen mains is measured by the МК-13М oxygen pressure gauge, and in the liquid oxygen converters it is measured by the pressure gauge mounted directly on the oxygen converter.

3. Check airtightness of the oxygen regulator set at rarefaction.

For this purpose close the oxygen valve, open the emergency oxygen supply valve and release oxygen pressure till the МК-13М pressure gauge reads zero. Then close the emergency supply valve and connect the КП-23 parachute oxygen apparatus to the КП-24М oxygen regulator. Put on and adjust the КМ-30М oxygen mask. Connect it to the hose of the КП-23 parachute oxygen apparatus. By means of the joint lock connect the mask to the mask-to-face tightness compensator.

After this close the air diluter, close the holes on the excessive pressure limiter with the fingers and inhale. If inhalation is impossible, the system is airtight.

4. Check the efficiency of the oxygen regulator set without excessive pressure.

For this purpose open the oxygen regulator valve and make sure by the МК-13М pressure gauge that the oxygen pressure is within the limits of 8 - 10 kg/cm$^2$. Close the emergency oxygen supply valve. During this the excessive pressure knob should be fully turned to the right. Then it is necessary to make several inhalations through the mask with the closed and opened air diluter. If the oxygen regulator set functions normally, breathing should be free and the blinkers of the oxygen-flow indicator should close and open following the rhythm of breathing.

5. Check airtightness and efficiency of the oxygen regulator set in the presence of excessive pressure.

For this purpose close the air diluter and the emergency oxygen supply valve, close the holes on the excessive pressure limiter with the fingers, and by smoothly turning the excessive pressure knob to the left create the excessive pressure underside the mask of not less than 250 mm of the water column to be read off the М-1000 pressure gauge. During this the bladders of the mask-to-face tightness compensator should be inflated with oxygen.

Having made sure that the oxygen regulator set is airtight, make several inhalations. If during inhalation a pressure drop of 30 - 40 mm of water column is read off the М-1000 pressure gauge and during exhalation an increase in pressure is noticed, the oxygen regulator functions normally.

Having made sure of the normal operation of the oxygen regulator set, release the excessive pressure by fully turning the excessive pressure knob to the right with the following opening of the hole on the excessive pressure limiter.

## Use of Oxygen Equipment

Prior to the flight the dial of the BC-46 cabin-pressure warning unit is set to an altitude of 4000 m.

During the flight all the members of the crew should check functioning of the oxygen equipment by the control instruments: the oxygen-flow indicator, the oxygen pressure gauge, the oxygen excessive pressure gauge, and the pilots should additionally check the readings of the liquid oxygen level indicator.

The oxygen pressure in the mains should be within the limits of 8 - 10 kg/cm$^2$ , the blinkers of the oxygen-flow indicator should close and open following the rhythm of breathing.

## Check and Adjustment of DC Power Sources

1. Storage Battery Check.

The check of the aircraft storage battery includes the check of the degree of charging and the check of good condition of the storage battery connections to the distribution bus bars of the electric mains. The check of the aircraft storage battery connection to the emergency circuit is carried out with both engines operating.

The check is carried out in the following order:

- make sure that all the aircraft electric consumers and the ground power unit are switched off;

- make sure that the storage battery safety switch is on (the generators cut off master bar is in the upper position);

- set the aircraft storage battery switch, mounted on the navigator-radar operator's electric panel, to the NORMAL position and by the ammeter make sure that the loading is absent;

-switch on the artificial horizons of the aircraft commander and the co-pilot and the СПУ-10 intercom; the voltage of the storage battery during this should be not less than 24 V read by the voltmeter;

- switch off the artificial horizons, the СПУ-10 intercom, and the storage battery;

- turn on the selector switch of the instruments storage battery supply, mounted on the navigator-radar operator's panel. During this only the master artificial horizon should function. Turn off the selector switch on the navigator-radar operator's panel. Repeat these operations, manipulating by the selector switch mounted on the aircraft commander's left control panel.

Note: The switch of the master artificial horizon should be on during this.

The operation of the artificial horizons is determined by the nose of their operating inverters.

After the check switch off the artificial horizons and set the switches and selector switches on the navigator-radar operator's electric panel to the initial positions.

## 2. Ground Adjustment of Generators

Adjustment of the generators voltage on the ground should be made in the following order:

- set the voltmeter selector switch to the position corresponding to the voltage measurement of the generator to be adjusted (the generators should be disconnected from the aircraft electric mains, the electric consumers are supplied by the ground power unit at this time);

- set the speed of the engine, on which the given generator is mounted, at 3750 r.p.m.;

- by rotating the knob of the BC-20 extension rheostat adjust the generator voltage to be equal to 28.5 V;

- increase the engine speed up to 4100 r.p.m. for a short time and make sure that the generator voltage at this does not increase above 0.5 V.

The voltage of the rest of the generators is adjusted in the same sequence.

### 3. Connection of Generators to Aircraft Electric Mains

The generators are connected to the aircraft electric mains in the following order:

- switch off the electric consumers, leaving only the minimum number of the consumers switched on which ensure the engines operation;
- switch off the ground power unit and quickly switch on all the generators in turn;
- switch on all the required consumers.

### 4. Adjustment of Parallel Operation of Generators

Adjustment of the generators parallel operation should be carried out in the air 30 or 40 minutes after the take-off. Do this in the following order;

- apply the loading of more than 50 per cent of the nominal to the generators; for this purpose switch on the tail unit de-icer, the electric devices, and the armament electric system;at such switching on the medium loading on each generator will constitute 420 A approximately; the switching on of the powerful consumers should be performed in turn in order to prevent dangerous overloading of one of the generators;
- check the distribution of current between the generators;

if the difference in loading of separate generators exceeds 120 A, it is necessary to level it by changing the generators voltage with the help of the BC-20 extension resistances. For this purpose increase the voltage of less loaded generators and decrease the voltage of more loaded generators;

- set the voltmeter selector switch to the NORMAL MAINS position; if the voltage of the aircraft electric mains does not correspond to 28 - 28.5 V, it is necessary to increase or decrease the voltage of all the generators up to the required value by turning the knobs of all the BC-20 extension rheostats by the same angle;

- switch off all the consumers, which are not required for the continuation of the flight and check the generators loading by the ammeters; the difference in currents, produced by separate generators, under small loadings is of no importance, however, all the generators should supply power to the aircraft electric mains. Under the excessively small loadings the disconnections of separate generators are possible, which is permissible, because during the following increase of loading they will get connected to the mains again.

Note: The readjustments of the generators parallel operation should be carried out only in those cases when the difference in currents of the separate generators output exceeds 150 A under the loadings from 25 up to 50 per cent of the nominal and 120 A under the loadings of more than 50 per cent of the nominal.

### 5. Disconnection of Generators from Aircraft Electric Mains Prior to Engines Cut Out

The disconnection of the generators from the aircraft electric mains prior to the engines cut out should be made in the following order:

-switch off all the consumers except for channel No.1 of the СПУ-10 intercom, the stand-by fuel pumps, and the engine instruments;

- disconnect the generators from the aircraft electric mains;

- cut out the engines;

- on the aircraft commander's order switch off the storage battery;

- switch off the consumers, which have remained on.

## Electrical Mains

There are three possible operating conditions of the aircraft electrical mains: normal, emergency, and deenergized mains condition.

The normal operating condition of the electrical mains, - power is supplied into the normal electrical mains by all generators and the storage battery.

Under the normal operating condition of the electrical mains the selector switches and switches mounted on the electric panel of the navigator-radar operator, should be set as follows:

- the switches of all four generators - to the ON position;

- the storage battery selector switch - to the NORMAL position;

- the voltmeter selector switch - to the NORMAL MAINS position;

- the emergency mains switch - to the OFF position;

- the generators selector switch to the emergency mains - to the LEFT No.2 position;

- the switch of the instruments storage battery supply bus bar, with the circuit deenergized,-to the OFF position;
- the GROUND POWER UNIT switch - to the OFF position.

When the generators, the storage battery, and the mains are in good repair, all the four generators and the storage battery should be always connected to the normal mains in flight.

Notes: 1. To disconnect the generators it is necessary to use the master bar.

2. If one or several generators fail, the power supply for the normal mains should be delivered by the rest of the generators which are in good repair. At this:

- connection of consumers is not limited if three generators and the storage battery are switched to the mains;
- when two generators and the storage battery are connected to the mains, it is possible to switch on simultaneously either the armament system with the constantly functioning consumers or the tail unit de-icers with the constantly functioning consumers; in this case the simultaneous switching on of both the armament system and the tail unit de-icers is not allowed;
- when only one generator and the storage battery are connected to the mains, the consumers should be switched on in such a combination that the total loading does not exceed 600 A.

Transition to the second and third operating conditions of the aircraft electrical mains is described in Section "Special Cases in Flight".

Connection of ground power unit to aircraft

D.C. mains should be made

in the following order:

- make sure that the aircraft electric consumers and the ground power unit switch are turned off;

- connect the plug of the ground power unit with a power source connected to it to the aircraft ground power supply socket;

- set the voltmeter selector switch, mounted on the generators panel, to the GROUND POWER SUPPLY SOCKET (PAП) position and make sure that the normal voltage supplied by the ground power unit is available;

- move the voltmeter selector switch to the NORMAL MAINS position and, turning on the ground power unit switch, make sure that the voltage is supplied into the aircraft mains.

After this it is possible to switch on the consumers.

Disconnection of ground power unit should be made in the following order:

- switch off all the electric consumers;

- turn off the ground power unit switch;

- disconnect the plug from the ground power supply socket.

WARNING: In order to prevent the storage battery discharge when both engines do not operate, IT IS FORBIDDEN to disconnect the plug from the ground power supply socket or to switch off the ground power source before the ground supply switch, mounted on the navigator-radar operator's electric panel, is turned off (or the storage battery selector switch is set to the OFF position).

## A.C. Sources

For a centralized supply of the alternating current mains there are two ПО-4500 inverters installed in the aircraft, one of which is operational and the other is a reserve one.

The voltage adjustment of the ПО-4500 inverters should be made in the following order:

- set the inverters selector switch to the OPERATIONAL position;
- check the inverter voltage by the aircraft voltmeter; if after 5 minutes the voltage is more or less than 115±0.5 V, it is necessary to set the voltage equal to 115±0.5 V with the help of the РС-4М rheostat belonging to this inverter;
- switch on the A.C. constant consumers (the РБП-4 radar bombsight and the ПРС-1 fire control radar) and check the A.C. voltage; if the voltage is more or less than 115±0.5 V, it is necessary to set it again equal to 115±0.5 V;
- switch off the A.C. consumers;
- set the inverters selector switch to the RESERVE position and make voltage adjustment similar to the operational inverter adjustment.

# A P P E N D I C E S

Appendix 1

## AERODYNAMIC FEATURES OF Ty-16 AIRCRAFT
## Peculiarities of the Aircraft as Long Range High-Speed Heavy Bomber

1. The Ty-16 aircraft as a high-speed bomber flies at near-sonic speeds, To improve the aerodynamics of the aircraft at such speeds the wing and the tail plane of the aircraft are swept back and have high-speed profiles while the fuselage and the engine nacelles are of elongated shape.

2. The aircraft has a great thrust-to-weight ratio (0.32 kg of thrust/kg of weight in the normal variant), which ensures the achievement of high maximum speeds and altitudes of flight, the required take-off performance, and fast aircraft acceleration. Due to great aircraft gross weights and small middle section area the speed decreases slowly when the engines are throttled down.

3. The aircraft has high get-away speed, climb and descent speeds due to considerable loading per each sq.m. of the wing, comparatively small value of maximum lift coefficients which are peculiar to a sweptback wing, and due to an approximately constant value of the available thrust depending on the speed of flight at the given altitude.

4. The maximum range of flight is achieved by the Ty-16 aircraft, while flying at altitudes corresponding to the mini-

mum fuel consumption per kilometre; these altitudes are lower by 600 - 900 m. than the service ceiling of the aircraft with the given gross weight (Fig.19); near the ground the minimum fuel consumptions per kilometre increase two or three times versus the fuel consumptions at these altitudes (Fig.20). The indicated airspeed, which corresponds to the minimum fuel consumptions per kilometre, depends on the gross weight.

5. The aircraft has big dimensions of the wing, tail unit, and fuselage, which is a cause of formation of considerable damping moments which slow down the rate of the aircraft turn around this or that axis. These moments occur due to the counterpressure of the air masses, which are deflected by the aircraft surfaces in the process of its turn. The damping moments decrease with speed decrease and altitude increase.

The moments of inertia counteract both acceleration and deceleration of the aircraft rate of turn around this or that axis. Their numerical value depends both on the value and on the distance of distributed masses from the aircraft centre of gravity. The speed and altitude of flight do not influence the value of inertia moments. The moments of inertia, affecting the Ty-16 aircraft, are considerable due to great gross weights and big linear dimensions of the aircraft. Nevertheless the Ty-16 aircraft possesses the satisfactory characteristics of stability and controllability, which, however, suffer certain changes at high speeds of flight: the opposite reaction of the aircraft to bank when the rudder is deflected, the increase of efforts on the aircraft control units, especially from the rudder (in comparison with other aircraft of the same class, equipped with hydraulic amplifiers), and other phenomena, characteristic of all high-speed aircraft.

The stability and controllability of the aircraft are influenced by the change of the centre of gravity location in flight due to bomb release and fuel consumption (the weight of which may constitute up to 40 - 50 per cent of the initial weight).

That is why any divergence from the prescribed fuel consumption sequence is inadmissible.

The maximum shift of the centre of gravity aft is noticed when the gross weight is changed within the limits of 38 - 43 tons.

6. Due to good efficiency of the control surfaces, big reserve of lift, and available thrust the Ty-16 aircraft may perform sufficiently energetic manoeuvres for the given class of aircraft. But the maximum permissible load factors of the aircraft (as an aircraft with a limited manoeuvre) are small and decrease with the increase of gross weight and altitude of flight (See Figs 30-41).

## Measures Improving Aircraft Flight Performance

The Ty-16 aircraft has a long range of flight and flies at high altitudes and near-sonic speeds (maximum Mach number = 0.9), when the aircraft aerodynamic characteristics start to be considerably influenced by air compressibility. During this, the redistribution of pressures along the airfoil (chordwise and spanwise) and other parts of the aircraft takes place, the nature of which depends on the flight Mach number. At Mach numbers ≥ the critical Mach number (the critical Mach number is the Mach number at which the local speeds of the airflow, passing around the airfoil, become equal to the sonic speed) the shock waves begin to form and develop (the compressed air areas, in which the local supersonic speeds jump to subsonic).

This leads to the increase of the drag coefficient, to the change of the lift coefficient and the stability and controllability characteristics of the aircraft.

In order to decrease this bad effect of air compressibility on the aerodynamic performance of the aircraft, the critical Mach number is increased. For this purpose the aircraft wing and tail plane are swept back, the effect of which consists in the following.

It is known that the lift of a wing and tail plane is determined by the pressures, created due to the change of the local airflow speeds values under the effect of the external profile shape along the whole span of the wing (tail plane). The swept wing profiles are arranged at right angle to the leading edge of the wing for a shape in plane view illustrated in Fig.21.

Let us divide the speed of flight $V_{flt}$ into two components one of which is perpendicular to the leading edge of the wing and the other is directed along the leading edge of the wing. The component $V_{eff}$ ( effective speed ), which is directed at right angle to the leading edge of the wing, determines the value of local speeds and rarefactions along the profile and, consequently, the value of lift.

The effect of compressibility on the drag coefficient depends not only on the values of pressures but on the nature of pressure distribution as well, and that is why it is also determined by the value of $V_{eff}$ or by effective Mach number (Mach No.$_{eff.}$) corresponding to it. As $V_{eff.} < V_{flt}$, then the Mach$_{eff.}$ < Mach$_{flt.}$ Since the straight wing has Mach$_{flt}$ equal to Mach$_{eff.}$, then the critical Mach number of the swept wing will be greater than the critical Mach number of the straight wing by as many times as the hypotenuse is bigger than the adjacent cathetus (See Fig.21), with the exception of the central part of the wing, where, as it is known, the sweepback effect is absent. Besides, the sweepback of the wing decreases the nature of changes of the aerodynamic characteristics relative to Mach number, which are connected with the effect of air compressibility.

In order to increase the critical Mach number, the Ty-16 aircraft also has special high-speed profiles of small relative thickness, which pressures and local speeds are distributed chordwise more evenly and considerable rarefactions are absent.

In order to decrease the local speeds at the aircraft joints (which also leads to the increase of the drag, especially at high speeds of flight) the Ty-16 aircraft has special arrangement of the engine nacelles and undercarriage.

As it was pointed out before, $V_{eff}$ (which determines the amount of lift) is less than $V_{flt}$, that is why the sweptback wing has a smaller lift value than the straight conventional wing under the same conditions.

In order to achieve the required amount of lift during take-off and landing, the wing of the Ty-16 aircraft is equipped with a powerful extension flap.

The second component of the speed, directed along the leading edge of the wing (See Fig.21), does not influence the creation of the lift but causes the boundary layer flow in the direction from the wing root to the wing tips, which may cause the wing tip stall at the angles of attack which are near to the critical ones. In order to decrease the possibility of the wing-tip stalls besides the special arrangement of the wing profiles, the wing of the Ty-16 aircraft is equipped with two pairs of aerodynamic fences.

## Principal Aerodynamic Characteristics of Ty-16 Aircraft

The Ty-16 aircraft has a high lift-drag ratio, which is equal to 16.5 approximately, when the undercarriage and flaps are up and the aircraft flies at the optimum speed (angles of attack are 5 - 6 $^{o}$ and flight Mach number equals 0.74 - 0.78). During this the induced drag constitutes about 40 per cent of the total aircraft drag.

The change of the aircraft drag polar versus the speed of flight is shown in Fig.22.

When the undercarriage is extended and the flaps are deflected by 35$^{o}$, the lift-drag ratio is decreased almost double and is equal to 7 approximately.

The extended undercarriage causes the drag, which is approximately equal to the minimum drag of the aircraft. The 20$^{o}$ flaps cause the drag, which is approximately equal to the total drag of the aircraft (minus the induced drag).

The maximum lift coefficient with the flaps up is equal to 1.3; when the flaps are deflected by 20$^{o}$, the lift coefficient increases up to 1.45 and when the flaps are deflected by 35$^{o}$, it becomes equal to 1.65 (See Fig.23).

The critical angle of attack, when the flaps are retracted, is approximately equal to 18$^{o}$ and when the flaps are down by 20$^{o}$ and 35$^{o}$, it becomes equal to 15$^{o}$ approximately.

The optimum angles of attack while getting airborne and during landing are by 4 - 5$^{o}$ less than the critical angles of attack with the flaps down.

The general view of the aircraft drag polars at different Mach numbers is shown in Fig.24 and with different flap positions at small Mach numbers - in Fig.25.

## Special Flight Conditions

Minimum speeds of flight correspond to the maximum value of the lift coefficient. However, under flight conditions it is forbidden to bring the aircraft to these speeds in order to avoid the aircraft stall.

Usually in the range of angles of attack, in which the airstream stall occurs, the characteristics of stability and controllability start to worsen.

When the speed decreases and approaches the minimum speed, the efficiency of all the control surfaces is decreased (because the velocity head decreases). In this case the aircraft may pitch up, fall off on one wing with a transition into spiral, and when stalling without bank it may pitch down with a transition to glide with the following acceleration.

That is why, during the Ty-16 aircraft mass maintenance and operation the minimum permissible speeds are authorized, which are approximately by 30-50 km/hr higher than the speed corresponding to the beginning of the aircraft stall. However, both at minimum permissible and even at higher speeds the aircraft transition to the buffeting lift coefficient ($C_L$)is possible when the condition of flight is changed from straight and level to curvilinear (banked turn, zoom), because in this case the load factor increases as many times as the lift coefficient. Suppose that the load factor during the transition of the aircraft to the curvilinear flight has increased two times. If during the level flight the lift coefficient ($C_L$)=0.5, then it will also increase two times during the transition of the aircraft to the curvilinear flight at the same speed, i.e. becomes equal to 0.5x2==1. Let the flight Mach number be equal to 0.35 during this. Then from Fig.26 one may see that at the lift coefficient ($C_L$) equal to 1 and the Mach number = 0.35 the aircraft at the same IAS will be on the border line of buffeting area, i.e. the load factor 2 will be maximum permissible. From the chart,shown in Fig.26,it is seen that the value of the buffeting lift coefficient decreases with the increase of the Mach number.

At a constant indicated air speed with the increase of altitude the lift Mach number will increase (because the true air speed will increase and the speed of sound will decrease). The lift coefficient ($C_L$) of the stable flight does not change (at a constant gross weight), consequently, the permissible load factors will decrease when the altitude of flight increases. Generally speaking, during the high altitude flight rather considerable Mach numbers, at which the buffeting lift coefficients ($C_L$) are small correspond to the average indicated air speed. At the same time, the level flight lift coefficient is sufficiently great at high altitudes. That is why, during the high altitude flight the considerable decrease of permissible load factors occurs, which may be determined as follows:

$$\text{Permissible load factor } (n) \; \frac{C_L \text{ buffeting}}{C_L \text{ level flight}} .$$

The arrival of the aircraft at the angles of attack corresponding to the buffeting lift coefficient may take place during the flight under "bumping" conditions as well, because the aircraft entering the upward air currents is followed by the increase of load factor.

The limitations in the maximum permissible load factors depend on the aircraft gross weight, altitude, and speed of flight, and are determined by the charts (See Figs 33-41). It should be mentioned that the permissible load factors during banked turns and more complicated manoeuvres (turn with climb) are less than during the vertical manoeuvre because in this case the aircraft is under more complicated conditions (with regard to aircraft controllability) than during the vertical manoeuvre.

Thus, the pilot should always bear in mind (especially during the flight at high altitudes) the small value of the maximum permissible load factors and fly the aircraft very attentively, preventing it from arriving to the conditions at which stalling is possible.

During the accidental aircraft stall, which occurs as a result of exceeding the permissible values of the lift coefficient ($C_L$) (great angles of attack) and load factors, the pilot should know that the pilotage technique during the aircraft recovery to the normal flight condition depends on the speed at which the stall has occurred. If the stall has occurred at low or medium speeds (at Mach number $< 0.8$), one should decrease the angle of attack by pushing the control column sharply forward thus increasing somewhat the speed in order to prevent the possibility of the second stall more easily, stop the aircraft rotation by deflection of the pedals and ailerons in the direction opposite to the direction of stall, recover from the bank and then pull the aircraft out of dive. If the stall has occurred at Mach numbers $> 0.8$ or at higher indicated air speeds (IAS $>$ 550 km/hr), in this case the bank is eliminated by the ailerons. The rudder is applied during the recovery if the stall has occurred with a bank, in order to prevent the aircraft nose from pitching down (at a bank) only at Mach number $< 0.8$. If the stall has occurred at Mach number $> 0.8$ or at IAS $>$ 550 km/hr, then it is difficult to apply the rudder due to the big hinge moments, which can be overcome by the pilot's strenuous efforts only.

## Aircraft Stability and Controllability

There are two kinds of stability: longitudinal and lateral which in their turn are subdivided into:

1. Dynamic stability at which the aircraft completely recovers its initial attitude after unbalance (the Ty-16 aircraft is dynamically stable in the range of the operational locations of centre of gravity).

2. Static stability, which is determined by the creation of the aerodynamic moment, which appears at the initial moment of misbalance and is acting towards recovery of the initial angle of attack.

This aerodynamic moment of the statically stable aircraft is created in the following way. When the aircraft balance is upset, the aerodynamic moments, created mainly by the wing and tail plane, begin to act up on it. If, for example, the balance was upset towards the increase of the wing angle of attack (vertical gust), during this the tail plane angle of attack is also increased, that is why the lift is created on the tail plane, which acts upwards. The moment of this force in relation to the aircraft centre of gravity acts in the direction of the angle of attack decrease (stabilizing moment), i.e. it tries to return the aircraft to its initial attitude. The value of this moment depends on the additional increase of the tail plane angle of attack, the area of the tail plane, and the distance separating it from the aircraft centre of gravity. This recovering moment is usually counteracted by the wing moment, which depends on the aircraft centre of gravity location (the aircraft centre of gravity location relative to the leading edge of MAC) and is increased when the centre of gravity is shifted aft. Besides, the wing creates the downwash near the tail plane, because during the increase of the lift of the wing the rate of the downwash, produced by the wing, is also increased and the increase of the tail plane angle of attack and, consequently, of its lift is somewhat decreased. Due to this the tail plane stabilizing moment is also somewhat decreased.

## Aircraft Longitudinal Stability and Controllability

The presence of longitudinal static stability is the most important safety factor of flight, because it prevents the aircraft from fast arrival at the angles of attack, at which dangerous load factors occur, or at the angles of attack, at which the aircraft stall is possible.

The static stability is numerically determined as the difference between the value of the neutral location of the centre of gravity (at which the aircraft has indifferent balance) and the given operational location of the centre of gravity, expressed in per cent MAC (the so-called C.G. margin).

The stable flight is possible both with checked and released control. In the first case the elevator remains motionless when the balance is upset (the pilot holds the control column in the constant position). In the second case the elevator is free (the control column is released) and the elevator may deflect upward or downward under the effect of the air load and the elevator inertia forces.

Due to these reasons the longitudinal stability margin at the checked and released control happens to be unequal under the same conditions. In the Ty-16 aircraft the elevator is deflected when the control is freed, in the direction opposite to the deflection of the aircraft tail unit, which decreases the value of the recovery aerodynamic moment and, consequently, the C.G. margin.

Thus, the stability of aircraft with the released control is usually worse than that of the aircraft with the checked control.

An operational location of the aircraft centre of gravity depends on variants of its loading and may change during the flight due to the fuel consumption and bomb release. The maximum permissible aft operational location of the centre of gravity, which ensures the required minimum margin of longitudinal stability of the Ty-16 aircraft equals 32.3% MAC. The neutral C.G. location of the Ty-16 aircraft shifts backward with the increase of Mach number under the influence of air compressibility. Owing to that the C.G. margin increases, which results in the increase of efforts exerted to the control column, especially at great flight Mach numbers.

The influence of air compressibility on the shift of the neutral C.G. location aft is generally caused by the redistribution of pressures chordwise and spanwise and by the change of airflow downwash near the tail plane.

The aircraft longitudinal controllability is mainly determined by its ability "to follow the column" with the smallest lag, when the efforts exerted by the pilot to the control column within the limits prescribed for the given class of aircraft are changed.

The manoeuvres performed by the Ty-16 aircraft during normal flight basically include:

1. The change of flight direction (flight path) both in horizontal (turns and banked turns) and vertical planes (transition to climb or descent from the level flight), during which the load factor changes but the speed and the flight Mach number practically remain constant.

2. The change of speed and, consequently, the Mach number of level flight (acceleration and deceleration) when the

load factor remains constant; and in the common case of manoeuvre both the speed and load factor change (zoom, spiral with acceleration, etc.).

When the direction of flight is changed in the vertical plane (or while flying the aircraft under "bumping" conditions) the pilot deflects the elevator and as a result of this the angle of attack is changed and, consequently, the lift and the load factor of the aircraft are also changed. If it is possible to change the load factor faster and in wider range (for the aircraft as a limited manoeuvre aircraft, this range is limited Figs 33-41) or vice versa, if it is possible to quicker stop the commenced accidental load factor change (for example, under "bumping" conditions), the better is the longitudinal controllability of the aircraft.

When the angle of attack and load factor are changed, the pilot, by deflecting the elevator should overcome the static stability moments and besides that he should parry the inertia and damping moments, which appear in the process of the aircraft turn around its lateral axis.

The aerodynamic moments counteract the load factor change, i.e., make the aircraft more stable with respect to the load factor.

In order to overcome the load factors the pilot should create the moment acting in the opposite direction by deflecting the elevator and applying a certain force to the control column. The magnitude of effort, which should be applied by the pilot to change the load factor by one unit, is the most significant sign of the aircraft longitudinal controllability. For example, if the aircraft is balanced by the efforts (i.e. the effort on the control column is equal to zero) in level flight (when the load factor (n) is equal to 1) and the pilot receives the stable load factor (n) equal to 2 units by pulling the control column backward, then this effort corresponds to the change of load factor by one unit.

For the Ty-16 aircraft the effort, spent per unit of load factor, constitutes 20 - 100 kg, depending on the location of the centre of gravity, altitude, and speed of flight (from 1.2 of the minimum speed up to 0.8 of the maximum speed).

When the altitude of flight is increased and, consequently, the damping moments are decreased or the operational location of the centre of gravity is shifted aft (due to this fact the C.G. margin decreases), the efforts spent to create one unit of load factor decrease because the smaller deflections of the elevator are required for this. With the increase of speed of flight above 0.8 of the maximum speed the efforts per one unit of load factor increase, reaching the values of 150 - 200 kg at the maximum speed. It is mainly caused by a considerable shift of the neutral C.G. location aft (under the influence of air compressibility) and by the increase of the C.G. margin owing to this fact and, consequently, the magnitude of efforts per one unit of load factor as well. But at greater angles of attack the C.G. margin relative to the load factor somewhat decreases.

The second kind of manoeuvre as it was mentioned above, is performed during the aircraft acceleration and deceleration along the straight path, when the load factor remains constant and, as a rule, is equal to 1 and only the speed and, consequently, the Mach number are changed. In comparison with the first kind of manoeuvre during the aircraft acceleration or deceleration along the straight path, its turn around the lateral axis (the change of angle of attack) takes place slowly and, owing to this fact, the inertia and damping moments are practically absent. That is why by deflecting the elevator one should overcome only the aerodynamic moment of static stability, which will also change under the influence of air compressibility depending on the range of the Mach number change during the given manoeuvre. This moment of the aircraft, which is stable in speed, will also act in the direction of the aircraft return to the initial speed relative to the flight condition under which the effort on the control column was equal to zero. The effort, which the pilot applies to change the speed by any selected value (for example by 10 km/hr), will depend on the change of the aerodynamic moment of stability relative to the Mach number and the lift coefficient.

In the aircraft, which is stable in speed, the pressing efforts should continuously rise when the speed of flight increases (relative to the balance condition by efforts when the efforts are equal to zero), and vice versa, when the speed decreases (relative to the same condition), the pulling efforts should rise.

In the Ty-16 aircraft at high Mach numbers (within the limits of Ma = 0.82 - 0.87) a certain decrease of stability in speed is noticed, which is due to the air compressibility effect. The flight trials have shown that if the aircraft is balanced by the efforts by a trim tab for Mach 0.82, then during the aircraft acceleration from Ma = 0.82 - 0.83 up to Ma = 0.87, the slight pulling efforts appear on the control column. When the Mach number is further increased from 0.87 up to 0.9, the considerable pressing efforts appear.

The friction in the Ty-16 aircraft control is within the normal limits, notwithstanding the considerable length of the lines; but the controls need thorough care during operation because the excessive friction in the aircraft controls complicates the aircraft control (in perfect case the pilot should feel only the efforts produced by the aerodynamic loads).

The efforts on the control column during the aircraft control also depend on the hinge moment.

The hinge moment is equal to the product of the total aerodynamic force of control surface R by the arm of this force relative to the axis of rotation (hinge) of the control surface (Fig.27).

The value of the hinge moment depends on the sizes of the control surface and the air speed and also on the axial compensation, which determines the distance (arm) of the control surface centre of pressure from its axis of rotation. Besides, the hinge moment and, consequently, the efforts rise with the increase of the elevator dimensions, the speed of flight, and they decrease with the increase of the axial compensation.

In the Ty-16 aircraft the elevator, which is designed to ensure the aircraft controllability, has rather considerable dimensions. The range of speeds of the Ty-16 aircraft and its maximum speed are sufficiently great. That is why in order to get the acceptable values of the hinge moment and the efforts, which appear during the aircraft control, the considerable axial compensation is used in the Ty-16 aircraft elevator. The elevator axis of rotation is situated rather close to the elevator centre of pressure. The hinge moment should be with such a sign that the pilot should always feel the direct efforts on the control column, i.e., that the elevator should tend to return to the position corresponding to the balance condition. It is quite inadmissible that the hinge moment changes its sign to the opposite one, because in this case the elevator will tend to deflect spontaneously to this or that direction from the balance position . This phenomenon is called overcompensation.

In the Ty-16 aircraft the phenomenon of overcompensation is absent in the whole operational range of speeds and altitudes, if the elevator is in good repair. The correct sign of the hinge moment is ensured by the location of the elevator axis of rotation in front of its centre of pressure. The position of the elevator centre of pressure depends on the shape of its profile and especially on the shape of its leading and trailing edges and also on the relative dimensions of its axial compensation. The slight changes of the elevator leading edge profile shape or of the axial compensation relative dimensions may lead to certain shifts of the centre of pressure. But because of the fact that in the Ty-16 aircraft the axis of rotation passes quite close to the elevator centre of pressure, these slight displacements of the centre of pressure may lead to the overcompensation phenomena on one hand, and to the sharp increase of efforts on the other hand. That is why, in the process of the Ty-16 aircraft operation special attention should be paid to the preservation of the elevator leading edge profile shape and the condition of the elevator trailing edge (ground-adjustable trim tab) should carefully be watched.

According to the conditions of controllability each aircraft has the forward operational C.G. limit, which is determined by the sufficiency of the elevator "reserve" to give the aircraft the landing angle of attack near the ground with the undercarriage and flaps fully extended. For the Ty-16 aircraft it is equal to 21.7% MAC. With the more forward C.G. limits, the angles of attack will be less than the landing angles of attack. Owing to this fact the landing speed should be increased on an average by 8 - 10 km/hr per each 1% MAC of C.G. location forward shift relative to 21.7 % MAC. More forward C.G. location than 18.4% MAC is not permissible for landing.

The shift of the operational C.G. location forward in flight increases the C.G. margin (which leads to some increase of efforts), but due to great values of the neutral C.G. location the Ty-16 aircraft controllability is not substantially influenced byeven most forward operational C.G. locations; therefore the shift of the C.G. location forward beyond 21.7% MAC has no limitations in flight.

## Aircraft Lateral Stability and Controllability

The static lateral stability can be found out in flight when the lateral balance is upset and is mainly determined by the ratio of the banking moment change to the yawing moment change at the sideslip angle change.

The banking moment change relative to the sideslip angle characterizes by itself the lateral stability, which can be determined in flight, if the pilot creates the bank with the help of the ailerons and maintains the straight path of flight by the corresponding deflections of the rudder. Owing to sideslip in the direction of the lowered wing the lift is created, the moment of which acts in the direction of the bank elimination and, consequently, the elimination of sideslip.

The change of the yawing moment relative to the sideslip angle characterizes by itself the directional stability, which may be determined in flight, if the pilot by deflecting the rudder creates the sideslip angle by changing the heading, and preventer the aircraft from bank by the ailerons.

The lateral force, which is formed mainly on the aircraft fin, creates the yawing moment, which acts in the direction of the sideslip angle elimination.

When the aircraft with sweptback wings flies with a sideslip, the effective speeds of theport and starboard wings are not equal. That is why both the effective speed and the lift of the leading wing will be more than the effective speed and the lift of the lagging wing. This causes the creation of the moment, which banks the aircraft to the side of the lagging wing, i.e. the stability moment. The sweepback of the wing increases the aircraft lateral stability. If in the aircraft with straight wings in order to obtain the lateral stability it was necessary to raise the wing tips upward, i.e. , to make the wing dihedral. But the sweepback wing has such a great lateral stability that in order to reduce it the wing tips are lowered downward, i.e., to make the wing anhedral. The Ty-16 aircraft has an anhedral angle of minus $3^{o}$. The banking moment, which is created on the sweptback wing during sideslip, is directly proportional to the lift coefficient in the initial stable flight and it is the more, the more the initial lift coefficient is.

If the wing characteristics are selected in such a way that at the maximum speed the aircraft has the required banking moment during the sideslip, then during the transition to low speeds of flight and, consequently, to the greater values of the lift coefficient, the banking moment will increase relative to the sideslip angle and, consequently, the aircraft stability will increase as well.

When studying the lateral stability characteristics one should also take into account both the damping moments and the inertia moments (which also substantially influence the lateral stability). Moreover, the latter cause the aircraft vibration around the longitudinal and vertical axes, which takes place under "bumping" conditions in particular.

The Ty-16 aircraft possesses great lateral stability at low speeds and especially during landing. This leads to great lateral vibration while flying at low speeds under "bumping" conditions. That is why while flying under "bumping" conditions one should fly at higher speeds within the authorized limitations.

During landing approach at crosswind, the great lateral stability of the Ty-16 aircraft makes it difficult to compensate for the drift by slipwing. Therefore, during landing approach at crosswind, the drift should be compensated for by creation of the advance angle, which is equal to the angle of drift, on the landing path. Such a method allows the landing at crosswind of up to 15 metres per second.

As it is known, when the flight Mach number increases, the lift coefficient of the wing at the constant angle of attack increases up to the critical Mach number due to the compressibility effect. After this the value of the wing lift coefficient at the constant angle of attack drops due to formation of supersonic areas and shock waves on the wing.

The curve indicating the development of the lift coefficient relative to the Mach number at the constant angle of attack looks like it is shown in Fig.28.

On the sweptback wing the speeds, which are perpendicular to the leading edge of the starboard and port wings, are not equal during the sideslip, consequently, as it was mentioned above, the effective Mach numbers of the starboard and port wings are also unequal (Fig.29).

The leading wing has higher effective speed and corresponding effective Mach number than the lagging wing. Until the effective Mach number of the leading wing does not exceed $Ma_o$ (See Fig.28), the lift coefficient of the leading wing will be more than the lift coefficient of the lagging wing; and because of the fact that the speed, which is perpendicular to the leading edge of the wing, has a greater value at the leading wing during the sideslip than at the lagging wing, then the lift of the leading wing will be more than the lift of the lagging wing.

If the effective Mach number of the leading wing exceeds $Ma_o$, then, as it is seen from the chart (See Fig.28), the lift coefficient of the leading wing will decrease while the lift coefficient of the lagging wing will increase (if the effective Mach number of the lagging wing is less than $Ma_0$). This will result in the fact that if the difference in the lift coefficients of the starboard and port wings is considerable, the lift of the leading wing may become less than the lift of the lagging wing. During this, the moment is created, which banks the aircraft to the leading wing, i.e.,there appears the so-called opposite reaction of the aircraft banking motion to the rudder deflection (when the right pedal is applied the aircraft banks not to the starboard wing but to the port one due to the sideslip which occurs at that time,which is opposite to the conventional reaction of the aircraft to the pedal applied).

This phenomenon is typical to some degree to all aeroplanes with the sweptback wings. This phenomenon of the opposite reaction of the aircraft to the rudder deflection is slightly expressed in the Ty-16 aircraft and is felt only at the speeds close to the maximum speed of flight. However, the pilot should bear in mind this phenomenon of the Ty-16 aircraft.

The yawing moment of the aircraft, i.e. the moment relative to the vertical axis of the aircraft, appears at low speeds of flight at the angle of sideslip mainly due to the fin and is directed to the decrease of the sideslip angle. While flying at high Mach numbers, at which the wave drag appears, the influence of the wing on the value of the yawing moment considerably increases.

As it was mentioned above, the effective Mach numbers of the leading and lagging wings are not equal during the sideslip of the swept wing.

The effective Mach number and the drag of the leading wing exceed the effective Mach number and, consequently, the drag of the lagging wing. During the flight at speeds corresponding to the Mach numbers, which are close to the critical Mach number or even exceed it, the difference in the drags of the leading and lagging wings reaches a considerable value. During the sideslip, this leads to the additional yawing moment, which acts in the direction of the sideslip angle decrease. Thus, the directional stability of the aircraft, with the sweptback wing increases relative to the flight Mach number increase, which takes place in the Ty-16 aircraft as well, and because of the fact that the efficiency of the rudder does not increase when the flight Mach number increases, the relative efficiency of the rudder drops. Consequently, in order to direct the aircraft at the same angle of sideslip at high Mach numbers, the bigger deflection of the rudder is required, which calls forth the necessity of greater efforts to be applied to the pedals, than during the flight at low Mach numbers.

The principal characteristic of the dynamic lateral stability is the damping of the lateral vibration.

When the speed of flight is increased, the static lateral stability, as it was ascertained above, is decreased. The directional stability of the aircraft is increased with the increase of the speed of flight. In accordance with this fact the characteristics of the aircraft dynamic lateral stability change as well.

The aircraft lateral controllability is characterized by deflections of the ailerons and the rudder, required to balance the aircraft in the stable flight condition with a sideslip in the whole range of the speeds of flight and by the efforts caused by these deflections.

The flight of the aircraft with a sideslip is usually followed by the presence of bank and because it is easier to determine the value of the bank in flight than the angle of the sideslip, the angles of the ailerons and rudder deflections and the efforts required to balance the aircraft in the stable flight condition with a sideslip, change relative to the angle of bank, which occurs during the aircraft sideslip.

In order to balance the Ty-16 aircraft under the condition of the stable sideslip, the required amount of efforts to be applied to the control column and the pedals is characterized by the following values.

On the control column the amount of effort, required to balance the aircraft during the sideslip at an angle of bank of $1^{\circ}$, approximately constitutes 2 - 3 kilograms in the range of the Mach numbers from 0.5 to 0.84.

At Mach number $\geqslant$ 0.84 this effort is decreased, at Mach number of 0.86 it is equal to zero and at Mach number $>$ 0.86 it changes its sign to the opposite one. This phenomenon corresponds to the flight when the aircraft opposite reaction to the rudder deflection to bank is present.

On the pedals the amount of effort, required to balance the Ty-16 aircraft in the stable sideslip at an angle of bank of $1^{\circ}$, approximately constitutes 45 kilograms at flight Mach number = 0.5 and it reaches the value of 100 kilograms at flight Mach number which equals approximately to 0.88.

The peculiarity of the Ty-16 aircraft lateral stability and controllability during sideslips is the decrease of efforts produced by the rudder in the second half of the pedals travel which corresponds to the deflection angles of the rudder, which exceed the value of $10^{\circ}$. The deflections of the rudder in flight at the angles exceeding $10^{\circ}$ are possible at IAS, which are less than 400 - 420 km/hr because at high speeds the efforts, applied by the pilots to deflect the rudder up to $10^{\circ}$, are not sufficient. If at speeds lower than 400 - 420 km/hr one continues to further deflect the rudder above 10°C, the pedal efforts remain to be straight acting, but decrease in value down to zero, when the rudder is completely deflected, which may produce the false sensation of the spontaneous travel of the pedals (rudder) to the extreme position.

Note: When the pedals are completely pressed, their slight vibration is noticed, due to the airflow stall from the completely deflected rudder.

In these cases the release of pedals does not lead to the return of the rudder to the initial neutral position. However, under such conditions of flight the pilot may easily return the rudder to the neutral position by pressing the opposite pedal with a slight effort.

The above mentioned phenomenon corresponds to the normal aircraft balance, when with the controls released the aircraft flies in straight and level flight without sideslip.

When the aircraft is balanced by the trim tabs in level flight, when there is a considerable sideslip, (the deflection of the ball of the ЭУП turn and slip indicator by 1/4 - 1/2 of its diameter, which corresponds to the pedals deflection of approximately 1/4 of their travel) the efforts on the forward deflected pedal for its further deflection, will be less than during the correct aircraft balance and the probability of the pedals "travel" to the extreme position becomes greater. The required efforts to return the pedals to the initial position will increase with the increase of the angle of deflection of the rudder trim tab, when the aircraft is being balanced.

In these cases the pilot, in order to return the pedals to the neutral position should turn the rudder trim tab selector switch to the position, opposite to the pedals deflection

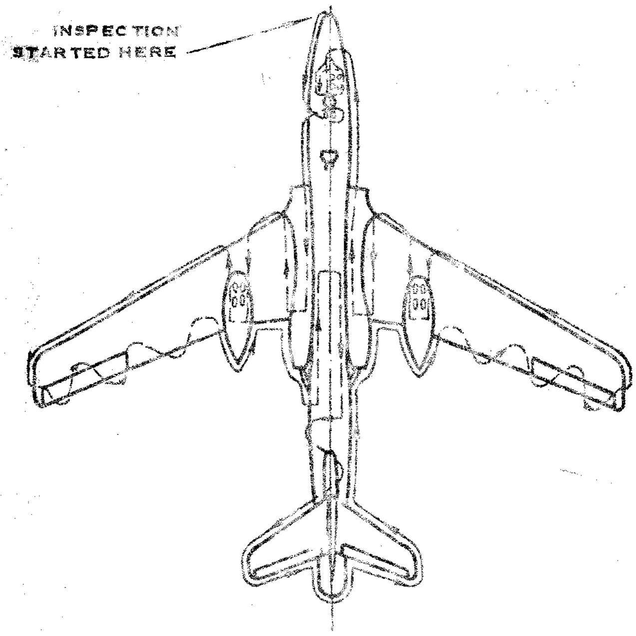



FIG. 1. ROUTE OF AIRCRAFT INSPECTION

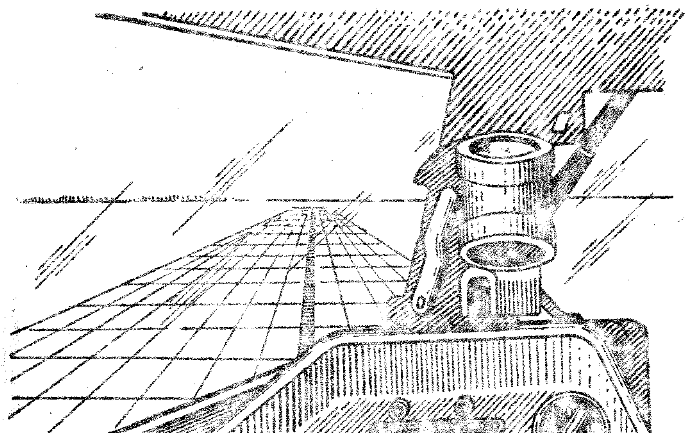
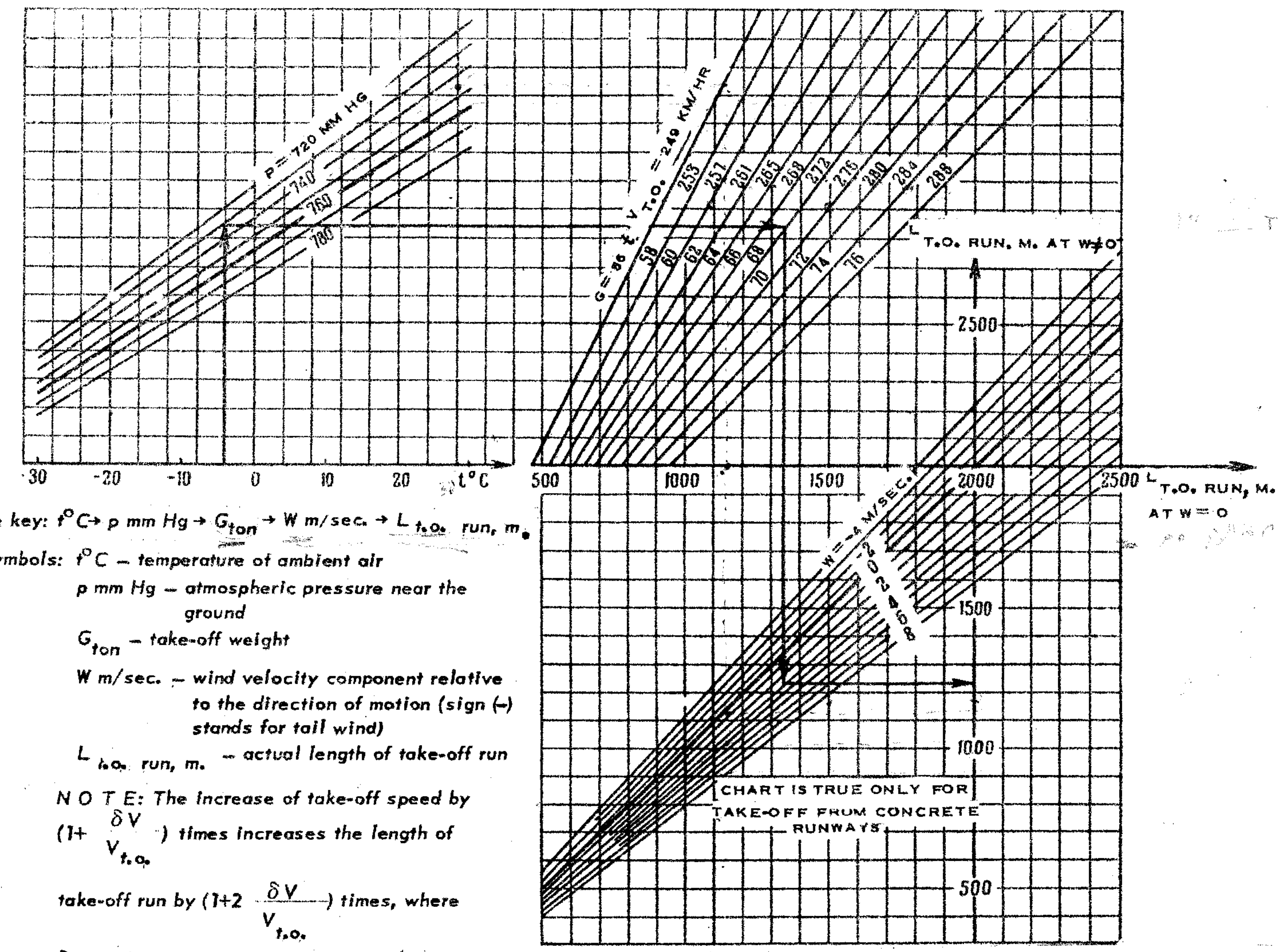


FIG. 2. VIEW OF TAXIWAY CENTRE LINE FROM AIRCRAFT COMMANDER'S SEAT DURING TAXIING




*The key:* $t^\circ C \rightarrow p$ *mm Hg* $\rightarrow G_{ton} \rightarrow W$ *m/sec.* $\rightarrow L_{t.o.}$ *run, m.*

*Symbols:* $t^\circ C$ – *temperature of ambient air*

*p mm Hg – atmospheric pressure near the ground*

$G_{ton}$ – *take-off weight*

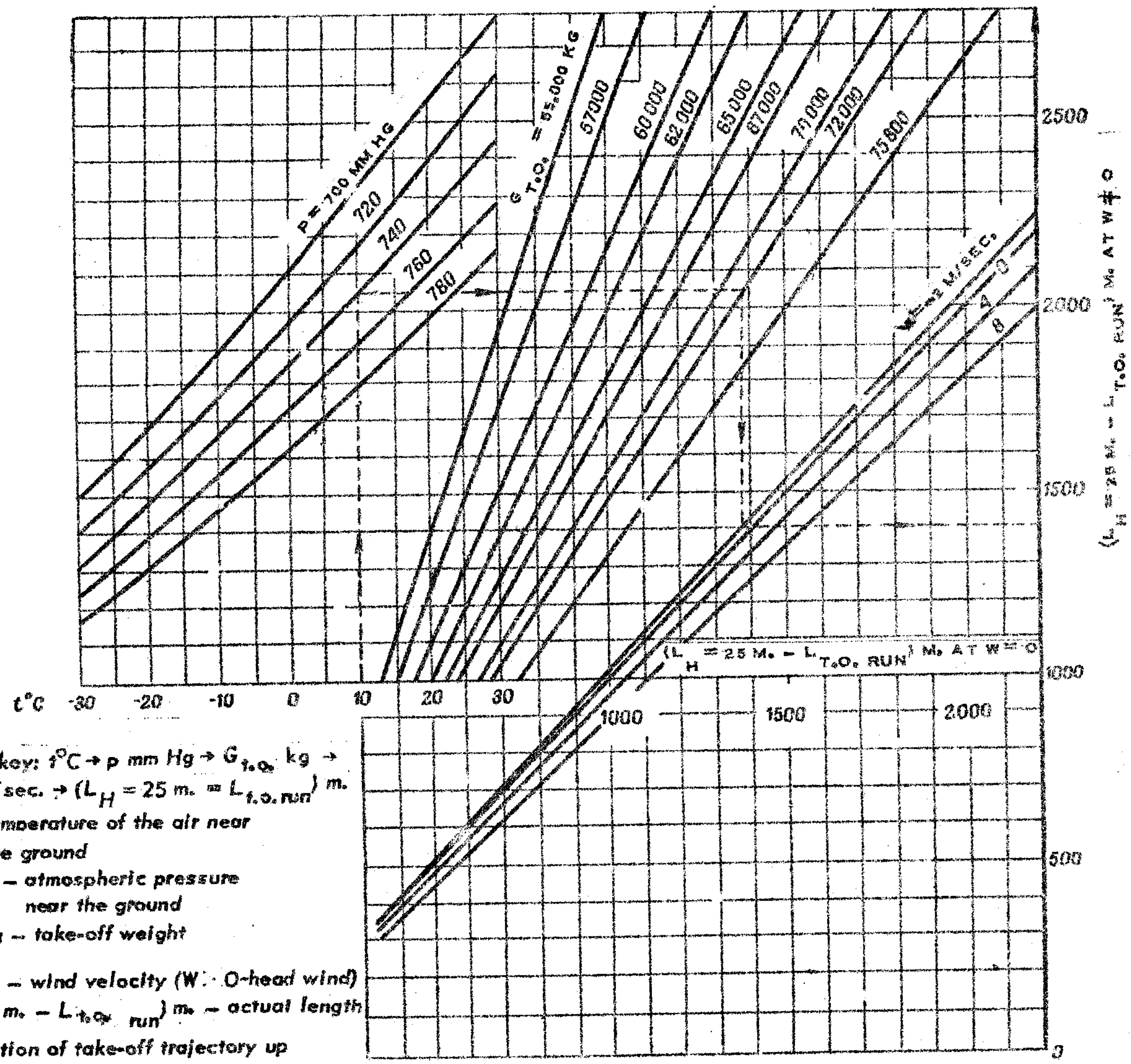
*W m/sec. – wind velocity component relative to the direction of motion (sign (–) stands for tail wind)*

$L_{t.o.}$ *run, m. – actual length of take-off run*

*N O T E: The increase of take-off speed by* $\left(1+\frac{\delta V}{V_{t.o.}}\right)$ *times increases the length of take-off run by* $\left(1+2\frac{\delta V}{V_{t.o.}}\right)$ *times, where*

$\delta V$ *is the increase of take-off speed as compared to that indicated in the chart.*

FIG. 3. CHART FOR DETERMINING AIRCRAFT TAKE-OFF RUN LENGTH VERSUS WEATHER CONDITIONS AND TAKE-OFF WEIGHT AT MAXIMUM RATING OF РД-3М ENGINES AND 20° FLAPS




*The key:* $t°C \to p$ mm Hg $\to G_{t.o.}$ kg $\to$ W m/sec. $\to (L_H = 25$ m. $- L_{t.o.\,run})$ m.

*Symbols:* $t°C$ — temperature of the air near the ground

*p mm Hg* — atmospheric pressure near the ground

$G_{t.o.}$ *kg* — take-off weight

*W m/sec.* — wind velocity (W > 0-head wind)

$(L_H = 25$ m. $- L_{t.o.\ run})$ m. — actual length of air section of take-off trajectory up to an altitude of 25 metres

FIG. 4. CHART FOR DETERMINING LENGTH OF AIR SECTION OF TAKE-OFF TRAJECTORY UP TO AN ALTITUDE OF 25 METRES VERSUS WEATHER CONDITIONS AND AIRCRAFT GROSS WEIGHT AT ENGINES MAXIMUM RATING AND 20° FLAPS

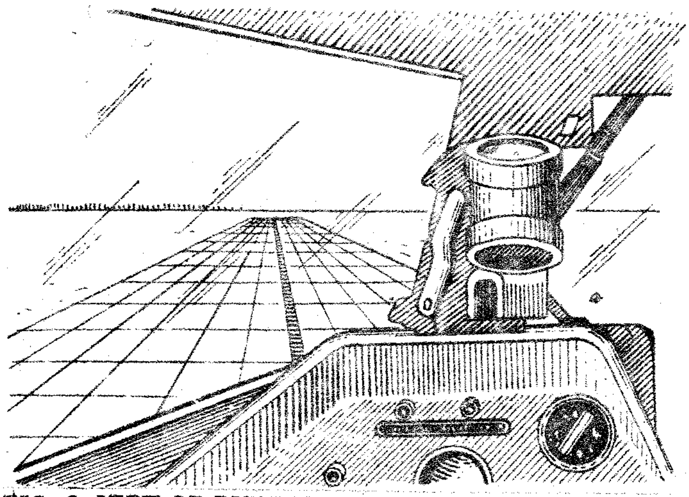


FIG. 5. VIEW OF RUNWAY CENTRE LINE FROM AIRCRAFT COMMANDER'S SEAT BEFORE TAKE-OFF

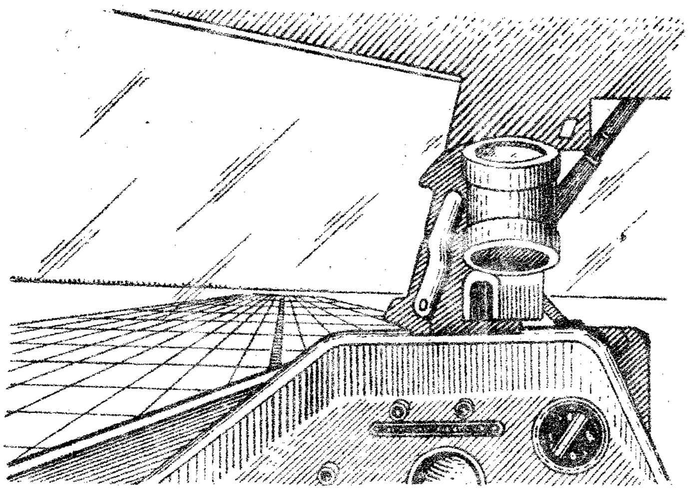


FIG. 6. VIEW OF SKY-LINE FROM AIRCRAFT COMMANDER'S SEAT AT TAKE-OFF ANGLE OF ATTACK

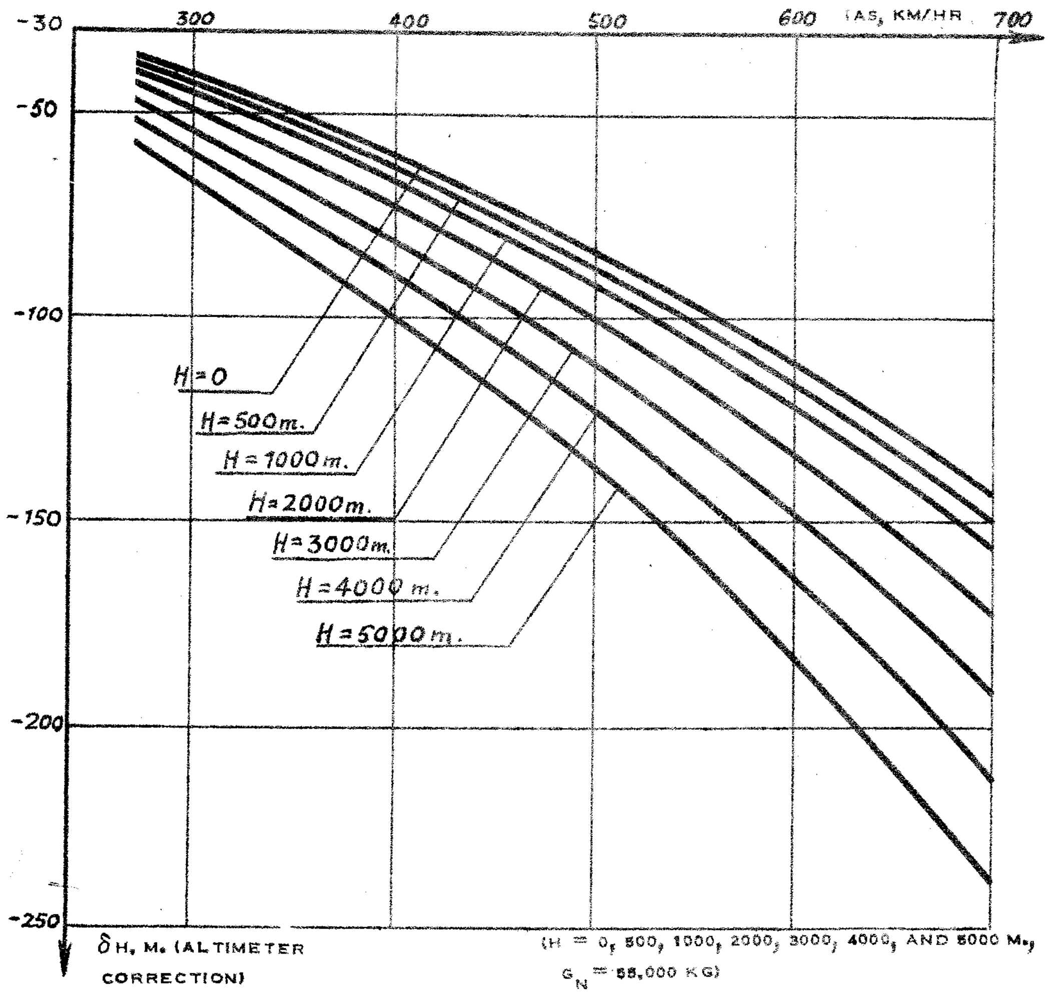



FIG. 7. AERODYNAMIC CORRECTIONS TO ВД-20 BAROMETRIC ALTIMETER READINGS VERSUS AIRSPEED AND ALTITUDE OF FLIGHT WITH FLAPS AND UNDERCARRIAGE IN RETRACTED POSITION

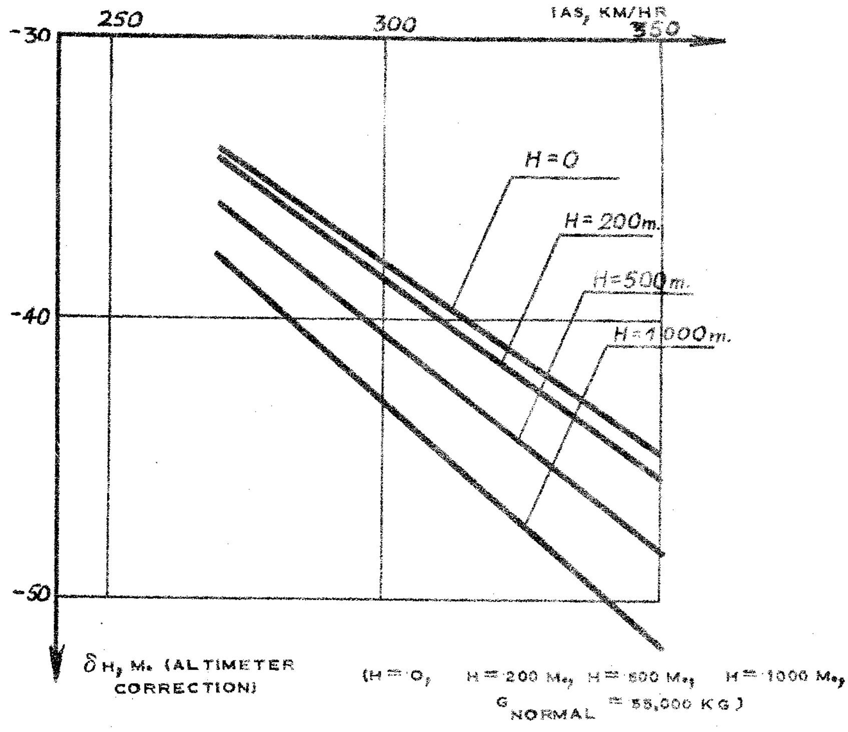
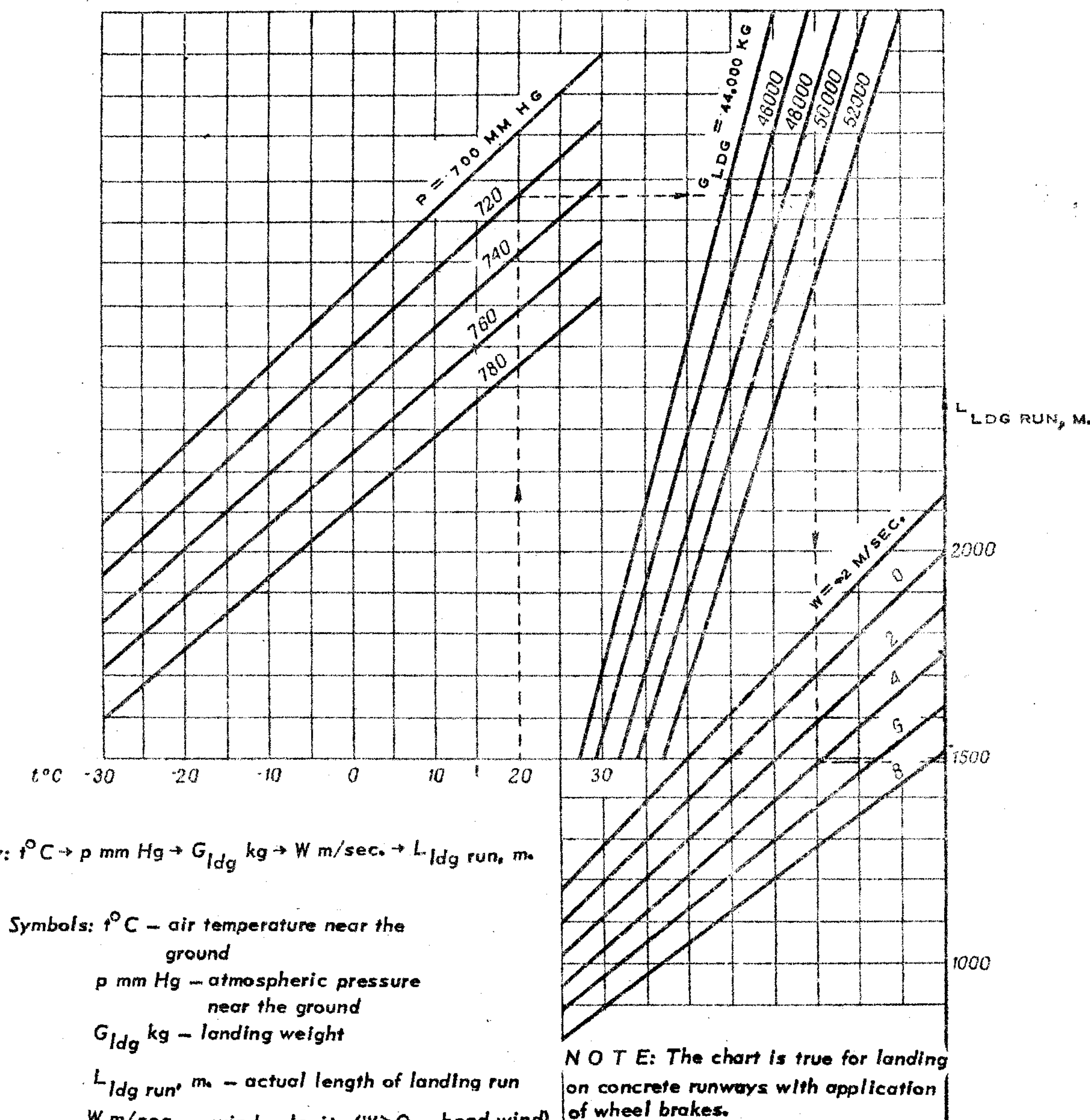



FIG. 8. AERODYNAMIC CORRECTIONS TO ВД-20 BAROMETRIC ALTIMETER READINGS VERSUS AIRSPEED AND ALTITUDE OF FLIGHT WITH FLAPS DEFLECTED TO LANDING POSITION AND UNDERCARRIAGE EXTENDED




*The key:* $t^{\circ}C \rightarrow p$ *mm Hg* $\rightarrow G_{ldg}$ *kg* $\rightarrow$ *W m/sec.* $\rightarrow L_{ldg\ run}$, *m.*

*Symbols:* $t^{\circ}C$ – *air temperature near the ground*

*p mm Hg – atmospheric pressure near the ground*

$G_{ldg}$ *kg – landing weight*

$L_{ldg\ run}$, *m. – actual length of landing run*

*W m/sec. – wind velocity (W>0 – head wind)*

FIG. 9. CHART FOR DETERMINING LANDING RUN LENGTH VERSUS WEATHER CONDITIONS AND AIRCRAFT GROSS WEIGHT WITH FLAPS EXTENDED BY 35°

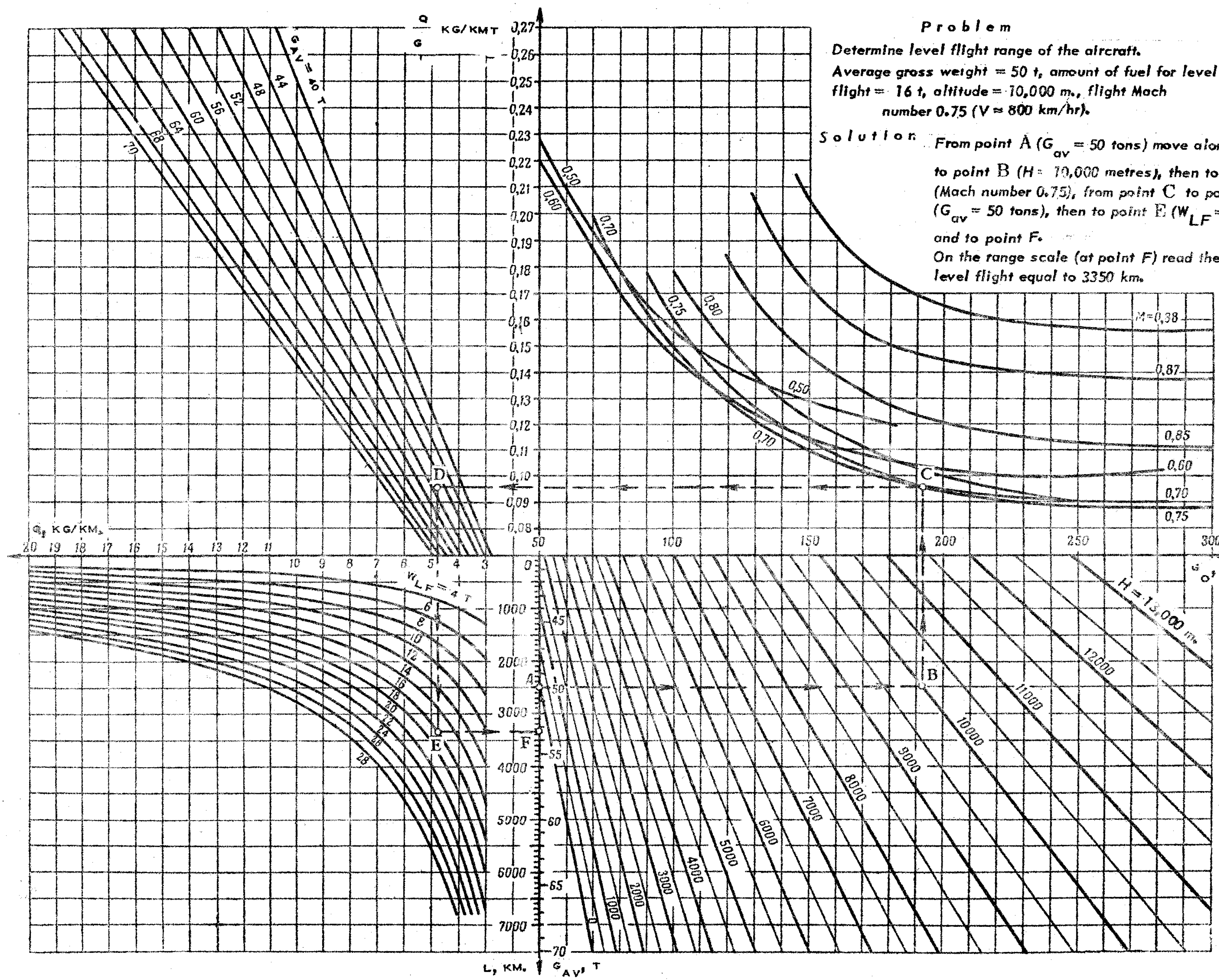



FIG. 10. NOMOGRAM FOR DETERMINING RANGE OF LEVEL FLIGHT FOR ТУ-16 AIRCRAFT

360 km/hr

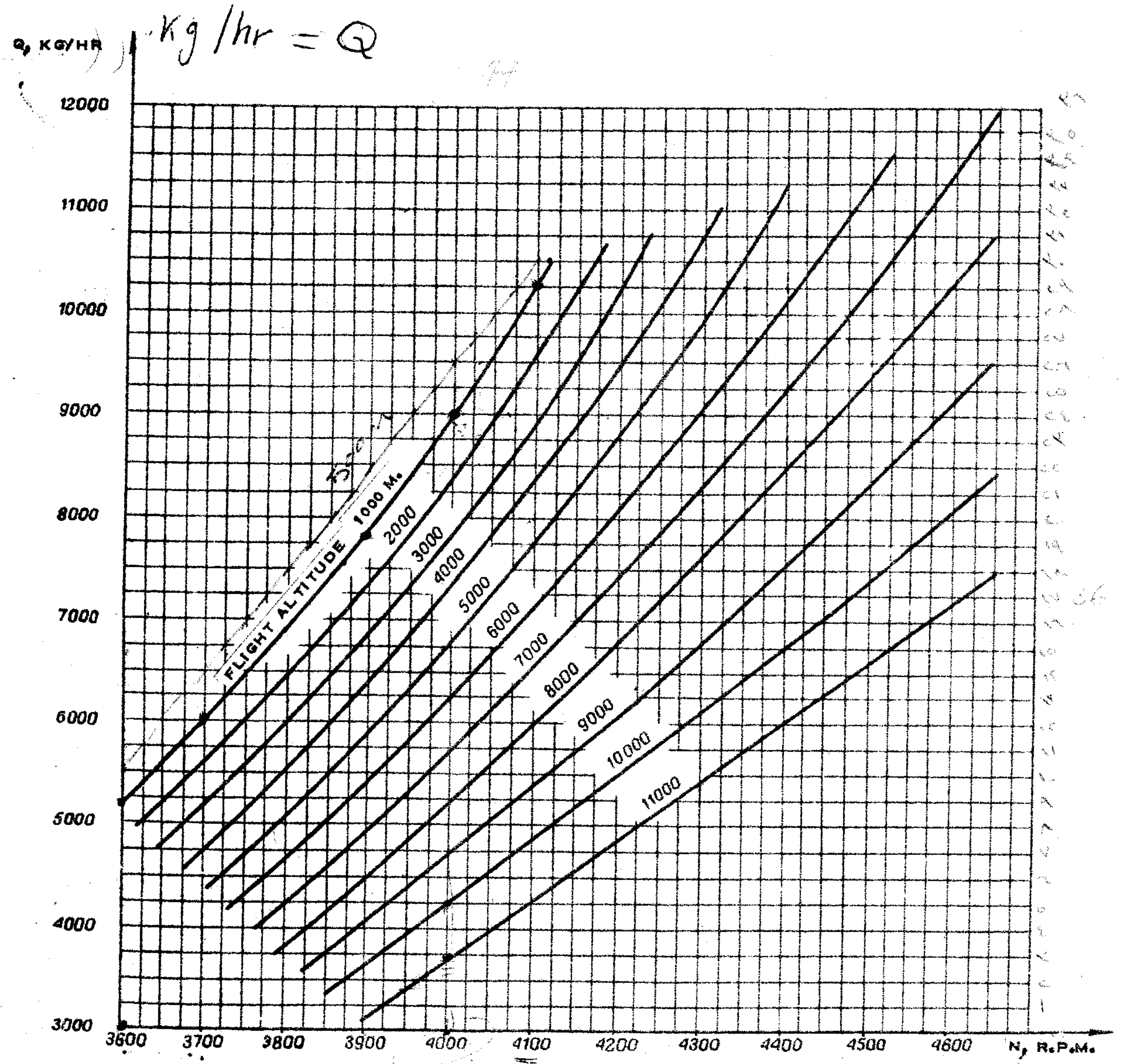



FIG. 11. CHART OF FUEL CONSUMPTION PER HOUR VERSUS ENGINE SPEED AT VARIOUS ALTITUDES

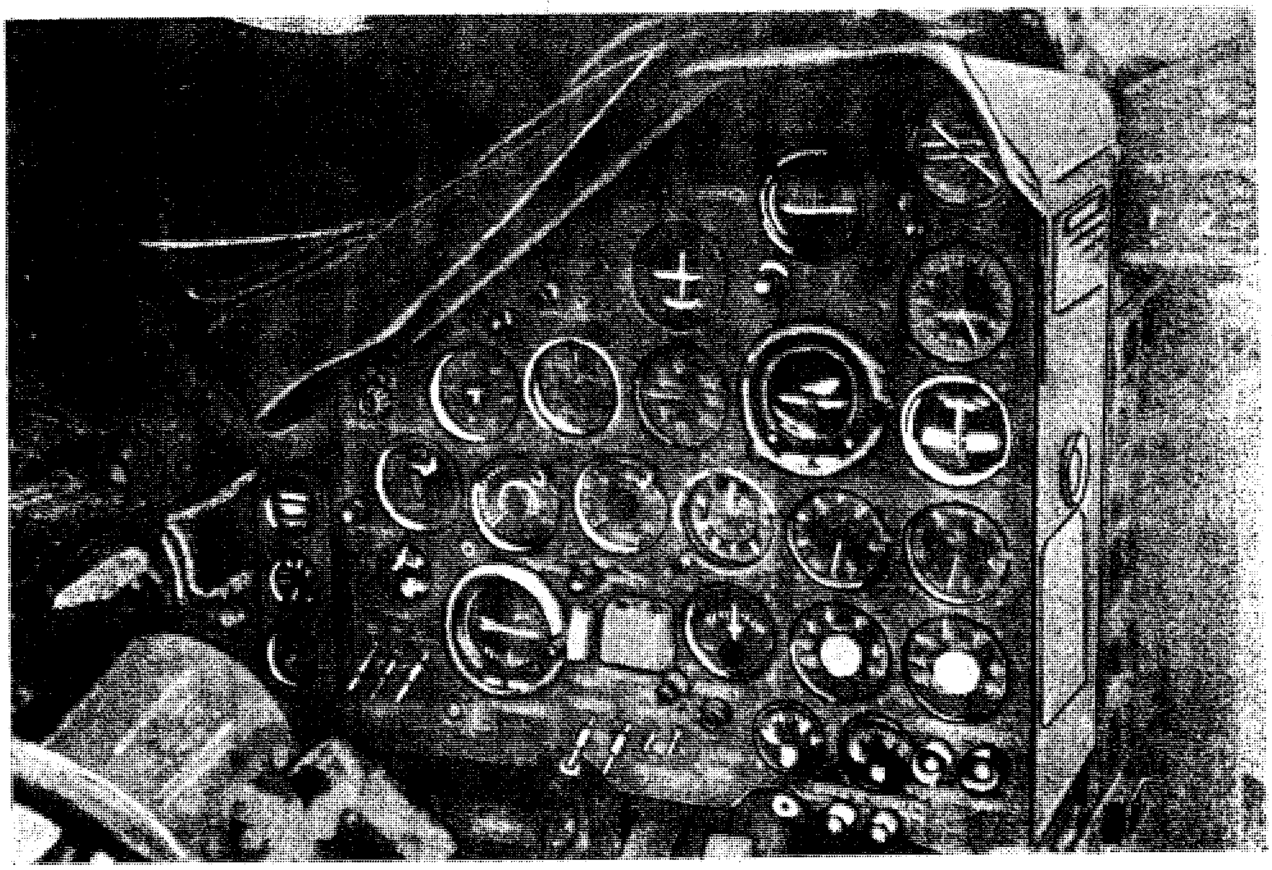


FIG. 12. AIRCRAFT COMMANDER'S INSTRUMENT PANEL

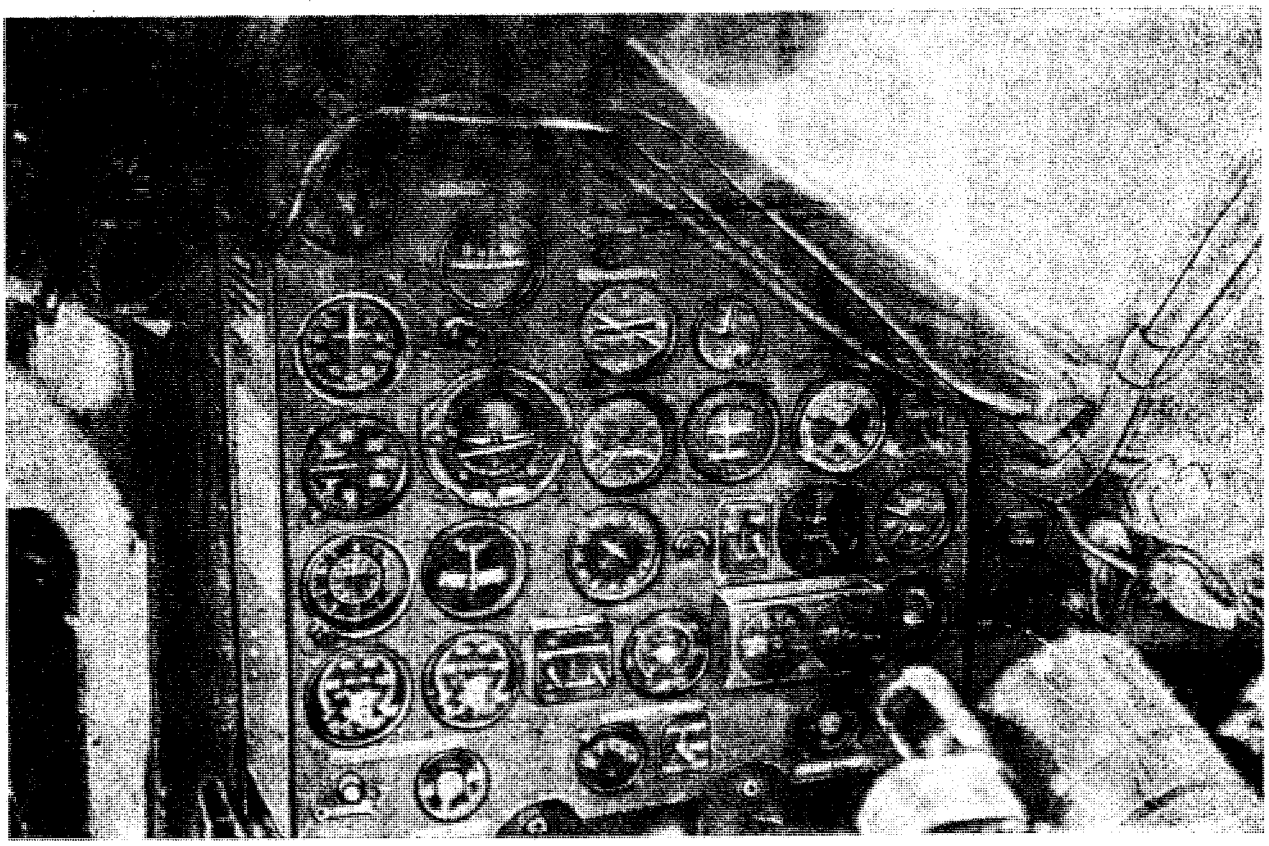


FIG. 13. CO-PILOT'S INSTRUMENT PANEL

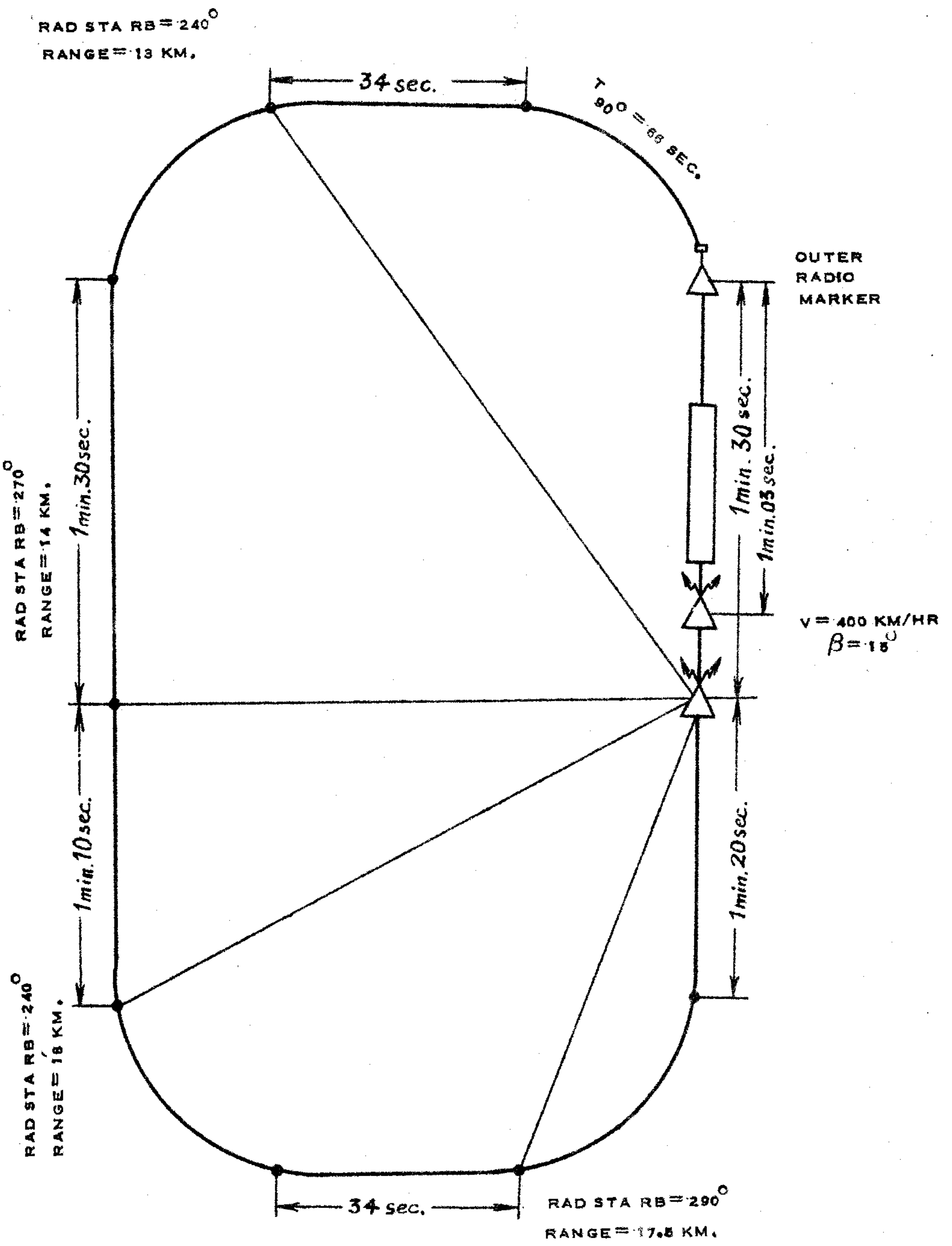



FIG. 14. DIAGRAM OF LANDING APPROACH BY RECTANGULAR LANDING PATTERN METHOD

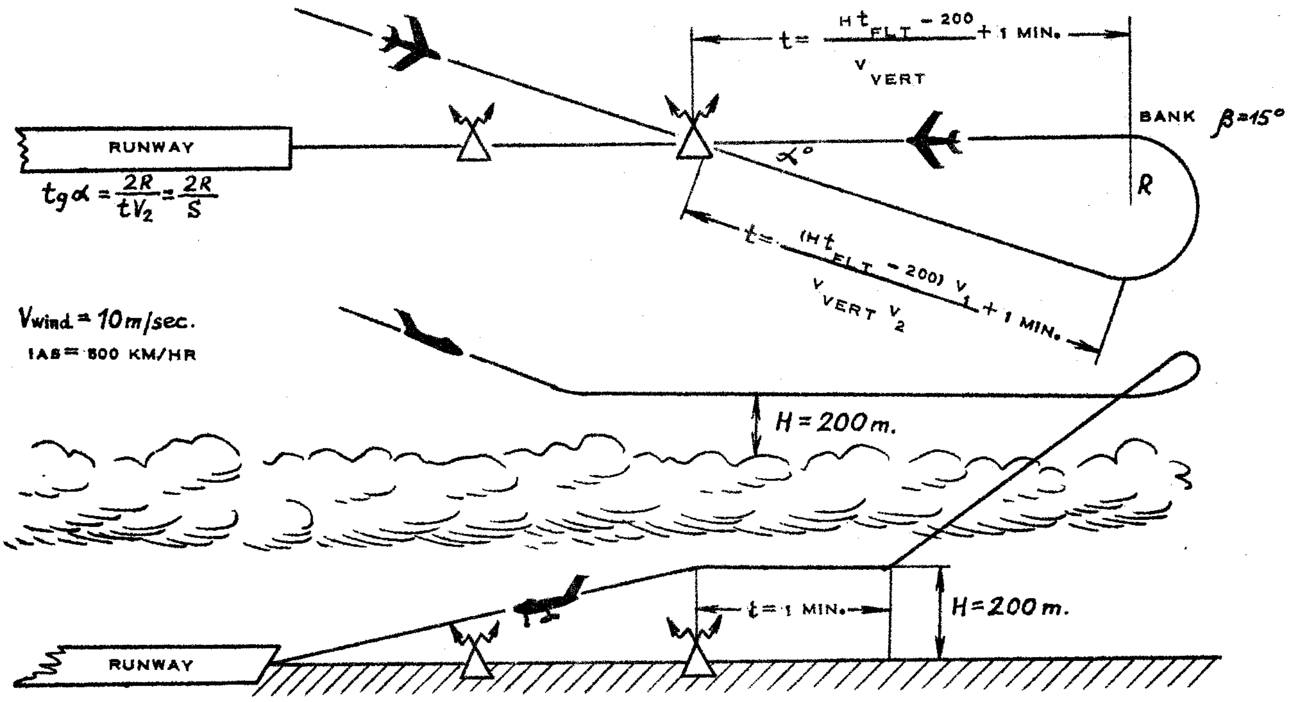



FIG. 15. DIAGRAM OF STRAIGHT-IN APPROACH USING RADIO AIDS

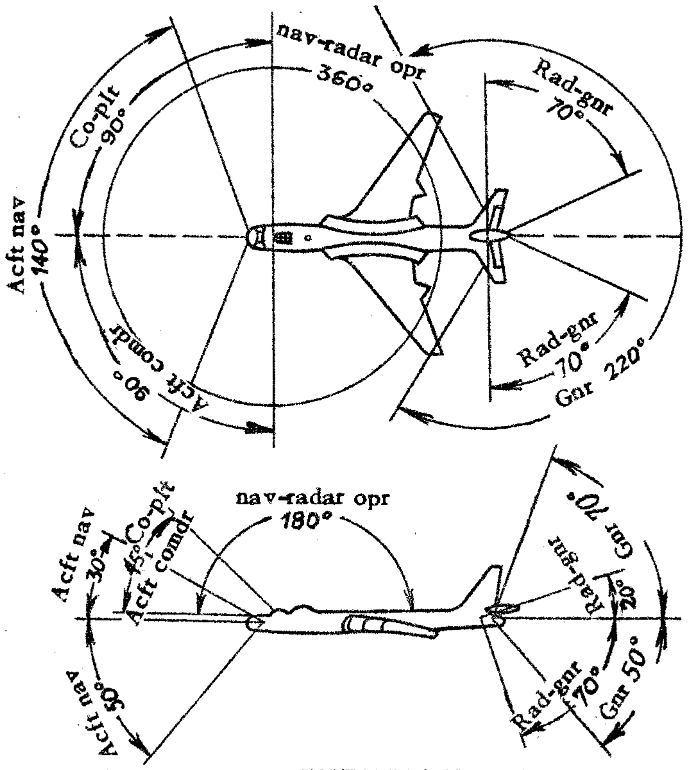
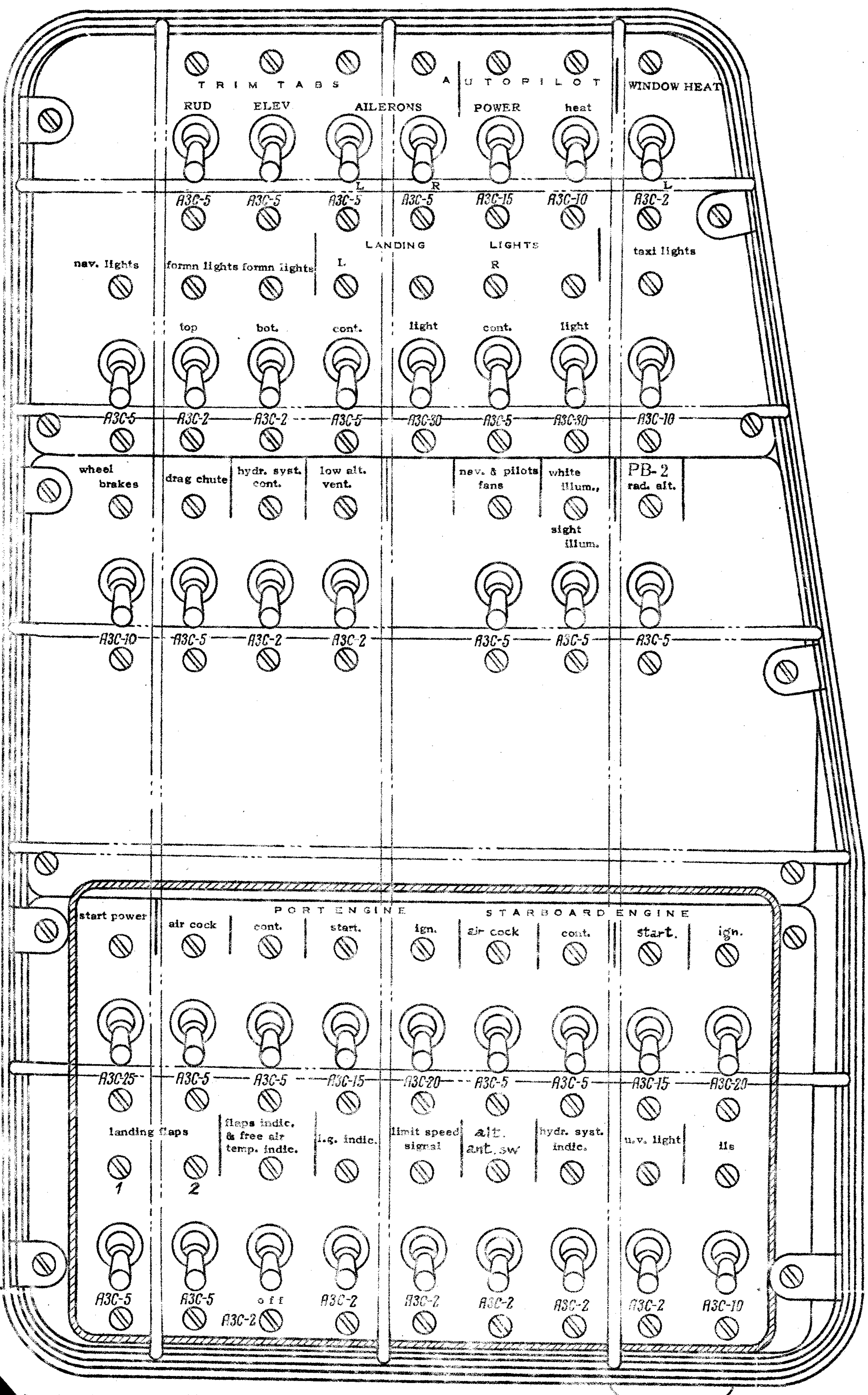



FIG. 16. DIAGRAM OF DISTRIBUTION OF SECTORS OF OBSERVATION BETWEEN CREW MEMBERS

acft comdr – aircraft commander; acft nav – aircraft navigator; co-plt - co-pilot; nav-radar opr - navigator-radar operator (or second navigator); rad-gnr - radio-gunner; gnr - gunner




*Russian abbreviation "A3C-5" stands ... "CIRCUIT-BREAKER FOR 5 AMPERES"*

FIG. 17. AIRCRAFT COMMANDER'S CIRCUIT BREAKERS PANEL

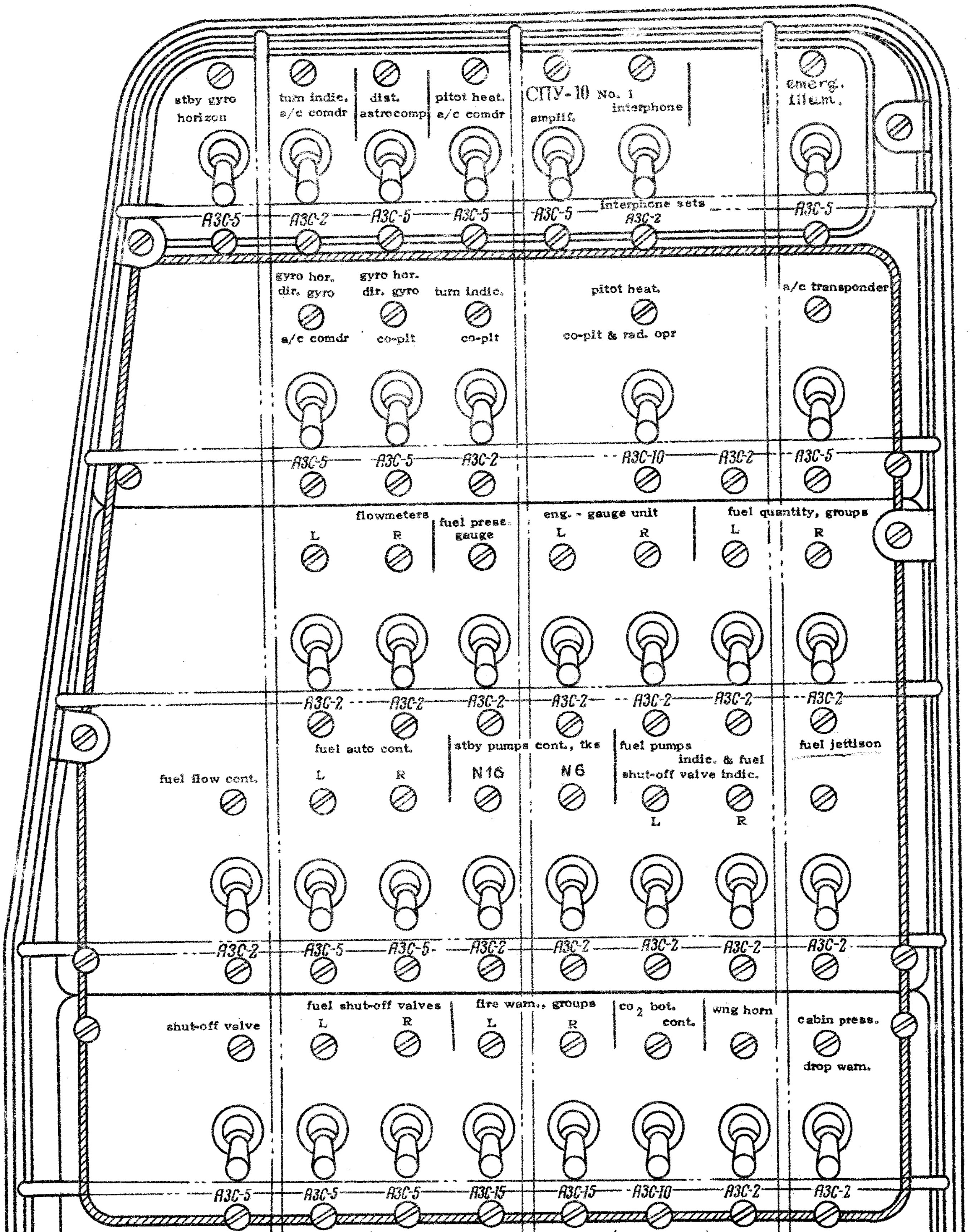



FIG. 18. CO-PILOT'S CIRCUIT BREAKERS PANEL

*Note: Russian abbreviation "АЗС-5" stands for "CIRCUIT-BREAKER FOR 5 AMPS"*

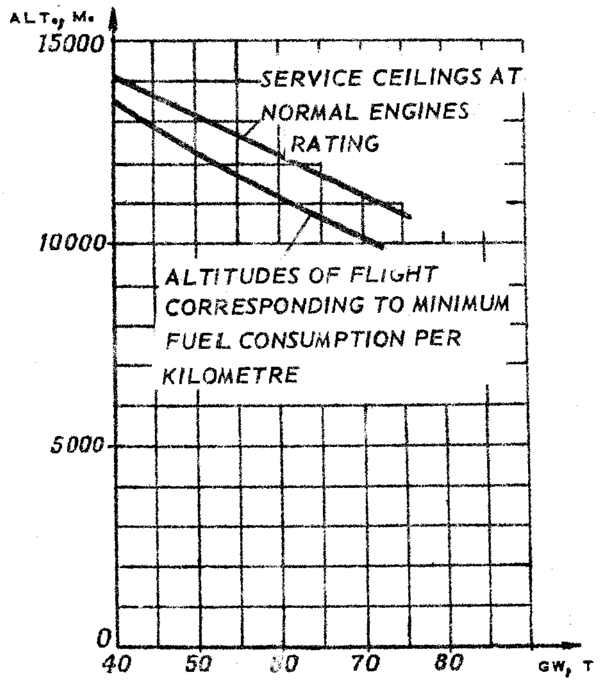



FIG. 19. CHART OF SERVICE CEILINGS AND OPTIMUM ALTITUDES DURING TY-16 AIRCRAFT FLIGHT FOR RANGE VERSUS AIRCRAFT GROSS WEIGHT (WITH TWO ENGINES OPERATING)



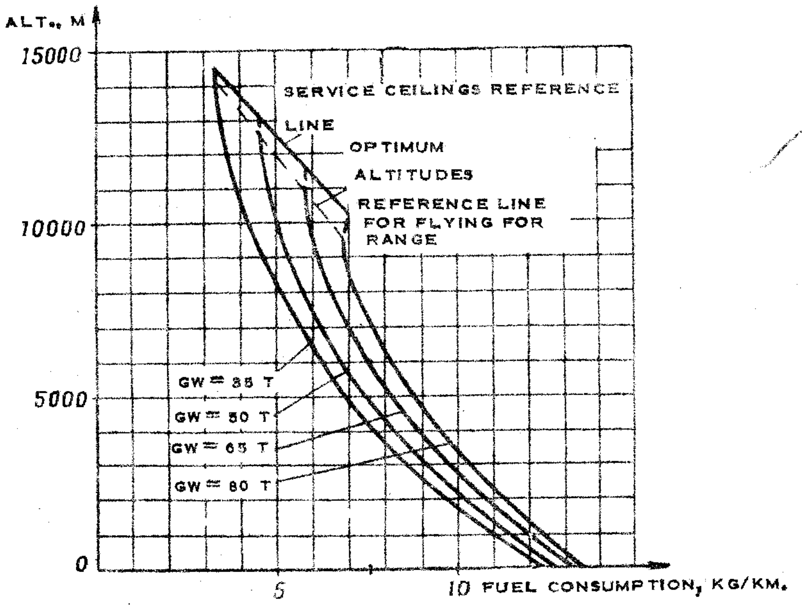



FIG. 20. CHART OF FUEL CONSUMPTION PER KILOMETRE FOR TY-16 AIRCRAFT LEVEL FLIGHT VERSUS ALTITUDE AND AIRCRAFT GROSS WEIGHT

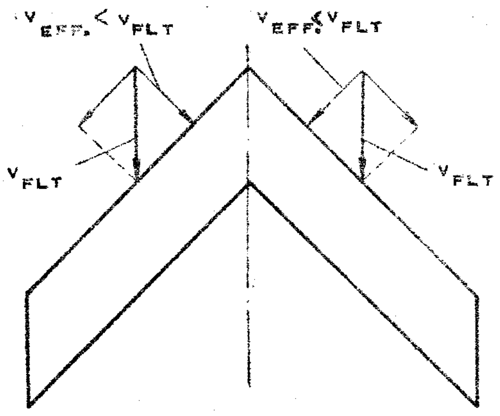



FIG. 21. SWEPTBACK WING PROFILE IN PLANE VIEW

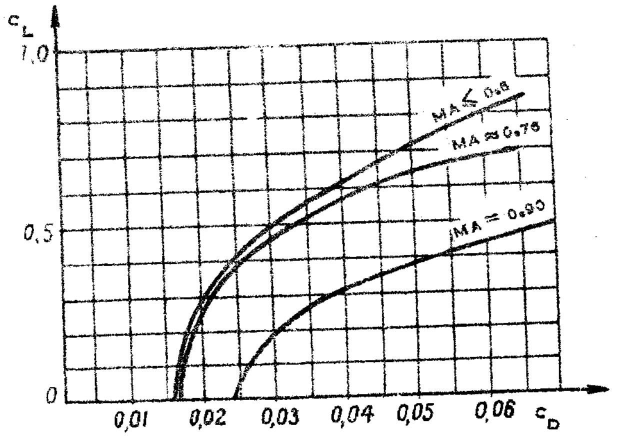



FIG. 22. CHART OF TY-16 AIRCRAFT DRAG POLAR CHANGE VERSUS THE SPEED OF FLIGHT

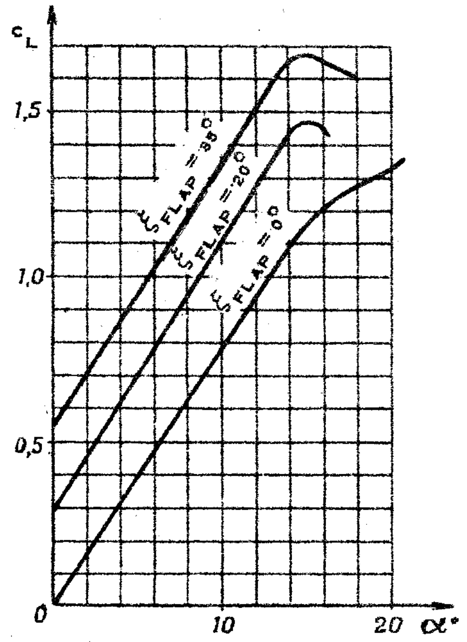



FIG. 23. CHART OF TY-16 AIRCRAFT WING LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AND FLAPS DEFLECTION ANGLE

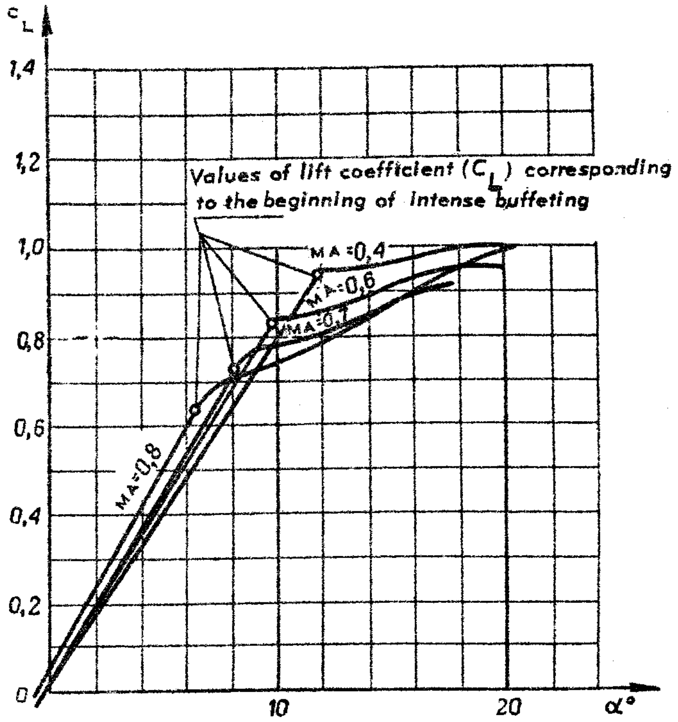



FIG. 24. CHART OF LIFT COEFFICIENT CHANGE VERSUS ANGLE OF ATTACK AND FLIGHT MACH NUMBER

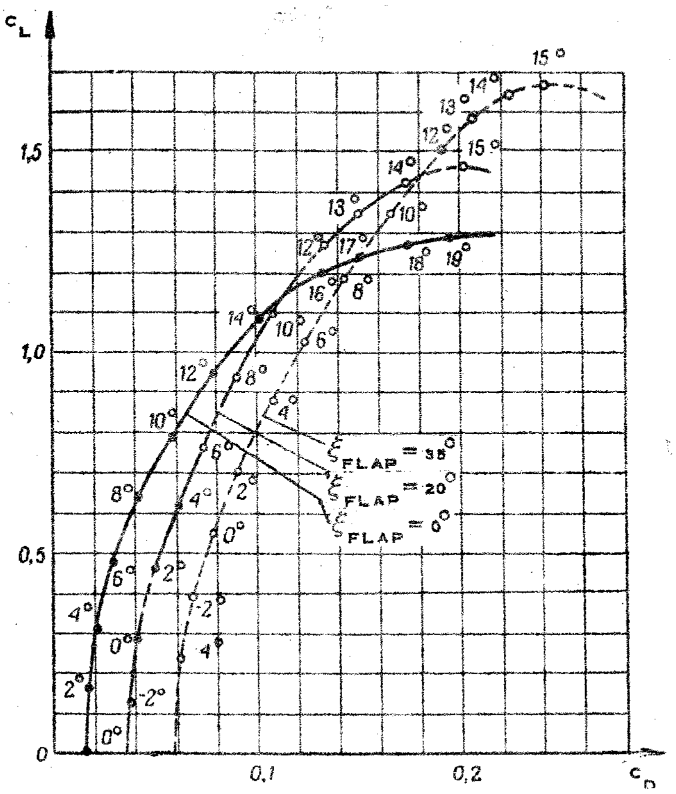



FIG. 25. TY-16 AIRCRAFT DRAG POLARS (L.G. UP)

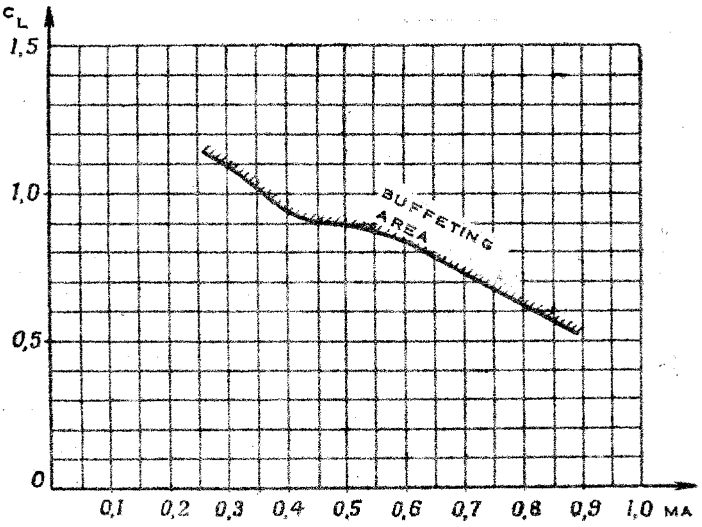



FIG. 26. CHART OF LIFT COEFFICIENT ($C_L$)

VALUES AT WHICH WING STALL OCCURS (VERSUS MACH NUMBER)

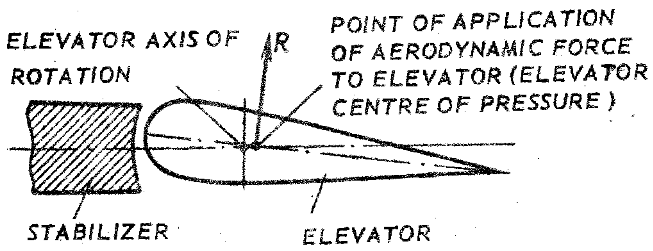



FIG. 27. HINGE MOMENT OF ELEVATOR

## CHARTS OF TY-16 AIRCRAFT FLIGHT CHARACTERISTICS

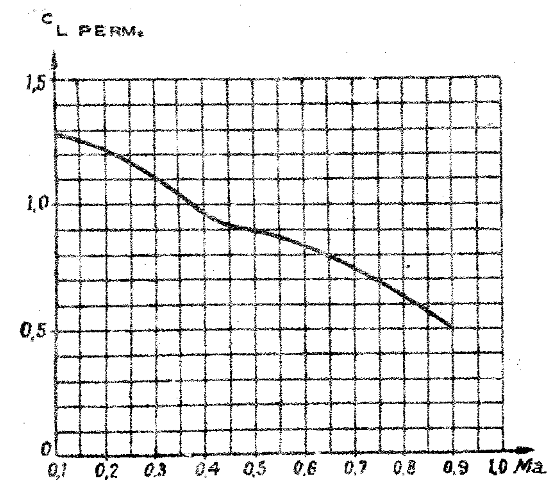



FIG. 30. CHART OF MAXIMUM PERMISSIBLE VALUES OF LIFT COEFFICIENT ($C_L$) VERSUS FLIGHT MACH NUMBER

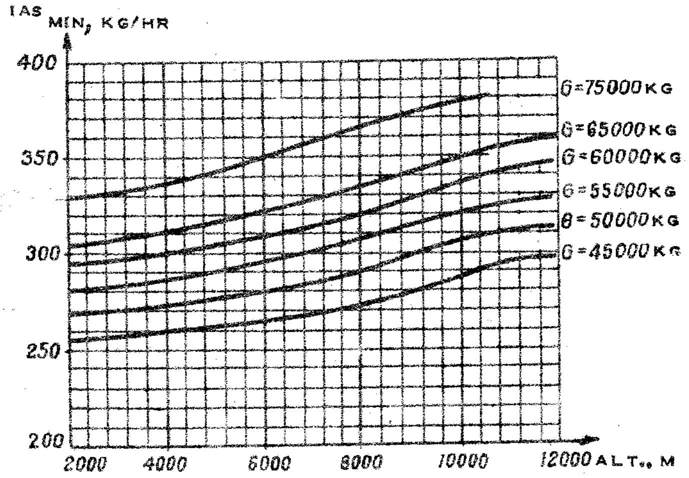



FIG. 31. CHART OF MINIMUM PERMISSIBLE SPEEDS OF FLIGHT FOR VARIOUS ALTITUDES AND AIRCRAFT GROSS WEIGHTS (L.G. AND FLAPS ARE RETRACTED)

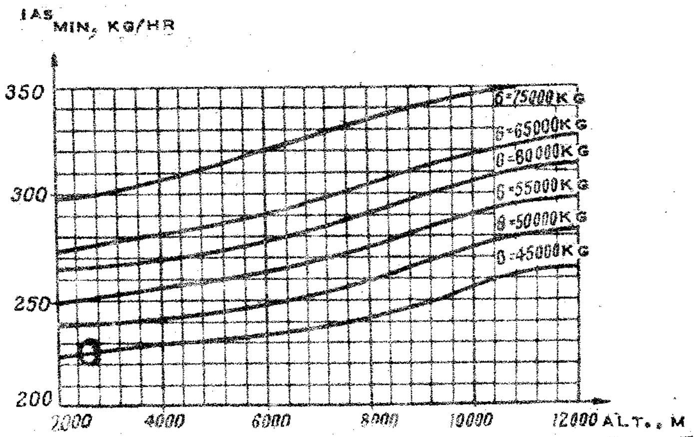



FIG. 32. CHART OF MINIMUM PERMISSIBLE SPEEDS OF FLIGHT PRECEDING WING STALL AND AIRCRAFT STALL

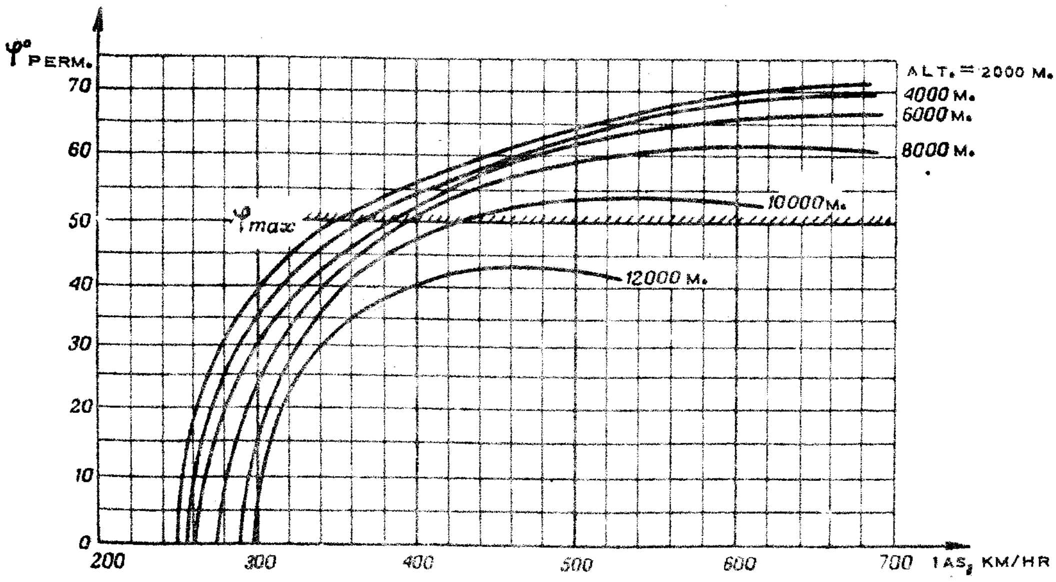



FIG. 39. CHART OF MAXIMUM PERMISSIBLE BANKS VERSUS ALTITUDE AND SPEED OF FLIGHT (FOR AIRCRAFT GROSS WEIGHT OF 55 TONS)

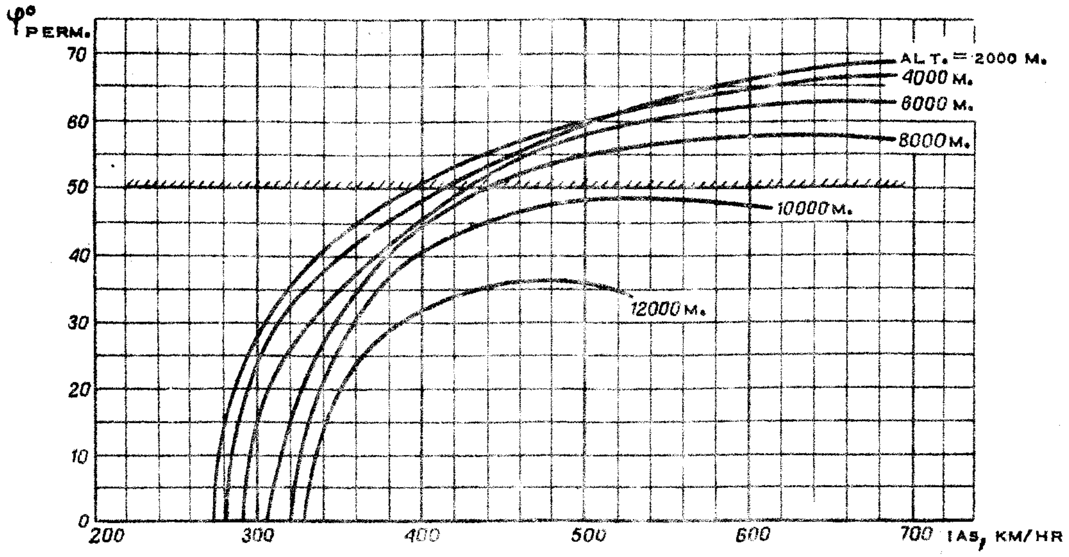



FIG. 40. CHART OF MAXIMUM PERMISSIBLE BANKS VERSUS ALTITUDE AND SPEED OF FLIGHT (FOR AIRCRAFT GROSS WEIGHT OF 65 TONS)

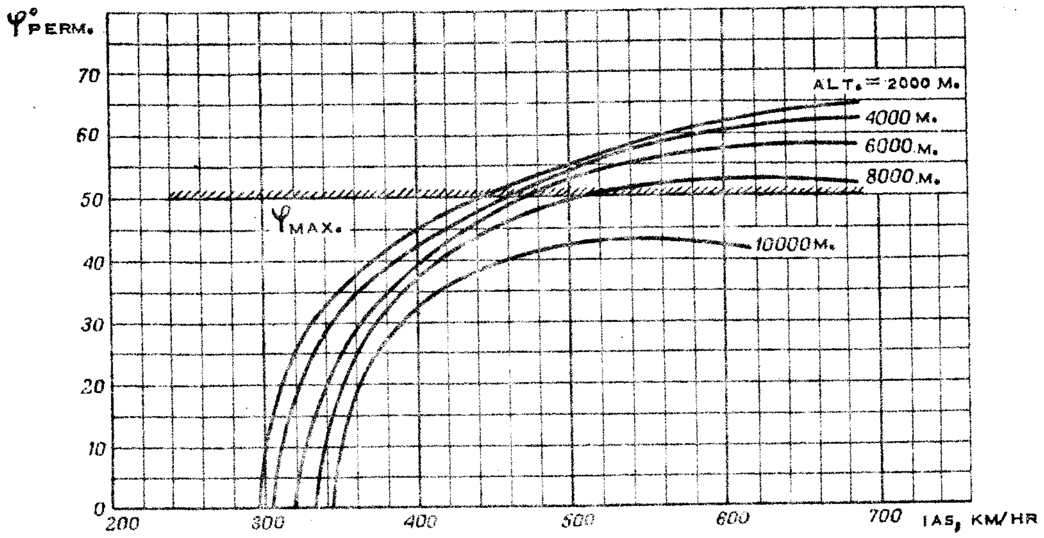



FIG. 41. CHART OF MAXIMUM PERMISSIBLE BANKS VERSUS ALTITUDE AND SPEED OF FLIGHT (FOR AIRCRAFT GROSS WEIGHT OF 75 TONS)