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INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

S-E-C-R-E-T

[redacted] 50X1-HUM

COUNTRY	USSR 1412794-8	REPORT	[redacted]
SUBJECT	Pilot's Flight Operating Instructions for Aircraft MIG-21FL	DATE DISTR.	January 1966
		NO. PAGES	[redacted]
		REFERENCES	
DATE OF INFO.	[redacted]		
PLACE & DATE ACQ			

[redacted]

1. One copy of a Soviet English-language manual, consisting of 190 pages, entitled Pilot's Flight Operating Instructions for Aircraft MIG-21FL [redacted] 50X1-HUM No publishing data are given. The book consists of four chapters, titled as follows: Pilot's Preparation for Flight, Operation of Aircraft on Ground and in the Air; Rectangular Circuit Flights, Advanced Flying and Combat Employment; Pilot's Actions in Emergency Cases; Description of Aircraft, its Systems and Equipment.

2. The electronic equipment of the MIG-21FL is listed as consisting of the RSIU-5g radio, ARK-10 radio compass, SRO transponder, RP-9-21 radar, and the MRP-56p receiver.

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STATE	DIA							
	NAVY/STIC	Army/FSTC	Air/FTD	SAC		NSA	NIC	OCR

(Note: Field distribution indicated by "#".)

50X1-HUM

PILOT'S FLIGHT OPERATING INSTRUCTIONS

FOR AIRCRAFT MIG-21FL

SECRET

PILOT'S FLIGHT OPERATING INSTRUCTIONS FOR AIRCRAFT

МиГ-21фи

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Section II

PILOT'S PREPARATION FOR FLIGHT AND OPERATION OF AIRCRAFT ON GROUND AND IN FLIGHT

PREPARATION FOR FLIGHT

1. Prior to a flight the aircraft technician (crew chief) will report to the pilot on the aircraft readiness for flight including: the pilot of amount and grade of fuel and oil filled in the tanks, amount of oxygen, air, alcohol; he will inform the pilot on rockets suspended and on all maintenance operations performed on the aircraft since the last flying day.

Aircraft Inspection

2. When inspecting the aircraft external check, check the following:

(a) condition of the airframe, landing gear and doors;

(b) the landing gear wheel tires for proper inflation; the shock struts for proper compression;

(c) the engine intake duct for absence of foreign objects and cracks in the skin.

(d) condition and position of the air intake cone (which should be retracted and secured; the cone position should be checked by reference to the notches on the rim and on the cone ring;), condition of the antishuffle flaps;

(e) the engine and aircraft for absence of oil, fluid and fuel leaks;

(f) all access hatches for proper closing;

(g) airspeed tubes MDU-7 and MI-155 to see that the plugs and the covers are removed; the static openings to see that they are free of clogging;

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(h) the drop tank for proper [illegible] fuel;

(i) the mission for proper and reliable [illegible]

(j) the landing gear chocks for proper and [illegible] by chocks.

Preparation of Parachute

3. Before placing the parachute into the [illegible] it and check to make sure that:

(a) parachute oxygen apparatus KM-27M is [illegible] oxygen as required and that the mechanism for [illegible] oxygen apparatus is locked with wire;

(b) time-release mechanism KAM-5 is not to operate [illegible] of 2 sec (setting of the apparatus to altitude [illegible] for the parachute opening at an altitude not lower [illegible] over the terrain relief);

(c) the flexible pin of the automatic time-release mechanism is locked with wire and that the rip cord is properly packed;

(d) the flexible hose of the automatic time-release mechanism is sound and securely attached to the flexible [illegible] parachute;

(e) the flexible hose of the automatic time-release mechanism is securely attached to the supporting pivot of the parachute pack cover flap;

(f) the automatic time-release mechanism cable is properly connected to the rip cord of the parachute and the rip cord pin is locked as required;

(g) the rubber shock absorber is connected to the parachute pack cover (for attachment of the upper block of the connector OPL-2).

This done, close the parachute flap and give a signal for the aircraft technician to place the parachute into the seat pan and connect it to the harness and to the oxygen system of the aircraft.

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Cockpit Inspection

4. Before entering the cockpit the pilot must make sure that:

(a) the ground lock pins used for the canopy catching cylinder rod, the two-arm rocker of the canopy jettisoning system are installed;

(b) the red notch on the engaging hook of the canopy rear locks coincides with the notch on the lock body and the locks are safetied;

(c) the ground safety devices have been installed both in the firing mechanisms of the ejection seat and stabilizing drogue and in the canopy autonomous jettisoning lever; the protective covers are placed on the ejection seat arm rests;

(d) the storage battery switch, all other switches and circuit breakers on the left-hand, front right-hand, and horizontal panels are OFF;

(e) all circuit breakers including circuit breakers BUSBAR No.3 (ШИНА No. 3) on the rear right-hand electrical switch panel are ON (circuit breaker EJECTION DROP (ВЫБРОС. СБРОС) should be switched on depending on the mission to be performed, while circuit breaker LAMPS, LANDING GEAR'S POSITION SIGN. (ФАРЫ, ВНЕШНЯЯ СИГНАЛИЗАЦИЯ ШАССИ)should be switched on before night flying).

(f) the oxygen supply valve of the engine ignition [illegible];

(g) the pilot's oxygen supply system valve is open;

(h) the selector switches on amplifier U-2 are set correctly; when flying with a pressurized helmet on, they should be placed to position FR. HELM. (ШМ) and HOT. (Г); when flying with an oxygen mask on, they should be placed to MASK (КМ) and THR. MICR. (Б);

(i) the handles on remote control panel [illegible] positions MIXTURE (СМЕСЬ) and NEUTRAL (Н). After the [illegible] is turned home to the right;

(j) the landing gear valve control handle [illegible] locked with the latch;

(k) the landing gear wheel crossguy [illegible] and locked;

(l) the integrating ampere-hour meter (type [illegible]) capacity of the storage batteries not less than [illegible] the engine is started from the ground power unit [illegible] less than 40 A-hr when it is started autonomously;

(m) the valve of automatic cabin-pressure [illegible] is set to ON (ВКЛ.) and locked;

(n) no foreign articles are present in the [illegible]

5. Check oxygen and air mask in the system [illegible] indications of the fuel flowmeter and make sure that:

(a) the oxygen pressure in the oxygen bottle [illegible] is within 9 - 10.5 kg/sq.cm;

(b) the oxygen pressure in the pilot's [illegible] is within 130-150 kg/sq.cm;

(c) the pressure in the main oxygen [illegible] within 110 - 130 kg/sq.cm;

(d) the fuel flowmeter pointer reads 2520 [illegible] flying without the drop tank or 3240 lit when [illegible] drop tank (starting from aircraft No. 76210501, [illegible] 3190 lit respectively).

6. Check that the aircraft oxygen bottles [illegible] prepared correctly and make certain that:

(a) the firing mechanism of the ejection [illegible] with explosive charge;

(b) safety harness automatic unlock mechanism [illegible] been cocked and set to the operating time of 3.5 [illegible] by its scale;

(c) the flexible pin of safety harness quick-[illegible] mechanism АД-5 is locked and the quick-lock of the [illegible] connected to the aircraft side;

(d) the snap hook of the zip cord is connect[illegible] on the lower block of common connector ОРК-5;

(e) the ejection seat is adjusted to fit the pilot's [illegible]

7. Check that the parachute is arranged properly on the seat pan and that all joints are connected correctly; make sure that:

(a) the bowden cable of the mechanism for releasing the parachute oxygen apparatus КП-24 is connected to the mask [illegible]

block of common connector OPK-2 and the h[illegible] of apparatus KП-27 is connected to pressure ratio con[illegible]oller PДЛ-3м;

(b) common connector OPK-2 is connec[illegible]ed properly (for checking pull greater handle of upper blo[illegible]);

(c) the rubber shock absorber is con[illegible]ected to the upper block of common connector OPK-2;

(d) the cord of parachute release [illegible] with KПП-3 is connected to the seat.

Pilot's Actions after Taking [illegible]s Seat in Cockpit

8. Check to make certain that the [illegible] is adjusted to fit your size and the pedals fit the length [illegible] your legs.

Put on the parachute harness, pass [illegible]e leg straps through the parachute main side loops and throug[illegible] the buckles of the waist restraint, after which fix them in [illegible] the master lock. Connect the shoulder strap of the pilot'[illegible] restraint harness. Check to see that the shoulder straps fit [illegible] your body tightly and that the central lock of the harness is [illegible]losed securely.

9. Connect the hoses of the pressu[illegible]zed helmet (or the mask) and of the pressure suit to pressu[illegible] ratio controller PДЛ-3м and to the upper block of common [illegible]onnector OPK-2. Connect the hose of the anti-G device [illegible] the outlet of pressure controller АД-5а. Connect the plug conne[illegible]tor of the pressurised helmet glass piece heater to the split [illegible]ock of the pressurised helmet (the head phone) cord. Using a [illegible] [illegible] the upper block of common connector OPK-2 [illegible] [illegible] half-loop of the parachute harness.

10. Secure pressure ratio controll[illegible] [illegible] chute harness lock. Check operation of [illegible]e oxygen [illegible] set (KKO) under excessive pressure and [illegible]thout [illegible] pressure. Check the harness reel and lo[illegible] mechanism [illegible] operation.

11. Command the aircraft technicia[illegible] to remov[illegible] [illegible]tive covers and all ground safety lock [illegible] from [illegible] ground safety lock pins should be remov[illegible] from [illegible] the ejection seat firing mechanism befo[illegible] the pil[illegible] [illegible] the cockpit).

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Check to see that the locks of the canopy [illegible] are closed (the red marks on the hooks of the [illegible] canopy lifting rods should not be seen). If the red marks on the hooks come out of the two-arm rocker fork of the canopy lifting rod, it will indicate that the canopy emergency lock got opened; this being the case, the aircraft is not allowed to take off for a mission unless the defect is eliminated.

12. Check the brake system for proper operation with the front wheel brake switched on and then off. The pressure as read by the two-pointer pressure gage for the brake [illegible] within 9 - 10 kg/sq.cm. When deflecting the pedals with the brake lever pressed, the pressure inside the [illegible] unbraked wheel should drop to zero.

13. Check the engine control lever (RUD) [illegible] for security of locking and for proper stop when placed in positions STOP (СТОП), IDLE RATING (МАЛЫЙ РАЗ), MAXIMUM (МАКСИМАЛЬНЫЙ), [illegible] AUGMENTED (МИНИМАЛЬНЫЙ ФОРСАЖ) and FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ).

CAUTION. It is forbidden to perform checks with the storage battery and aircraft breaker [illegible] (РАЗОДНЫЙ НАСОС) switched on.

14. The aileron booster switch should be [illegible] all times.

CAUTION. When no pressure exists in the hydraulic system it is forbidden to operate the aileron booster switch with the line energized to avoid binding of the slide valves of the booster control valves.

15. Give command to switch on the ground power source, 27 V D.C. and 115 V A.C., 400 c.p.s.

CAUTION. When checking the aircraft instruments and radio, use should be made of ground power source only.

Switch on the storage battery. While watching the aircraft voltmeter, make certain that the ground power source is connected to the aircraft mains (the voltmeter should read 28 - 29 V).

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16. Check to make sure that the lamps [illegible] ППО-2м and on light panels T-4 and T-10У [illegible] by pressing the respective check buttons in turn.

17. Set the altimeter pointers to zero and check the [illegible] metric pressure by reference to the scale (see that it corresponds to the pressure at the departure airfield). Check the aircraft clock for correct reading and prepare it for flight.

18. Check the position of the control switches of the cone and antisurge shutters:

(a) the mode of operation selector switch of the cone should be placed to position AUTOMATIC (АВТОМАТ), while the cone switch should be placed to OFF (ВЫКЛЮЧ.);

(b) the selector switch for control of the antisurge shutters should be placed to position SHUT. [illegible] (СТВОРКИ АВТОМ.).

Check the cone position indicator for [illegible] (with the cone control switched on, the [illegible] zero).

19. Check to make sure that [illegible] for operation:

(a) the mode of operation selector [illegible] position AUTOMATIC (АВТОМАТ) and locked;

(b) the manual control switch should [illegible]

(c) the pointer of the АРУ-3в control [illegible] be in the extreme left-hand position;

(d) light STABILIZER FOR LANDING ([illegible]) on light panel T-4 should be burning.

20. Check operation of gyro horizon [illegible] gyro horizon ДА-200 (200). To this end, do the following:

(a) switch on circuit breaker АГИ, ДА-200 (200);

(b) make sure that the indicating light on gyro [illegible] АГИ-1 is burning and switch on circuit breaker АГИ;

(c) make sure that the cage indicating light [illegible] horizon indicator АГИ-1 goes out in not more than [illegible] switching on the instrument;

(d) after the indicating light has gone out, [illegible] that the gyro horizon indicates the [illegible] properly;

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(c) In 1 - 1.5 min the gyro horizon [illegible] aircraft ground angle with no bank or pitch.

(d) Check operation of the turn indicator [illegible] horizon AA-300 (200); to this end, slightly [illegible] the instrument board (on the right or left). The pointer of the turn indicator should [illegible] right or to the left.

22. Check operation of directional [illegible]

(a) After the cage indicating light [illegible] indicator AVU-1 has gone out, switch on [illegible]

(b) 2 - 3 min after switching on the [illegible] fighter directional system KUR according to the [illegible] To this end, press button SBROSKA KUR (FOR [illegible] hold it pressed until the indicating [illegible] done, compare the indications of the [illegible] aircraft course when parked.

Checking Operation of Radio Equipment

23. Check operation of the communication [illegible] for which purpose:

(a) switch on [illegible]

(b) set the selector [illegible] panel to RADIO (RADIO);

(c) wait for 1 - [illegible] communication channel;

(d) press the transmitter switch [illegible] monitoring, call the ground radio station [illegible] required volume by turning the volume control;

(e) check operation of the radio station [illegible] suppressor being on and then off;

(f) after consulting the ground radio station, check operation of the aircraft radio set on the [illegible] if they are to be used;

(g) after checking the operation of the radio set, [illegible] switch on the required channel.

NOTE: 1. The radio station should be checked under the conditions of maximum and the reduced power.

2. Maximum range of radio communication can be

(k) set selector switch OUTER - INNER (НАР - ВНУТ - ВНЕШНИЙ) to OUTER (НАРУЖНЯЯ) and make sure that the radio compass has tuned to the outer beacon;

(l) with the aid of selector switch ROUT [illegible] check the loop (the pointer of indicator UKS-2) for rotation to the right and to the left.

If required, check operation of the automatic radio compass on other fixed channels (buttons).

24. Check operation of automatic switch [illegible] purpose proceed as follows:

(a) switch on circuit breaker MPN;

(b) set radio compass mode of operation [illegible] to LOOP (РАМКА);

(c) by operating selector switch ROUT [illegible] set the loop (by reference to indicator UKS-2) [illegible] $0 \pm 20^{\circ}$ as read from the outer beacon bearing;

(d) command the technician to switch on the marker beacon simulator; after switching on, the marker radio set should operate (this is checked by indicating light МАРКЕР (МАРКЕР) on light panel T-4 and audio signal heard in the head phones); then the automatic radio compass should automatically change over to INNER (ВНУТРЕННЯЯ) which will be indicated by flashing up of light АРК - ВНУТ (АРК - ВНУТ). Make sure that the radio compass has changed over to the inner beacon by listening to its call signs; see to it that all knobs and switches are in the proper positions;

(e) turn the loop of the automatic radio compass (through $40 - 150^{\circ}$ or $320 - 210^{\circ}$) by means of selector switch ROUT (РАМКА I - II) till light АРК - ВНУТ (АРК - ВНУТ) goes out; make certain that automatic radio compass has tuned to the inner beacon frequency.

Having made sure that automatic switch PAK operates properly, set the mode of operation selector switch to PU (КОМПАС), the selector switch on control panel [illegible] communication set PONY to RADIO (РАДИО); see to it that the required channel (button) on the control panel [illegible] the radio compass is set properly.

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25. Check operation of ...

proceed as follows:

(a) set the required code;

(b) switch on circuit breaker ...

ПЕРЕМЕННОГО ТОКА);

(c) switch on selector switch ...

should be checked by flashing-up of light ...

When receiving response to the interrogation ...

RESPONSE INDICATOR (ИНДИКАТОР ОТВЕТА) ...

Note. When ground A.C. power supply ... connected, responder СРО is energized by ... ПО-750а. In this case radio set СРО ... operate under the conditions of ...

26. Having made sure that the radio ... properly, switch it off; switch ... starting the aircraft engine.

PREPARATION OF OXYGEN EQUIPMENT ... PRESSURIZED CABIN

Checking Oxygen Equipment ...

27. Make certain that the hoses of the ... the pressurized helmet (or the oxygen mask) ... nected to the pressure ratio controller ... block of common connector (ОРК-2); check ... wheel and the handles on remote control ... the proper position. Be sure that the ... clockwise, the oxygen emergency supply ... tion NEUTRAL (Н) and the air ... (СМЕСЬ).

CAUTION. When flying without a ... emergency supply handle should ... AUTOMATIC CUT-OFF (ВЫКЛ.АВТ.)

28. Check the heater of the pressurized ... for sound condition. To this end, connect the heater plug ... connector, switch on the storage battery ... knob HELMET HEATER (ОБОГРЕВ ШЛЕМОФОНА) ...

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some 2 - 3 min breath on the helmet glass and make sure that it is not dimmed. When the check is over, set the index of the rheostat knob in accordance with the assigned temperature in the cockpit.

29. Check operation of the oxygen equipment under excessive pressure conditions. To this end, proceed as follows:

(a) put on the face-piece of the pressurized helmet (the mask);

(b) change over the oxygen emergency supply valve from position NEUTRAL (N) to position PRESSURE SUIT ON (KRASNYM KOSTYUMA);

(c) close the holes in pressure valve-cranks on both sides with the fingers;

(d) build up pressure in the helmet or the mask to 2000 or 1000 mm of water accordingly by rotating the flywheel counterclockwise; check pressure increase by readings of the pressure gauge M-2000;

(e) make two or three inhalations and exhalations.

If with the increase of pressure in the pressurized helmet (mask) there also increases tightening of the suit and the pointer of pressure gauge M-2000 deflects to the left during inhalation (by some 100 - 120 mm of water) and returns to the initial position during exhalation, the set is considered to operate properly.

30. The check over, turn the flywheel clockwise as far as it will go, take away your fingers from the holes of the pressure ratio controller PDK-3M, set the oxygen emergency supply handle to NEUTRAL (N).

CAUTION: 1. When it is impossible to build up the required pressure in the pressurized helmet (up to 2000 mm of water) or in the mask (up to 1000 mm of water) with the handwheel turned out completely it is indicative of the failure of the aircraft oxygen equipment. This being the case, flying is forbidden.

2. It is strictly forbidden to build up excessive pressure in the pressurized helmet or mask when the pilot is not wearing pressure suit, for this may cause injury to the pilot.

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33. Check operation of the set without [illegible]
sive pressure. To this end, do the following:

(a) set the air suction handle on [illegible]
ДУ-2 to position 100% O_2;

(b) make two or three inhalations and [illegible]
segments of indicator ИК-13 will successively go [illegible]
together, it will be considered that the [illegible] operation [illegible]

(c) set the air suction handle to [illegible] (СМЕСЬ).

Operation of Oxygen Equipment for [illegible]

34. Put on the face-piece of the pressurized helmet
oxygen mask before starting landing when the [illegible]

When in flight, keep checking the oxygen supply by
to the pressure gauge of indicator ИК-13 [illegible]
operation of oxygen apparatus КИ-24 by variometer; the [illegible]
indicator ИК-13. Check periodically cabin altitude by [illegible]
to cabin altitude and pressure differential gauge [illegible]

If oxygen pressure as read by the pressure gauge [illegible]
30 kg/sq.cm, it is necessary to descend to a safe altitude
(4000 m).

35. Should it become difficult for you to breathe because
of poor oxygen supply or should you be [illegible],
switch on the oxygen emergency supply line by placing the
oxygen emergency supply handle on panel [illegible] to position
ON (ВКЛЮЧЕНИЕ КОСТЮМА). This done, the suit [illegible]
tubes will get inflated and oxygen will be supplied [illegible]
pressurized helmet or the mask continuously.

When flying in a zone where suction [illegible]
move the air suction handle on panel ДУ-2 [illegible]
МИХТУРЬ (СМЕСЬ) to position 100% O_2.

36. Should the glass of the pressurized helmet [illegible]
become dimmed, turn the heater rheostat knob [illegible]
as it will go. When the glass becomes [illegible]
index of the rheostat knob as required [illegible]
the scale and somewhat to the right [illegible]
position.

In case of failure of the rheostat for heating the pressurised helmet face-piece (if dimming persists), ascend to a safe altitude (4000 m) while periodically pressing button FAST HEATING OF PRES. HELMET (БЫСТРЫЙ ОБОГРЕВ ГЕРМ[illegible]ШЛЕМА) for 1 - 2 min. When at an altitude of 4000 m, take off the pressurised helmet face-piece and secure it to a permanent [illegible] look provided for the purpose.

Operation of Pressurised Cabin

35. Irrespective of altitude, flying in the aircraft should be performed in the pressurised cabin with the supercharger on and with cabin heater selector switch set to AUTOMATIC (АВТОМАТ).

The cabin should be pressurised on the ground before taxiing by placing the pressurisation valve handle to the extreme front position; the cabin is supercharged by moving the cabin supply valve lever to the extreme front position.

36. Used in all the flights should be oxygen pulmonary and parachute oxygen apparatus.

When flying up to an altitude of 10,000 m at an indicated airspeed not exceeding 750 km/hr, it is allowed to wear oxygen mask without a pressure suit and a pressurised helmet; however, in this case wearing of a crash helmet is obligatory. When accomplishing a combat mission or performing aerobatics, one should be made of an anti-G suit. When wearing an anti-G suit, the hose for supplying oxygen into the suit (the [illegible] pressure ratio controller РСД-3м) should be plugged.

37. When flying at altitudes up to 15,000 m at indicated airspeeds up to 750 km/hr, it is allowed to use an oxygen mask and a crash helmet with obligatory use of a pressure suit. Flying at altitudes exceeding 15,000 m or at airspeeds exceeding 750 km/hr (in the latter case irrespective of flying altitude) as well as flying for a combat mission require obligatory usage of a pressure suit and a pressurised helmet.

CAUTIONS: 1. Prior to a flight with the use of pressure suit МК-1м or pressure suit МБК-3м the handle of pressure controller АД-5м should be set to МАКСИМУМ (MAXIMUM) and locked.

In case of failure of the oxygenat for boosting the pressurized helmet face-piece (if diving penalty), descend to safe altitude (4000 m) while periodically pressing button FAST HEATING OF PRES. HELMET (БЫСТРЫЙ ОБОГРЕВ К[illegible]). 1 - 2 min. When at an altitude of 4000 m, take off the pressurized helmet face-piece and secure it to a provided for the purpose.

Operation of Pressurized Cabin

35. Irrespective of altitude, flying in the [illegible] be performed in the pressurized cabin with the [illegible] and with cabin heater selector switch set to AIR [illegible]

The cabin should be pressurized on the ground by placing the pressurization valve handle in the front position; the cabin is unpressurized by moving the supply valve lever to the extreme front position.

36. Used in all the flights should be oxygen [illegible] and parachute oxygen apparatus.

When flying up to an altitude of 30,000 m at airspeed not exceeding 750 km/hr, it is allowed to use mask without a pressure suit and a pressurized helmet; in this case wearing of a crash helmet is obligatory. When accomplishing a combat mission or performing aerobatics, one should be made of an anti-G suit. When wearing an anti-G suit the hose for supplying oxygen into the suit (the pressure ratio controller РСД-3м) should be plugged.

37. When flying at altitudes up to 15,000 m at airspeeds up to 750 km/hr, it is allowed to use oxygen and a crash helmet with obligatory use of a pressure suit. Flying at altitudes exceeding 35,000 m or at airspeeds exceeding 750 km/hr (in the latter case irrespective of flying altitude) as well as flying for a combat mission require obligatory usage of a pressure suit and a pressurized helmet.

CAUTIONS: 1. Prior to a flight with the use of anti-G suit (МК-4м or pressure suit ВКК-3м the [illegible] pressure controller АД-5м should be set to [illegible] (МИНИМУМ) and locked.

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2. Refer to a flight with the use of pressure suit: BK-4 the head of pressure cont[illegible] is set to MAXIMUM (МАКСИМУМ) and lea[illegible].

38. If the cockpit canopy glass gets dir[illegible] is necessary to place the cockpit air temperature controller switch to HOT (ГОРЯЧО). Should clouding persist, increase the engine r.p.m.

39. The cockpit air temperature is cont[illegible] cally. If the temperature controller fails, it is necessary to press the selector switch for cockpit heating to place it in the COLD (ХОЛОДНО) or HOT (ГОРЯЧО) position in order to obtain the required temperature in the cockpit.

40. Depending on a flying altitude the cabin pressure is maintained automatically by cabin-pressure regulator АРК-5Ж.

Control of cabin pressure is performed [illegible] cabin altitude and pressure differential gauge УВИД-20. If cabin supercharge system operates properly, excessive pressure in the cockpit starts increasing from an altitude of 2000 m reaching its maximum value equal to 0.3 kg/sq.cm at an altitude of 5000 - 10,000 m. A further increase of the altitude will not change the maximum value, the latter remaining constant.

Depressurization of the cockpit should [illegible] ground after taxiing to the parking site.

AIRCRAFT TOWING, ENGINE STARTING AND TESTING AIRCRAFT SYSTEMS

Aircraft Towing

41. Towing the aircraft about the airfield [illegible] only with the aircraft cockpit canopy closed.

The towing speed should not exceed 15 - [illegible] of a concrete airfield, 10 km/hr in case of [illegible] and 5 km/hr when towing close to obstacles. [illegible] is being towed, the pilot or technician should be in the cockpit and be ready to apply the brakes [illegible]. When towing takes place at night, be sure to switch on navigation lights.

Preparation for Engine Starting

42. As a rule, whon starting aircraft engine[illegible] be made of a ground power source. In case of [illegible] the aircraft storage batteries. Before starting th[illegible] sure that the aircraft wheels are chocked, the [illegible] extinguishing means are on hand and no obstacles o[illegible] articles are present in front of the aircraft and [illegible] of it. See that protective gauzes are installed on the [illegible] of the take-off shutters and the engine tent nitro[illegible] the engine intake is free of any articles.

43. Before starting the engine make sure that [illegible] STORAGE BATTERY (АККУМУЛЯТОР) and D.C. GENERATOR ([illegible] ПОСТОЯННОГО ТОКА) as well as the following aircraft [illegible] breakers: АГК, ДА-300 (200), RADIO (РАДИО) (be sure the radio [illegible] on the fuel flowmeter and the oil pressure gauge), [illegible] PUMP (РАСХОДНЫЙ НАСОС), STARTING UNITS (АГРЕГАТЫ З[illegible] ЗАПУСКА), CONE AND SHUTTER CONTROL (УПРАВЛЕНИЕ КОНУСОМ И СЕ[illegible] ЗАСЛОНКИ), AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ), FIRE EQUIPM[illegible] ПОЖАРНОЕ ОБОРУДОВАНИЕ, ПЕРЕКРЫВНОЙ КРАН) are [illegible].

Note. To ensure autonomous starting of the engine do not switch on the consumers which are not [illegible] starting.

CAUTION. It is forbidden to perform shocking [illegible] IN-FLIGHT ENGINE START (ЗАПУСК В ВОЗДУХЕ) [illegible] engine dead, for with no air flow through the engine the parts of the combustion chamber and of [illegible] may get burnt out due to oxygen being supplied.

Engine Start from Ground Power Source

44. Give command CLEAR OUT ENGINE (ОТ ДВИГАТЕЛЯ) to the technician and then after receiving his answer ENGINE CLEARED OFF (ВОТЪ ОТ ДВИГАТЕЛЯ) start the engine. To this end, proceed as follows:

(a) move the engine control lever on the [illegible] (МАЛЫЙ ГАЗ);

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(b) press button GROUND START (НАЗЕМНЫЙ ЗАПУСК) and hold it pressed for 2 - 3 secs; this should result in flashing-up of indicating light SWITCH OFF IGNITION (ЗАПУСТИТЕ ДВИГАТЕЛЬ) on light panel T-10y.

The engine should automatically start accelerating rotor r.p.m. equal to 29.5% within 50 sec.

45. During engine start the exhaust gas temperature should not exceed 700°C.

46. As soon as the engine speed reaches 14 - 15 % of high-pressure rotor r.p.m., the pointer of the oil pressure gauge should indicate building-up of pressure; after r.p.m. value has reached 25 - 30 % the pressure in the hydraulic systems should become equal to 210^{+5}_{-10} kg/sq.cm.

47. Indicating light SWITCH OFF IGNITION (ЗАПУСТИТЕ ДВИГАТЕЛЬ) will go out after reaching the engine speed equal to 46 - 50 % of high-pressure rotor r.p.m.

CAUTIONS: 1. When starting the engine, do not place the engine control lever to a position that will be forward of the idle rating stop, for the sake of engine surge.

2. When the engine fails to start or the gas temperature exceeds permissible limits, or when the oil pressure gauge indicates no pressure after the high-pressure rotor r.p.m. being equal to 15 - 20 %, discontinue starting the engine. To this end, put the engine control lever to the STOP (СТОП) position and switch off circuit breakers ENGINE START (ПУСК ДВИГАТЕЛЯ) and (АЭРОПАТН ЗАПУСКА).

Engine start being discontinued before the light SWITCH OFF IGNITION (ЗАПУСТИТЕ ДВИГАТЕЛЬ) has gone out, switch on circuit breaker ENGINE START (АЭРОПАТН ЗАПУСКА) for 40 sec to allow the rotor automatic mechanism to complete the operating cycle that has been interrupted. This done, switch off the circuit breaker. Repeat starting only after the cause of the engine start failure has been found and eliminated and the engine high-pressure rotor has come to a halt completely.

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48. After the engine speed has reached [illegible] see that:

(a) the engine low-pressure rotor speed is [illegible] 33 ± 2.0 % (with atmospheric pressure being [illegible] increase (decrease) of pressure by 15 mm Hg the [illegible] pressure rotor R.P.M. should drop (grow) by 1 %;

(b) the exhaust gas temperature does not [illegible]

(c) the oil pressure is at least 3 kg/cm².

Engine Autonomous Starting

49. When preparing for engine autonomous [illegible] the procedure used for engine starting from ground [illegible].

To perform autonomous starting of the engine [illegible] engine control lever and [illegible] step IDLE (ЗАЗЕМЛ [illegible] button ENGINE GROUND START (ЗАПУСК НА ЗЕМЛЕ) [illegible]

The engine should develop high-pressure [illegible] equal to 29.5 % within 80 sec.

Notes: 1. Engine autonomous starting should [illegible] not more than three times with the storage batteries having capacity of 45 A-hr (on the MCA motor) and not more than two with the storage batteries having capacity of 36 A-hrs.

2. When starting the engine autonomously, switch off light GENERATOR OFF (ГЕНЕРАТОР ВЫКЛЮЧЕН) will go out with the engine high-pressure rotor [illegible] reaching 31 - 34 %.

3. To provide most favourable conditions for starting and to ensure additional charging of the storage batteries in flight, it is recommended to switch off the D.C. generator for not longer than one minute after the autonomous starting of the engine.

Engine Warm-Up and Ground Test. Checking Aircraft Systems

50. Give a sign with your hand to the technician to connect the ground power source, after which make sure that the generator is switched into the aircraft power line. This should be made by reference to indicating light GENERATOR OFF (ГЕНЕРАТОР ВЫКЛЮЧЕН) which should go out and by reference to the voltmeter which should read 27 - 29 V.

Next switch on the following units:

(a) circuit breaker MARKER RECEIVER (МРП), DIRECTION SYSTEM (КСИ), RADIO COMPASS (АРК), TRIM. EFFECT (ТРИММЕРНЫЙ ЭФФЕКТ) and AUTOPILOT (АП) on the [illegible] right-hand switch panel;

(b) the fuel pumps of tank groups 2 and 3;

(c) the pressurized helmet heater by setting the change-over to the required position;

(d) switch AUTOM. WHEEL BRAKE (АВТОМ. ТОРМ., КОМБО);

(e) radio compass АРК-10 by setting the selector switch on the control panel to COMPASS (КОМПАС);

(f) transponder СРО by operating the switch on the control panel;

(g) pumping unit НН-27.

CAUTION. Engine warm-up and ground tests should be performed with the air intake cone fully retracted. See that indicating light CONE EXTENDED (КОНУС ВЫПУЩЕН) on right panel T-4 is not burning and the pointer of the cone position indicator reads zero.

51. Warm up the engine for some 0,5 - 3 min [illegible] (МАЛЫЙ ГАЗ) rating and check the following:

(a) operation of the trimming offset mechanism. For this purpose:

- press the selector switch on the control stick sideways and then forward; when released, the control stick should follow the movement of the selector switch;

- after checking set the trimming offset mechanism [illegible] by reference to indicating light TRIM. EFFECT ON, NEUTRAL (ТРИММЕРНЫЙ ЭФФЕКТ НЕЙТРАЛЬНО) on right panel T-4 (the [illegible] cating light should be burning); to set the trimming offset mechanism neutral, press the selector switch [illegible] forward position;

- on setting the trimming offset mechanism neutral, deflect the control stick to the extreme left- and [illegible] right-hand positions and make sure that the [illegible] will not go out;

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(b) operation of the aileron controls. [illegible]

- with the aileron boosters at datum the control [illegible] smoothly to the extreme right-hand and then left-hand [illegible] three or four times and make sure that while doing this the control stick expenditure [illegible] that effort is applied to the control stick for [illegible] feel mechanism;

- deflect the control stick forward and [illegible] check the stabilizer control system; the control stick must deflect to the extreme positions without jamming and when released, the control stick should return [illegible] position;

(c) operation of the hydraulic system [illegible] MI-3A, for which purpose:

- attain the engine speed equal to [illegible] high-pressure rotor r.p.m.;

- move the control stick several times [illegible] maximum possible speed; see that during this operation the pressure in the main and in the booster hydraulic [illegible] not drop below 180 kg/sq.cm;

- press button BOOSTER SYSTEM OFF (ОТКЛЮЧЕНИЕ БУСТЕРНОЙ СИСТЕМЫ) and move the control stick several times diagonally at a maximum possible speed; see that the pressure in the main hydraulic system does not drop below 100 kg/sq.cm and the pressure in the booster system remains constant [illegible] kg/sq.cm;

- extend and retract the flaps; check that they are properly extended and retracted by reference to the indicating light FLAPS EXTENDED (ЗАКРЫЛКИ ВЫПУЩЕНЫ) on KLS indicator [illegible] light is ON when the flaps are extended and is OFF when they are retracted), and by the signs made by the aircraft technician; the check over, leave the flaps extended;

- extend and retract the air brakes by moving the engine control lever slipper; indicating light AIR BRAKES EXTENDED (ЩИТКИ ВЫПУЩЕНЫ) on KLS indicator MIG-21M should light up with the air brakes extended and should be out when the flaps are retracted; the aircraft technician should check the air brakes for synchronous extension and retraction.

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CAUTIONS: 1. The engine is allowed to operate [illegible] at the idling r.p.m. for not longer than 10 min.

2. Under icing conditions operation of the engine with the speed equal to 50 % of the high-pressure rotor r.p.m. is allowed for no longer than 2 min. When the engine should operate at a speed exceeding 50% of the high-pressure rotor r.p.m. for no longer than 30 min.

52. By smoothly moving the engine control lever, increase the engine r.p.m. within 10 sec to 88 - 93% of low-pressure rotor r.p.m., warm up the engine for at least 30 sec (or at least 10 sec if the engine has already been tested at the beginning of the flying day) and check operation of the electric air distributor valve. To this end, place the cabin air-supply valve handle to OPEN (ОТКРЫТО) and the cabin heater selector switch first to COLD (ХОЛОДНЫЙ) and then to HOT (ГОРЯЧИЙ). The temperature of the air supplied to the cabin should change; the check over, set the selector switch to AUTOMATIC (АВТОМАТ).

Check operation of the D.C. generator. If the generator operates properly, indicating light GENER. OUT (ГЕНЕРАТОР ВЫКЛЮЧЕН) on light panel E-10y is not burning and the voltmeter reads a voltage of 27 - 29 V.

53. Check operation of the engine at the ground idling by moving the engine control lever to MAXIMUM (МАКСИМАЛ), make sure that the readings of the instruments are as follows:

- low-pressure rotor r.p.m. - 100 ± 5%;
- exhaust gas temperature - not over 600°;
- oil pressure - 3.5 - 4.5 kg/sq.cm.

Duration of continuous operation shall not exceed 5 min.

Note. Prior to a flight the pilot should position the engine at all ratings up to the nominal rating (the low-pressure rotor r.p.m. should be equal to 93 ± 0.5% and the oil pressure should equal 3.5 - 4.5 kg/sq.cm).

54. If required, check operation of the engine at the augmented ratings, for which purpose the engine control lever should be placed to MINIMUM AUGMENTED (МИН. ФОРСАЖНЫЙ) position.

CAUTION. Checking the engine operation at [illegible] maximum ratings as well as checking [illegible] at ratings up to the maximum and engine [illegible] should be performed on a special engine [illegible] the aircraft handles [illegible] by mooring cables.

Switching-on of the augmented rating [illegible] reference to indicating light AUGMENTED (GORIAN) [illegible] light panel T-10y which should flash up and by [illegible] charged sound of engine operation and explosion [illegible] shaking the aircraft. Besides, switching on the [illegible] mented rating is accompanied by a short-time (3-5 secs) [illegible] drop of the exhaust gas temperature by 20 - 30° (as compared [illegible] with the exhaust gas temperature at the maximum [illegible] rating) and [illegible] a short-time change in the low-pressure rotor [illegible] high-pressure rotor r.p.m. Momentary increase of the engine low-pressure rotor r.p.m. is allowed to be up to 106.5% for not more than 5 secs and up to 101.5% for not longer than 2 min. Momentary decrease of the engine high-pressure rotor r.p.m. is not limited.

Move the engine control lever to FULL AUGMENTED (POLNAYA GORYAK) and in 5 - 7 sec move it back to place corresponding to MAXIMUM AUGMENTED (MAKSIMAL'NYY GORYAK). The engine should operate steadily without any surging and thrust pulsations.

When the engine operates at the augmented rating the instrument readings should be as follows:

(a) low-pressure rotor r.p.m. - 100^{+1.0}_{-2.0}%;

(b) exhaust gas temperature - not over 720°;

(c) oil pressure - 3.5 - 4.5 kg/sq.cm.

The total time of operation at the augmented position should not exceed 15 sec.

Switch off the afterburner and cool the engine at the low-pressure rotor r.p.m. of 80% for 30 sec; then move the engine control lever rearward to the idling position.

Notes: 1. Should it occur that the fuel has not been ignited after switching on the afterburner (the gas temperature has dropped down below 450°C), change over the engine control lever to MAXIMUM (MAKSIMAL).

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2. If switching on and switching off the afterburner is accompanied by engine surge or rise in the exhaust gas temperature in excess of permissible value, switch off the afterburner by placing the engine control lever to MAXIMUM (МАКСИМАЛ) or to a lower power rating.
3. If the surge and the rise in the exhaust gas temperature persist, stop the engine by moving the engine control lever to STOP (СТОП). Further switching-on is not allowed until the fault is found out and eliminated.
4. If the afterburner has failed to get switched off following the change-over of the engine control lever, switch off the afterburner with the help of circuit breaker AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ).

55. Check acceleration of the engine within idle to maximum ratings by moving the engine control lever within 1.5 - 2 sec.

Time of engine acceleration from the idle rating r.p.m. to the low-pressure rotor r.p.m. equal to 99% at ambient air temperature of +15°C should amount to 11.5 - 14.5 sec. With the ambient air temperature decreasing (increasing) by 20°C, the time of engine acceleration should increase (decrease) by 0.5 sec.

The time of engine acceleration from the idle rating to the augmented ratings (to be checked if required) should not exceed 20 sec. The time of engine acceleration from the low-pressure rotor r.p.m. equal to 95% to those equal to 99% should amount to 8 - 11 sec.

When checking engine acceleration, momentary increase of the exhaust gas temperature should not exceed 750°C. The momentary increase in the low-pressure rotor r.p.m. should not exceed 106.5% for not more than 5 sec and 101.5% for not more than 2 min.

56. Under emergency conditions (when it is necessary to take off as soon as possible) it is allowed to bring the engine to the operation at the augmented rating immediately after reaching idling r.p.m. To this end, proceed as follows:

(a) shift the engine control lever as for an stop MAXIMUM (МАКСИМАЛ) within 1 - 2 sec;

(b) keep the engine operating at the maximum rating for 5 sec;

(c) switch on the afterburner.

Momentary increase of the exhaust gas temperature in this case should not exceed 750°C.

57. After testing the engine switch on successively autopilot KAП-2 damping and stabilization operating duties, the former by operating switch BANK DAMPER (ДЕМПФЕР КРЕНА) and the latter by pressing the right-hand button on the control stick. Make sure that the control stick is set neutral which corresponds to the neutral position of the ailerons. Make certain that the stabilization operating duty has been switched on by flashing-up of indicating light AUTOPILOT ON (АВТОПИЛОТ ВКЛЮЧЕН) on the instrument board.

The check over, switch off the stabilization operating duty by pressing the left-hand button on the control stick; in this case indicating light AUTOPILOT ON (АВТОПИЛОТ ВКЛЮЧЕН) will go out.

Notes: 1. Switching-on of the autopilot operating duties should be made after checking the operation readiness of gyro horizon АГД-1 (this should be made at least 2 min after circuit breaker АИ has been switched on).

2. Switching-on of the autopilot operating duties should not be accompanied by jerks of the control stick.

58. Close the canopy and pressurize the cabin. Check to see that there is no smoke in the cockpit and that no pressure differential exists as read by cabin altitude and pressure differential gauge УВПД-20.

Make sure that air is supplied to the cabin for which purpose move the air supply valve smoothly forward. Place the cabin air temperature controller switch in turn to COLD (ХОЛОДНЫЙ) and to HOT (ГОРЯЧИЙ). Hold the switch pressed for not less than 30 sec. Handfeel whether cold and then warm air is supplied to the canopy glass. After checking the system place the selector switch to AUTOMATIC (АВТОМАТ).

59. Prevent [illegible] in flight.

Engine rating	R.	L.P.
Augmented (from full augmented to minimum augmented)	100	[illegible]
Maximum	100	
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ENGINE OPERATION IN FLIGHT

59. Presented in Table 1 are the basic engine ratings when in flight.

Table 1

Engine rating	R.p.m., %		Exhaust gas temp., °C	Oil pressure at engine inlet, kg/sq.cm	Duration of continuous operation
	L.P.R.	H.P.R.			
Augmented (from full augmented to minimum augmented)	$100^{+1.0}_{-0.5}$	Not over 104	Not over 720	3.5 - 4.5 up to altitude of 15,000 m and at least 3.0 for altitudes higher than 15,000 m	Not over 30 min including not less than 10 min at altitudes up to 10,000 m
Maximum	100 ± 0.5	Not over 104	Not over 700	Same	Same
Idle	R.p.m. vary depending on flying altitude and amount to: 50 at 3000 m, 70 at 7000 m, 80 at 10,000 m, 85 for altitudes higher than 14,000 m		Not over 420	At least 1.0	Not limited

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Notes: 1. The time of the engine continuous operation within the r.p.m. range of 98 - 100% is limited within the same values as when operating at the maximum and augmented ratings. The time of continuous operation at the engine ratings from idle to 98% is not limited.

2. If the maximum permissible time for the engine continuous operation has expired, reaching of the maximum and augmented ratings anew is allowed only after the engine has operated at low-pressure rotor r.p.m. below 95% for 1 min.

3. When operating at the maximum and augmented ratings, the high-pressure rotor r.p.m. will increase with the increase of the flying speed. At the airspeeds close to M=2 the high-pressure rotor r.p.m. should not exceed 103.5 ± 0.5%. When attaining 104% of the high-pressure rotor r.p.m., further acceleration of the aircraft will result in decreased low-pressure rotor r.p.m.

4. When flying at the maximum rate of climb with the engine operating at the maximum rating, the exhaust gas temperature drops and the high-pressure rotor r.p.m. decrease approximately by 3%. When at an altitude of 10,000 m, the exhaust gas temperature should not be lower than 550°C.

60. The minimum indicated airspeed ensuring reliable switching-on of the afterburner is as follows:

- 500 km/hr up to 15,000 m;
- 550 km/hr at altitudes in excess of 15,000 m.

At lower flying speeds the afterburner may fail to get switched on and the engine may spontaneously get cut-off.

The afterburner can be switched on only by placing the engine control lever to FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ). Shifting the engine control lever within the augmented rating controllable range is allowed after 8 - 10 sec have expired since the engine control lever has been placed to FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ).

When switching on the afterburner indicating light AUGMENTED (ФОРСАЖ) on light panel T-10y will flash up; there will take place a short-time (up to 5 sec) drop of the exhaust gas temperature by 20 - 120°C, a momentary rise of the low-pres-

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sure rotor r.p.m. (not over 106.5%), a momentary drop of the high-pressure rotor r.p.m., and increase in the engine thrust felt by an impact.

61. With the engine operating within the augmented ratings, flying is allowed to be performed:

(a) within the entire range of the airspeeds permissible for the aircraft up to an altitude of 1000 m;

(b) at the indicated airspeed not less than 350 km/hr when at altitudes within 1000 - 15,000 m;

(c) at the indicated airspeed not less than 500 km/hr when at altitudes in excess of 15,000 m.

62. When the afterburner operates not steadily, producing longitudinal oscillations of the aircraft and fluctuation of the engine r.p.m., proceed as follows:

(a) with the engine operating at the fully augmented rating, increase the flying speed due to bringing the aircraft into descent while leaving the engine control lever at stop FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ);

(b) with the engine operating at the minimum or intermediate augmented rating, shift the engine control lever towards stop FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ) or increase the airspeed by descending the aircraft until the engine unsteady operation discontinues.

63. The interval between two switchings of the afterburner within the permissible limits of the engine continuous operation should be not less than 10 sec. If after placing the engine control lever to the AUGMENTED position the fuel has failed to ignite (the exhaust gas temperature has dropped below 450°C) or spontaneous cutoff of the afterburner has taken place, shift the engine control lever from the AUGMENTED (ФОРСАЖ) position.

Repeated switching-on of the afterburner (provided that it has failed to get switched on) should be made not earlier than 10 sec after the engine control lever has been shifted to MAXIMUM (МАКСИМАЛ). Higher reliability of switching-on of the afterburner requires increased airspeeds and lower flying altitudes.

It is allowed to switch off the afterburner and shift the engine control lever from the AUGMENTED (ФОРСАЖ) position in case of spontaneous cutoff of the afterburner or when the afterburner fails to be switched on. The flying conditions should be the same as indicated for the engine operation at the augmented ratings.

To switch off the afterburner, shift the engine control lever to position MAXIMUM (МАКСИМАЛ) within 1 - 3 sec. After switching off the afterburner, indicating light AUGMENTED (ФОРСАЖ) should go out. Should it occur that after shifting the engine control lever from the AUGMENTED (ФОРСАЖ) position the afterburner has failed to get switched off, switch it off with the help of circuit breaker AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ). Should it be the case that after shifting the engine control lever from the AUGMENTED to MAXIMUM position burning in the afterburner has stopped but the exhaust nozzle shutters have failed to close (the exhaust gas temperature is below 450°C, the high-pressure rotor r.p.m. are below the low-pressure rotor r.p.m. and amount to about 92%), close the shutters with the aid of circuit breaker SHUTTER EMERGENCY SWITCHING-ON, AUGMENTED, MAXIMUM (АВАР. ВКЛЮЧ. ОТВОРОК, ФОРСАЖ, МАКСИМАЛ).

64. At altitudes below 15,000 m normal acceleration of the engine and accelerations, preceded by speed decrease, from idle rating to maximum rating are allowed at the indicated airspeed of not less than 350 km/hr; it is also allowed to decrease the engine r.p.m. to those of the idle rating from any engine rating by shifting the engine control lever for 1.5 - 2 sec.

When flying higher than 15,000 m, it is not allowed to throttle down the engine below maximum rating.

OPERATION OF FUEL SYSTEM

65. Fuel consumption should be checked by reference to the fuel flowmeter and the indicating lights.

When flying without a drop tank, the indicating lights on light panel T-10y should indicate consumption of the fuel in the following way:

(a) when 900 - 1100 lit of fuel remain in the tanks, indicating light TANK GROUP 1 (1 ГР. БАКОВ) should come on;

(b) when 450 ± 50 lit of fuel remain in the tanks, indicating light REMAINDER 550 LIT (ОСТАЛОСЬ 550 Л) should come on;

(c) when 250 lit of fuel remain in the tanks, indicating light TANK GROUP 3 (3 ГР. БАКОВ) should come on.

Note. When flying with the drop tank, the fuel inside the drop tank is first to be consumed. With the drop tank emptied, further sygnalisation of fuel consumption will operate in the same sequence as when flying without the drop tank.

66. After proper amount of fuel has been consumed and indicating light TANK GROUP 1 (1 ГР. БАКОВ) has become on, switch off the respective circuit breaker.

67. When making approach for landing with the remainder of fuel less than 200 lit, switch on circuit breakers PUMP OF TANK GROUP 1 (НАСОС 1 ГР. БАКОВ) and PUMP OF TANK GROUP 3 (НАСОС 3 ГР. БАКОВ) to pump over the remaining fuel from tank group 1 and tank group 3 into the service tank group; it is allowed to switch off these circuit breakers after the respective indicating light is steadily burning.

OPERATION OF AUTOPILOT КАП-2

68. Autopilot КАП-2 is ready for operation after circuit breaker АП has been switched on (the circuit breaker should be switched on after preparing reference gyro АГД-1 for operation).

69. To change over the autopilot to operation under damping conditions, place switch NEUTRAL - BANK DAMPER (НЕЙТРАЛЬНО - ДЕМПФЕР КРЕНА) to BANK DAMPER (ДЕМПФЕР КРЕНА).

With the autopilot switched over to the damping operating duty it is allowed to perform all kinds of flying starting from take-off and up to landing under any weather conditions.

70. The autopilot should be changed over to stabilisation operating duty only after take-off at an altitude not lower than 200 m by pressing the right-hand (black) button on the control stick. When switching on this operating duty, indicating light AUTOPILOT ON (АВТОПИЛОТ ВКЛЮЧЕН) should come on.

With the autopilot at stabilisation operating duty it is allowed to perform level flying, turns, descending and climbing (at pitch angles not in excess of ±30°).

Note. To maintain the assigned bank when flying with the autopilot switched to stabilization operating duty, hold the control stick deflected with some effort to a bank of ±36°.

71. When flying under adverse weather conditions, it is necessary before entering the overcast to check operation of the autopilot by reference to the gyro horizon and to the natural horizon.

72. To bring the aircraft to a zero bank from any attitude, it is necessary to switch the autopilot to stabilization operating duty and place the control stick neutral (in the lateral direction). It takes some 3 - 10 sec to bring the aircraft to a zero bank from an inverted flight (this time depending on the engine rating at the moment).

73. Should any vibration occur which makes it difficult to control the aircraft with the autopilot on, switch off the stabilization operating duty. If vibration persists, switch off the damping operating duty too.

Note. When flying with the autopilot on, slight vibration of the aircraft which does not make flying difficult is allowed.

74. Provided that the landing approach is made with the autopilot operating under stabilization conditions, it is necessary to switch off the stabilization operating duty by pressing the left-hand (red) button on the control stick at an altitude of 200 - 300 m (below the overcast). This should cause indicating light AUTOPILOT ON (АВТОПИЛОТ ВКЛЮЧЕН) to go out.

75. It is obligatory to switch on the autopilot in the following cases:

(a) when entering a spin;
(b) before switching off the aileron boosters;
(c) in case of failure of the hydraulic systems;
(d) in case of failure of the generator;
(e) in case of engine fire.

76. The autopilot should be switched off at an altitude not lower than 200 m in the following sequence:

(a) switch off the stabilization operating duty by pressing the left-hand button on the control stick;

(b) switch off the damping operating duty by operating the switch on the left-hand panel;

(c) switch off circuit breaker AH when on the ground after landing.

CAUTIONS: 1. It is forbidden to switch off the autopilot by using circuit breaker AH without having previously switched off the autopilot stabilization and damping operating duties. Otherwise, the rod of the servo unit may remain not in the neutral position which will cause banking of the aircraft with the control stick in neutral and make flying more difficult.

2. The following will be the procedure to be used for setting servo unit PAY-107 exactly neutral before cutting out the engine with the aileron boosters on, provided that the autopilot damping operating duty has been switched off in flight:

(a) switch on circuit breaker AH;

(b) switch on the autopilot damping operating duty;

(c) after waiting for 2 - 3 min, switch off circuit breaker AH and then the autopilot damping operating duty.

3. When switching off the autopilot in flight on the aircraft balanced laterally, banking may occur which will correspond to aileron deflection through $\pm 0.55^{\circ}$. This being the case, constant effort is created on the control stick. This banking is due to the fact that when switching off the autopilot, servo unit PAY-107 is set neutral within ± 1.5 mm in the direction of the servo unit rod travel, which corresponds to aileron deflection through $\pm 0.55^{\circ}$.

OPERATIONAL LIMITS

Maximum Permissible Indicated Airspeed, Mach Numbers and G-Factors

77. The following operational limits exist for the air-

craft without external suspensions but with two missiles P-3c (without the drop tank):

(a) the indicated airspeed of 1100 km/hr up to an altitude of 5000 m;

(b) the indicated airspeed of 1200 km/hr at altitudes from 5000 to 12,500 m;

(c) the airspeed of M = 2.05 as measured in Mach number for altitudes higher than 12,500 m;

(d) the maximum permissible G-factor of 6 for fuel amount exceeding 1800 lit and 7 for fuel amount (remaining in the tanks) less than 1800 lit.

78. The following operational limits exist for the aircraft flying with the drop tank and two missiles P-3c or with two units UB-16-57y and the drop tank or with two units UM-16-57y without the drop tank:

(a) the indicated airspeed of 1000 km/hr up to an altitude of 12,000 m;

(b) the airspeed of M = 1.6 as measured in Mach number for altitudes higher than 12,000 m;

(c) the maximum permissible G-factor of 5 when flying both with the empty and with filled drop tank, or 6 when flying with two units UB-16-57y without the drop tank.

79. The minimum manoeuvring indicated airspeed when flying at any altitude should be 400 km/hr. The maximum permissible indicated airspeed when flying with the landing gear down is 700 km/hr. The maximum permissible airspeed when releasing the drag chute is 280 km/hr.

80. The minimum permissible indicated airspeed for the aircraft flying with two missiles P-3c without the drop tank is 260 - 280 km/hr. The stalling airspeed at which the aircraft spins is 220 - 230 km/hr.

81. The drop tank is allowed to be jettisoned at any altitude and engine rating at the indicated airspeed of 500 - 1000 km/hr or at Mach number up to 1.5.

82. It is allowed to release the air brakes at any airspeed and Mach number.

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83. The maximum permissible indicated airspeed with the canopy jettisoned should be:

- 500 km/hr when flying with the crash helmet on;
- 700 km/hr when flying with the pressurized helmet on.

84. The maximum permissible indicated airspeed for safe bailout should be:

- 1100 km/hr when using canopy protection;
- 700 km/hr with the canopy previously jettisoned.

Weight Limits for Landing

85. Normal landing weight for the aircraft will be obtained:

(a) without any suspension with the total fuel remainder in the tanks amounting to not more than 1100 lit;

(b) with missiles P-3c and with the total fuel remainder in the tanks amounting to not more than 1000 lit;

(c) with units YB-16-57y and with the total fuel remainder amounting to not more than 800 lit.

86. It is allowed to perform landing of the overloaded aircraft in the following exceptional cases:

(a) immediately after take-off on jettisoning the drop tank and all kinds of suspensions;

(b) when flying with missiles P-3c or units YB-16-57y with the total amount of the remaining fuel being not over 1850 lit.

87. Landing on a soil or snowy runway is allowed with the landing weight not exceeding 7250 kg under the following conditions:

(a) without missiles P-3c (or C-5x, C-5u) with the amount of remaining fuel not over 2400 lit;

(b) with missiles P-3c (or C-5x, C-5u) and with the amount of remaining fuel not over 2200 lit.

After landing the overloaded aircraft inspect the landing gear, the landing gear attachment units and check the landing gear for proper retraction.

Chapter III

RECTANGULAR CIRCUIT FLIGHTS, ADVANCED TAXIING AND COMBAT EMPLOYMENT

RECTANGULAR CIRCUIT FLIGHTS BY DAY-CONT

Taxiing

88. Having made sure that the engine, instruments and all aircraft systems operate properly, check to see that the landing gear wheel emergency brake lever is set to proper position (the lever should be sunk and locked), the front wheel brake is switched off and the flaps are extended.

89. Close the canopy and pressurize the cabin. See to it that the canopy jettison system is properly closed. Make sure that the canopy is reliably locked by reference to the indicating pins which should come out of the holes provided in the cockpit sides.

After braking the wheels, command the technician to remove the protective gauzes from the take-off shutters and to remove the chocks from under the wheels.

90. Having received permission for taxiing and having made sure that the chocks are removed (by the sign of the technician) and no obstacles are present in front of the aircraft, release the brakes and start taxiing.

The taxiing speed without any external suspension should not exceed 30 km/hr, whereas with external suspension it should amount to 15 km/hr. While taxiing, perform turns smoothly without sharp braking of any of the wheels.

91. After taxiing to the runway and making sure that it is clear, request permission for taxiing to the take-off position.

When on the runway, taxi straight 20 - 30 m to centre the front wheel along the aircraft axis of symmetry and brake the wheels. Apply the front wheel brake, unlock the landing gear valve control, lock the harness and after checking the compass readings (slave these if required) request permission for take-off.

Take-Off

92. Take-off should be made with the flaps extended and as a rule under the minimum augmented rating conditions. It is allowed to perform take-off under engine maximum power conditions (provided that the aircraft carries no drop tank) and under full augmented rating conditions. The take-off procedure at the augmented rating is similar to that at the maximum rating.

93. After being cleared for the take-off, hold the aircraft braked while smoothly shifting the engine control lever to the minimum augmented position. Make sure that the afterburner has got switched on (by a peculiar impact and rise in the exhaust gas temperature), release the brake and start the take-off run.

After taking off, when further climb is not to be made at the augmented rating, switch off the afterburner at an altitude not lower than 1000 m irrespective of the weather conditions.

94. At the beginning of the take-off run maintain the direction by application of the brakes. But as soon as the airspeed is gained, maintain the take-off direction by deflecting the rudder. At the beginning of the take-off deflect the control stick back by 3/4 of its full travel and hold it in this position till the front wheel starts rising.

As soon as an airspeed of 240 km/hr is reached, the front wheel breaks the ground smoothly (without any additional efforts).

Taking off with the drop tank and missiles on racket pads has no peculiarities.

95. When taking off, the cross wind whose velocity is up to 10 m/sec (even if it is blowing at an angle of 90° to the runway) should be neglected. Under these conditions the aircraft is steady in maintaining the take-off direction and has no tendency to turning.

Taking off under the conditions of a cross wind whose velocity exceeds 10 m/sec is characterized by the aircraft tendency to banking and turning its tail into the wind. This tendency can be easily counteracted by deflecting the ailerons and the rudder. In order to maintain the direction at the beginning of the take-off run, it is necessary to apply the brakes. As the airspeed is gained, the aircraft tendency to banking and turning considerably decreases.

96. After the aircraft has broken the ground it becomes steady in control and has no tendency to ballooning or wing-heaviness.

When flying with missiles P-3c, the aircraft breaks the ground at an airspeed of 310 - 320 km/hr, when flying with missiles P-3c and the drop tank - at an airspeed of 320 - 340 km/hr.

97. When at an altitude of 10 - 15 m, retract the landing gear. While retracting the landing gear, be sure that the airspeed does not exceed 600 km/hr. The landing gear should be retracted within 6 - 8 sec. If the airspeed exceeds 600 km/hr, the time of retraction increases and the landing gear may fail to get fully retracted. When retracting the landing gear, warning light EXTEND LANDING GEAR (ВЫПУСТИ ШАССИ) should come on. This warning light should go out after retracting the flaps.

Having made sure that the landing gear is up by reference to the indicating lights and by the build-up of pressure in the hydraulic system up to 210 kg/sq.cm, place the landing gear valve control neutral and check to see that the cone is extended by watching indicating light CONE EXTENDED (КОНУС ВЫНУТ) and the cone position indicator.

CAUTION. If one of the lights indicating landing gear up position is not burning after retracting the landing gear under excessive airspeed conditions, leave the

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landing gear valve control in the RETRACTED (УБРАНО) position and dissipate the airspeed down to 550 km/hr. This done, the landing gear should get retracted. After retracting place the landing gear valve control neutral.

When reaching an altitude of 200 m, retract the flaps. When flying rectangular pattern with the landing gear up or down, be sure that the airspeed is not less than 500 km/hr (which should be the case if the flaps are not extended).

After increasing the airspeed in excess of 450 km/hr check operation of automatic transmission ratio controller АРУ-3в by the indicating light on the light panel Т-4 which should go out and by the deflection of the instrument pointer to the right.

CAUTION. When the indicated airspeed in flight exceeds 750 - 800 km/hr within an altitude range from the ground to 7000 m, check controller АРУ-3в for proper operation by watching the indicator pointer which should deflect to the right with the indicated airspeed increasing. Flying with controller АРУ-3в set to the greater arm within the above indicated ranges of airspeeds and altitudes may result in the aircraft experiencing dangerous longitudinal oscillations.

98. Aircraft operation from soil runways is allowed provided that the strength of the soil is at least 8 kg/sq.cm in summer or the thickness of the snow covering is not more than 10 cm (the snow density being at least 0.5 kg/sq.cm) in winter.

Note. Under these conditions pressure in the shock struts of the main landing gear as well as in the tires of the main and nose wheels remains the same as in the case of a concrete runway; pressure in the shock absorber of the nose strut should be as high as 40 ± 1.0 kg/sq.cm (instead of 37 ± 1 kg/sq.cm when operating from concrete runways).

Taking off from a soil or a snowy runway should be made at the FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ) rating with the flaps extended, the nose wheel brake switched off and the automatic wheel brake on.

Prior to taking off brake the aircraft by pressing the brake lever as far as it will go and shift the engine control lever to FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ). At the moment of a momentary decrease of the thrust before switching on the afterburner, release the brake lever. While in a take-off run hold the control stick neutral until the nose wheel breaks the ground.

The front wheel breaks the ground at an indicated airspeed of 230 - 265 km/hr; the aircraft becomes airborne at an airspeed of 290 - 340 km/hr. When taking off from a soil runway at fully augmented rating, the length of the take-off run is equal to 700-850 m; when taking off from a snowy runway, the take-off run length amounts to 800 - 1050 m.

When accelerating the engine to the augmented rating on a soil runway or to the maximum rating on a snowy runway, the aircraft cannot be held in position by the brakes. Therefore, simultaneously with shifting the engine control lever to the augmented rating (maximum rating) position release the brake lever. When the take-off run has started, check to make certain that the afterburner has become switched on.

When running along a soil or snowy runway, the aircraft is not so steady as in the case of a concrete runway. The nose wheel should be lifted in this case at an increased airspeed. Uneven soil (or snow covering) will cause longitudinal and lateral rocking of the aircraft which is not recommended to be counteracted by deflecting the control stick.

When running on a clayey (wet) soil or on a snowy runway covered with ice, the aircraft has a tendency to skidding and yawing. At the beginning of the run, skidding and yawing should be counteracted by applying brakes. As the airspeed is gained, they should be eliminated by deflecting the rudder.

To increase the aircraft manoeuverability, perform taxiing with the nose wheel brake and the automatic wheel brake OFF. When taxiing under the conditions of maximum or excessive take-off weight, maintain a taxiing speed not in excess of 15 km/hr. During taxiing make turns with a radius more than 25 m.

It is allowed to take-off from a soil runway provided that:

(a) the normal take-off weight is 7750 kg - with missiles P-3s (or C-5M, C-5M) without the drop tank;

(b) the maximum take-off weight is 8220 kg - with missiles P-3s (or C-5M, C-5M) and the drop tank.

99. Taking off from narrow metal runways is allowed under the crosswind conditions with the wind velocity not exceeding 10 m/sec and as a rule at the engine maximum rating.

When taking off, lift the nose wheel at an airspeed increased by some 10 - 20 km/hr. If the aircraft experiences longitudinal (or lateral) rocking during the take-off run, it is not recommended to eliminate it by deflecting the control stick.

Preparation for Landing

100. Before landing approach make certain that:

(a) the pressure in the hydraulic systems is equal to 210 kg/sq.cm;

(b) the air pressure in the main air system is equal to 80 - 100 kg/sq.cm and in the emergency air system, 130 kg/sq.cm;

(c) the automatic wheel brake and the front wheel brake have been switched on;

(d) no pressure is present in the brakes (which should be checked by reference to the two-pointer pressure gauge).

101. Before turning to the base leg extend the landing gear at an airspeed of 500 km/hr. Make sure that the landing gear has been extended by reference to the indicating lights which should be burning, to the nose strut position indicator (which should come out) and by building-up of the pressure in the hydraulic system to 210 kg/sq.cm. Leave the landing gear control in the EXTENDED (ВЫПУЩЕНО) position until starting taxiing to the parking place.

102. After extending the landing gear make certain that the cone has become retracted by reference to the CONE RETRACTED (КОНУС ВЫПУЩЕН) indicating light which should go out and by the cone position indicator. This done, lock the harness shoulder restraint mechanism and remove pressure from the control stick by operating the trimming offset mechanism.

Estimation for Landing

103. Before turning to the base leg report to the flight control officer that the landing gear has been extended and request permission for landing. Turning to the base leg should be started when on the beam of the outer marker beacon. The turn should be performed without losing altitude at a bank of 35 - 45° and through an angle of 100 - 110°.

104. While descending before the turn to final approach release the flaps at an airspeed not exceeding 450 km/hr. Make sure that the flaps have become extended by watching the indicating light on the ILS indicator (the light should be burning). When releasing the flaps there appears a slight pitching moment which can be counteracted by deflecting the control stick.

CAUTIONS: 1. If the aircraft starts banking energetically at the moment the flaps are released, it is necessary to retract them immediately and perform landing with the flaps retracted.

2. If EXTEND LANDING GEAR (ВЫПУСТИ ШАССИ) warning light becomes on after the flaps have been extended, this will be indicative that the landing gear has failed to go down or has gone down partially. This being the case, make a go-around, extend the landing gear fully and then perform landing.

Note. Landing is also allowed with the flaps extended not symmetrically. In this case aircraft banking should be counteracted by deflecting the ailerons and the rudder.

This being the case, the rudder should be deflected so that before roundout performed at an airspeed of 360 km/hr the ailerons are deflected against the bank by not more than half of the travel.

Landing should be made at an increased airspeed (320 - 330 km/hr).

105. After decreasing the flying speed down to 450 km/hr check the position of controller ARV-3э. The instrument pointer should be deflected to the left as far as the stop and indicating light STABILIZER FOR LANDING (СТАБИЛИЗАТОР НА ПОСАДКУ) on light panel T-4 should be burning.

106. Enter a turn to final approach at an airspeed of 450 km/hr and then decrease it gradually so that by the end of the turn it is equal to 400 - 420 km/hr. Rolling out of the turn should be completed at an altitude of at least 300 m.

107. After the turn to final approach has been made perform gliding at the low-pressure r.p.m. not less than 50 - 60% (or at the high-pressure r.p.m. equal to at least 65%) at a constant glide angle so as to fly over the inner marker beacon at an airspeed of 360 - 380 km/hr and at an altitude of 80 - 100 m. By the moment the roundout is to be started the airspeed should be equal to 340 - 360 km/hr (depending on the amount of fuel remaining in the tanks).

108. Estimation for landing should be made with slight application of power; change the engine r.p.m. to finalize the landing approach.

CAUTION. When throttling down the engine to a high-pressure rotor r.p.m. lower than 65%, the jet pipe will automatically change over to the augmented position. Due to this, obtaining the necessary thrust of the engine with the jet pipe open requires higher engine r.p.m. (73 - 80%) and greater time, which makes judgement and go-around more difficult.

Landing

109. When on a glide path at an altitude of 20 - 30 m, shift your look forward to the ground so that the line of sight passes through the left-hand front portion of the canopy at an angle of 10 - 15° and at an angle of 15 - 20° when looking downward. Having made sure that the estimation for landing is correct and having checked the airspeed, start rounding out from an altitude of 8 - 10 m without reducing the engine r.p.m. by smoothly deflecting the control stick rearward so as to bring the aircraft to the ground at an altitude not higher than 1 m. At the end of the roundout and while floating, as the aircraft approaches the ground, reduce smoothly the engine r.p.m. so that they correspond to the idling speed at the moment the aircraft touches the ground.

110. The floating should be performed while gradually descending. To this end, bring the aircraft at greater angles of attack by smooth and commensurable movements of the control stick while deflecting it to the rear at a rate that will ensure two-point landing without pancaking.

Under the normal landing conditions (with the fuel remainder equal to 500 lit and the flaps extended) the landing speed should be equal to 265 - 290 km/hr; with the fuel remainder amounting to 1200 lit the landing speed is equal to 275 - 300 km/hr. When landing is made with the control stick deflected not fully back, the aircraft will perform touch-down at an increased airspeed and the landing roll distance will be greater.

111. While floating, keep looking on the ground at an angle of 15 - 20° to the left and 30 - 40 m ahead. After touch-down the control stick should be held in the same position as at the moment of the touchdown; the line of sight should remain the same as when floating.

When in a steady roll, lower smoothly the nose wheel, shift your look forward and start braking by smoothly pressing the brake lever as the speed of the roll decreases and the distance to the end of the runway becomes reduced. The brake lever may be pressed all the way in, if required.

112. To reduce the length of roll after making a two-point landing under the conditions of a short airfield, excessive flying weight or wrong estimation for landing (e.g. overshooting), lower smoothly (within 1 - 2 sec) the aircraft nose, press the brake lever all the way in, retract the flaps, and release the drag chute.

The drag chute should be released at an airspeed not exceeding 280 km/hr.

It would be a sound practice to release the air brakes before making touchdown.

113. The landing roll over, switch off the nose wheel brake, retract the flaps and taxi off the runway.

The drag chute should be dropped after taxiing off the runway. When landing on a metal runway, the drag chute should

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CAUTION. Taxiing with the canopy open is forbidden.

114. In case of high roundout (higher than 1 m) discontinue deflecting the control stick rearward and then, as the airspeed decreases and the aircraft approaches the ground, perform normal landing.

If the aircraft balloons, due to some blunder in flying technique, resort to the following corrective actions depending on the cause of ballooning:

(a) when landing at an excessive airspeed, discontinue further ballooning at the moment the aircraft breaks the ground; then, as the airspeed decreases and the aircraft approaches the ground, perform normal two-point landing;

(b) when landing at a normal or somewhat reduced airspeed, at the moment the aircraft becomes airborne hold the control stick in the same position as at the moment of the balloon; as the aircraft approaches the ground, perform a two-point landing by smoothly and energetically moving the control stick rearward.

115. Landing on a soil or snowy runway should be made with the nose wheel brake off and the automatic wheel brake on.

When landing on a soil strip, after touchdown keep holding the nose wheel lifted as long as possible. After lowering the nose wheel perform braking in the same way as in the case of landing on a concrete runway; release the drag chute if required.

To obtain a minimum distance of roll after making a two-point landing, lower the nose wheel slowly (within 1 - 2 sec), press the brake lever all the way in, release the drag chute at an airspeed not over 280 km/hr and retract the flaps.

It is allowed to land the aircraft with the normal landing weight of 6200 kg with missiles F-3c (or C-5r, C-5m) and amount of remaining fuel not over 950 lit.

As an exception it is allowed to land an overloaded aircraft in the following cases:

(a) without missiles P-3c (or O-5K, C-5M) and with the amount of remaining fuel not over 2400 lit;

(b) with missiles P-3c (or O-5K, C-5M) and with the amount of remaining fuel not over 2200 lit.

After landing an overloaded aircraft weighing not over 7250 kg, thoroughly check the landing gear for sound condition.

When landing on a snowy runway, after making a two-point landing, lower smoothly the nose wheel, press the brake lever all the way in, retract the flaps and release the drag chute.

116. Landing on a narrow metal runway differs only slightly from landing made on a concrete runway as far as flying technique is concerned. In the former case landing requires from the pilot particular attention and skill, the metal runway being poorly observed when flying the landing pattern. Besides, the pilot should sit in the cockpit higher.

Crosswind Landing

117. Crosswind landing with the wind blowing at an angle of 90° and having velocity up to 10 m/sec is not complicated. Drift of the aircraft should be counteracted by slipping in the opposite direction at a bank up to 10 - 15°.

With the cross wind having a velocity up to 15 m/sec, landing will require from the pilot particular attention; this being the case, counteract the drift by a combination of slipping and crabbing into the wind.

118. By the end of the floating slipping should be gradually discontinued so that the touchdown is made with the two main wheels without any bank and with the pedals in the neutral position.

To increase the directional stability, lower the nose wheel slowly, start braking and release the drag chute.

Landing with Flaps Retracted

119. It is allowed to make landing with the flaps retracted only when they fail to become released or when they must not be released (the cause may be the failure of the hydraulic system, landing with the dead engine, banking when releasing the flaps, etc.).

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120. When landing with the flaps retracted, after turning to the final approach maintain an airspeed of 400 km/hr and gradually decrease it to fly at an airspeed of 360 - 370 km/hr by the moment the roundout is to be started.

When making estimation for landing, shift the point where the roundout is to be started by somewhat greater distance from the runway. In this case the glide path will be more sloping and the touchdown will take place at a higher airspeed as compared with the landing when the flaps are extended.

Go-Around

121. Going around is possible from any altitude including the roundout altitude. After taking decision to go around, accelerate the engine to the maximum rating without changing the glide angle. On attaining an airspeed of 360 - 380 km/hr, smoothly bring the aircraft into a climb and retract the landing gear. When at an altitude of 200 m, retract the flaps.

CAUTION. When performing a go-around procedure, do not forget that the time within which the engine can be accelerated from idling to the maximum rating is about 15 sec.

If the decision to start a go-around procedure has been taken too late, accelerate the engine to the maximum rating while continuing to perform landing and then after touching down bring the aircraft airborne on gaining the required airspeed.

Engine Cut-Out when at Parking Site

122. After taxiing to the parking site switch off all the electric power consumers except for circuit breakers SERVICE PUMP (РАСХОДНЫЙ НАСОС) and AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ). This done, let the engine to operate at the idle rating for some 5 - 7 sec and stop the engine by shifting the engine control lever to STOP (СТОП). Though the engine rotors are rotating, switch off the storage battery and circuit breaker SERVICE PUMP (РАСХОДНЫЙ НАСОС). After switching off the storage

battery switch off circuit breaker AUGMENTER, MAXIMUM (GORGAN, MAKCHMAN).

Flying with Aircraft Tanks Fueled not to Capacity

123. Short-duration flights may be performed without the drop tank and external suspensions, with the aircraft tanks filled not to capacity and with the engine operating at non-augmented ratings. This being the case, 1400 - 1500 litres of fuel should be filled to the tanks and the fuel flowmeter indicator should be set to the value which is 50 lit less than the actual value of the fuel contained in the tanks.

Note. The actual amount of the fuel contained in the tanks should be determined as a sum of the readings of the aircraft fuel flowmeter (after the previous flight) and the counter of the fuel bowser.

When on the ground before starting the engine perform additional checking of the fuel contained in the tanks by turning on switch PUMP OF TANK GROUP 1 (НАСОС 1 ГР. БАКОВ) for 2 - 3 min. In this case indicating lights TANK GROUP 1 (1 ГР. БАКОВ) and 550 LIT LEFT (ОСТАЛОСЬ 550 Л) on light panel 5-10y should be not burning.

When flying with the fuel tanks filled not to capacity, the warning lights which indicate fuel consumption for each group of the fuel tanks will flash up after the same amounts of fuel remain in the tanks as in the case of a flight with the tanks filled to capacity.

With the fuel tanks filled not to capacity it is allowed to make not more than four flights one after another after which the tanks should be filled to capacity.

FLYING WITH DROP TANK

124. Flying with the drop tank at the maximum airspeed and Mach number will not differ essentially from flying without the drop tank. The aircraft carrying the drop tank is quite steady in airspeed and G-load within the entire range of permissible airspeeds and Mach numbers.

Note. In practice no spontaneous roll of the aircraft has

over occurred within the entire range of the engine rating. Should it however occur, stop it by simultaneously moving the control stick forward (until the negative G-factor reaches not over 1) and to the side opposite to the roll. Then place the pedals neutral.

125. Flashing-up of warning light DROP TANK EMPTY (ВЫРАБОТКА ПОДВЕСНОГО БАКА) is indicative that the fuel contained in the drop tank has been consumed.

Jettisoning of the drop tank is allowed at all altitudes and engine ratings at an indicated airspeed within 500 - 1000 km/hr or at Mach numbers up to M = 1.5. To this end, press the drop tank jettison button on the control stick.

To make sure that the drop tank has been jettisoned, watch indicating light DROP TANK SUSPENDED (ПОДВЕСКА БАКА) on the lower portion of the instrument board. The indicating light should be out.

CAUTION. After jettisoning the drop tank which contained fuel the fuel flowmeter will indicate greater amount of fuel than it is actually contained in the aircraft tanks (the difference being the amount of fuel left in the drop tank).

FLYING AT MAXIMUM PERMISSIBLE MACH NUMBERS

126. When flying at maximum permissible Mach numbers, acceleration of the aircraft should be performed at the full augmented rating.

The following is the procedure to be used when accelerating the aircraft to the maximum Mach number with the training purpose.

Perform take-off and climb to an altitude of 1000 m at the minimum augmented rating. When reaching an altitude of 1000 m, switch off the afterburner and continue climbing to 10,000 - 11,000 m at the maximum engine rating and at a true airspeed of 850 - 870 km/hr (if flying without missiles and the drop tank, the true airspeed should be equal to 930 - 950 km/hr).

When at an altitude of 10,000 - 11,000 m, fly level 150 - 170 km off the airfield and perform a climbing turn to

assume the acceleration course (in the direction of the airfield). At the end of the turn set the fully augmented rating and continue climbing while increasing Mach number.

At an altitude of 13,000 m bring the aircraft into a level flight and accelerate it to M = 2.05.

While in acceleration, the aircraft is steady, the effects on the control stick change but slightly and can be removed by operating the trimming effect mechanism.

Transition from a subsonic speed to a supersonic speed has a negligible effect on the aircraft longitudinal balance.

At Mach numbers equal to 1.2 and higher there sharply increase the required efforts for pedals. The ailerons are effective within the entire range of flying speeds.

127. At the maximum Mach numbers the aircraft can be subjected to different manoeuvers with the control stick in the extreme rear position but under these conditions intensive deceleration of the aircraft takes place.

When building up excessive G-force at supersonic airspeeds, the cone additionally extends by 11 mm, which causes rather great noise in the intake duct and decrease in the Mach number by 0.03.

128. On some aircraft, when they are brought into a roll at Mach numbers equal to 2.00 - 2.05 with G-force amounting to 1.5 - 2.0 at altitudes of 13,000 m and higher, after the pilot releases the pedals the ball of the bank-and-turn indicator will drift away from the balanced position and the aircraft will start oscillating in bank and direction with a period about 3 sec. These oscillations will continue within the range of Mach numbers from 2.05 to 1.85 if the pilot continues climbing. The pilot feels the oscillations in direction rather strongly (with the pedals not applied, the ball may drift away through 2.5 dia.), the oscillations in bank being insignificant (up to 5°). These oscillations are accompanied by spontaneous drifting of the pedals.

When lateral oscillations of the aircraft occur, hold the pedals firm in position, after which the oscillations in direction should diminish. After decreasing Mach number to 1.85 the aircraft oscillations will discontinue.

When in a zoom with M = 1.95 and with further climbing to the ceiling as well as when making an interception flight using different profiles with Mach numbers ranging from 1.85 to 1.95 no lateral oscillations are observed.

In a level flight up to an airspeed corresponding to the maximum permissible Mach number (M = 2.05) the aircraft lateral stability is normal (no lateral oscillations occur even when the aircraft is slipping).

129. When accelerating a normally balanced aircraft at low and middle altitudes at an airspeed of 750 ± 100 km/hr, there appear pressing forces on the control stick. At airspeeds within 850 - 950 km/hr these forces approach to zero and with further increase in the airspeed to 1100 - 1200 km/hr they practically remain the same.

Note. With the trimming effect mechanism neutral the aircraft should be balanced at an altitude of 3000 m at an indicated airspeed of 750 ± 100 km/hr.

130. While in a flight, check periodically operation of controller APY-3m by the forces on the control stick and by the indicator of controller APY-3m. Besides, check periodically:

(a) position of the air intake cone;

(b) engine r.p.m.;

(c) exhaust gas temperature;

(d) oil pressure;

(e) indicating light panels T-4 and T-10y;

(f) fuel remainder.

131. Deceleration of the aircraft may be performed by extending the air brakes (at all airspeeds and flying altitudes) and by changing the engine rating. The latter should be done by shifting the engine control lever from AUGMENTED (FORSAZH) to MAXIMUM (MAKSIMAL) at altitudes higher than 15,000 m and to IDLE (MALYY GAZ) at altitudes lower than 15,000 m.

132. Switching off the afterburner at high Mach numbers may result in aircraft slipping (with the gyro horizon ball deflecting 2 diameters away from the balanced position). This slipping can be easily counteracted by the pedals. The above

change of the directional balancing will not make flying more difficult.

133. Flying at high altitudes and maximum Mach numbers should be performed with the autopilot switched on to operate under damping conditions.

FLIGHTS TO AIRCRAFT CEILING

134. When flying without the drop tank to the aircraft ceiling use one of the following methods:

1st method. Perform take-off and climb to an altitude of 1000 m at the minimum augmented rating. On reaching 1000 m switch off the afterburner and continue climbing at the maximum rating and at a true airspeed of 850 - 870 km/hr. When at an altitude of 8000 m, set fully augmented rating and continue climbing to an altitude of 11,000 m while flying at a true airspeed of 950 - 1000 km/hr.

If it is necessary to reach the ceiling as soon as possible, perform take-off and climb to an altitude of 4000 m at the minimum augmented rating; starting from 4000 m perform flying at the fully augmented rating. In this case the climbing airspeed should be as high as 950 - 1000 km/hr.

On reaching 11,000 m accelerate the aircraft to an indicated airspeed of 1100 km/hr and perform turning at a bank of 35 - 45° while gradually climbing; maintain this airspeed (1100 km/hr) up to an altitude of 13,000 m; when at this altitude continue accelerating to an airspeed corresponding to M = 1.9. Further perform climbing at constant Mach number equal to 1.9. At an altitude of 15,500 - 16,000 m increase the climb angle to 8 - 12° and climb further while gradually decreasing Mach number so as to reach an altitude of 19,000 - 19,500 m at Mach number equal to 1.7 - 1.75.

2nd method. Perform take-off and climb to an altitude of 1000 m at the minimum augmented rating. When at an altitude of 1000 m, switch off the afterburner and continue climbing at the [illegible]mum rating and at a true airspeed of 850 - 870 km/hr. On 11,000 m bring the aircraft into a level flight, [illegible] afterburner and accelerate the aircraft to an

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indicated airspeed of 1100 km/hr, after which perform turning at a bank of 35 - 60° to assume the flight course when on the ceiling. The turn should be made while climbing so as to obtain M = 1.9 at an altitude of 13,000 - 14,000 m. On reaching 15,500 - 16,000 m increase the climb angle to 8 - 12° and continue climbing while gradually decreasing Mach number so that it is equal to 1.7 - 1.75 when an altitude of 19,000 - 19,500 m has been reached.

135. At the ceiling with the engine operating at the augmented rating the aircraft is steady in flight permitting additional turns at a bank of 35 - 40°. The aircraft longitudinal control worsening at the ceiling, avoid bringing the aircraft into a descent because even fully deflected stabilizer fails to restore the level flight at this altitude.

136. On reaching the aircraft static ceiling (when flying without the drop tank) there remains 800 - 1000 lit of fuel in the tanks which will be sufficient for flying at the ceiling during 3 - 8 min.

Discontinue fulfilling the mission and perform landing under the following conditions: when the remaining amount of fuel does not exceed 550 lit with the flight made in the day-time under ordinary weather conditions; when the remaining amount of fuel does not exceed 800 lit with the flight made in the day-time under adverse weather conditions; when the remaining amount of fuel does not exceed 650 lit in the night-time under ordinary weather conditions; when the remaining amount of fuel does not exceed 900 lit in the night-time under adverse weather conditions. In all these cases the distance to the airfield should not be in excess of 120 - 150 km.

Note. The above amounts of remaining fuel will ensure descending from an altitude higher than 16,000 m, landing approach from the assigned line, landing approach made by two 180°-turns (in case of going around) and further climbing to 2000 m in order to perform bailing-out.

137. The mission accomplished, set the engine control lever to MAXIMUM (MAKSIMAL) to switch off the afterburner, extend the air brakes (if required) and perform descending

while gradually decreasing Mach number. Throttling down the engine to r.p.m. lower than the maximum rating should be made at an altitude not higher than 15,000 m. Descending from an altitude of 15,000 m should be made with the engine control lever set to IDLE and at an indicated airspeed of 500 - 550 km/hr.

138. To reach an altitude of 20,000 m, use the dynamic method (zooming) starting it from an altitude of 15,500 - 16,000 m. Zooming should be made in the same way as when climbing to 19,000 - 19,500 m. On attaining an indicated airspeed of 550 - 530 km/hr while in a zoom, smoothly deflect the control stick forward for 6 - 7 sec so as to attain an airspeed of not less than 500 km/hr by the end of the zoom.

Depending on the flying altitude and intensity of maneuvering a dynamic-altitude flight may last 1 - 2 min. When flying at dynamic altitudes, correction turns should be performed by smoothly deflecting the control stick. Energetic maneuvering will cause rapid loss of altitude and decrease of airspeed.

MANEUVERING FLIGHT

General

139. The aircraft allows performing elementary flight maneuvers, advanced flight maneuvers and aerobatics. When making first flights to master the aircraft, it is allowed to perform aerobatics at altitudes from 4000 to 10,000 m.

Before making a maneuvering flight it is necessary to balance the aircraft at an altitude of 6000 m and at an indicated airspeed of 800 km/hr.

140. It is forbidden to perform a maneuvering flight with autopilot KAP-2 switched to stabilization operating duty.

141. When maneuvering it is allowed to reach negative G-loads for not longer than 15 sec at the engine r.p.m. not exceeding maximum rating and for not longer than 5 sec at augmented rating. G-load approaching zero is allowed to be obtained for not longer than 1 - 2 sec.

Repeated negative G-loads are allowed to be obtained not earlier than 30 sec after flying under positive G-load.

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CAUTION. Flying under negative G-loads is allowed provided that the amount of fuel remaining in the tanks is not less than 500 lit.

Flying under negative and zero G-loads may cause drop of inlet oil pressure to zero (which is allowed for a period of not longer than 17 sec); after changing over to flying under positive G-loads the oil pressure becomes normal.

142. Manoeuvering in the vertical plane at Mach numbers exceeding 1.0 requires greater deflection of the control stick.

When performing vertical manoeuvering at the engine maximum rating, the aircraft rapidly loses the airspeed as it approaches the top point. This is why the pilot should deflect the controls in accurate and commensurated movements. When performing vertical manoeuvers at the augmented rating, the airspeed drops not so rapidly.

Making a series of ascending and descending manoeuvers at the maximum rating leads to general loss in altitude; when making these manoeuvers at the augmented rating no drop of altitude takes place.

Start entering ascending vertical manoeuvers when in a level flight at the assigned engine rating.

143. When manoeuvering at subsonic airspeeds, even small G-loads will cause vibration of the aircraft. Further increase of G-load will not cause aircraft spinning but it may result in aircraft wing rocking. This being the case, release the control stick to discontinue rocking.

144. When manoeuvering, the pilot should make use of the gyro horizon to see whether the manoeuvers are performed correctly. The gyro horizon helps the pilot to:

(a) precisely maintain the assigned banks, the dive angles and check them while performing manoeuvers;

(b) make coordinated movements of the control stick and the pedals when entering a manoeuver, in the course of the manoeuver and when recovering;

(c) determine the aircraft attitude relative to the natural horizon;

(d) become aware of inaccurate manouvering (wrong banks, slipping, poorly coordinated movements of the control stick and pedals) particularly when performing manouvers in the vertical plane.

Banked Turn

145. Banked turns are allowed to be made within the entire range of flying altitudes and airspeeds.

At altitudes up to 5000 - 6000 m it is allowed to perform banked turns at banks up to 60 - 70° with training purposes at the maximum rating and at an indicated airspeed within 550 - 750 km/hr.

The banked turns with the engine operating at the maximum rating at altitudes exceeding 5000 - 6000 m are allowed to be performed at bank angles up to 60° (greater bank angles will lead to decrease in airspeed).

Banked turns at a bank of 60 - 70° at altitudes of 6000 - 10,000 m should be performed at the engine augmented rating at an indicated airspeed of 550 - 750 km/hr; for altitudes higher than 10,000 m they are allowed at an altitude corresponding to M ≥ 1.2.

There is no difference in performing left and right banked turns.

146. Before entering a banked turn obtain the required airspeed and then by a coordinated movement of the control stick and pedals bring the aircraft into the manouver simultaneously increasing the engine thrust to the required engine rating.

When checking the banked turns for accuracy of performance, refer to the turn-and-bank indicator, vertical speed indicator, airspeed indicator and altimeter.

Rolling out of the turn should be made by a coordinated movement of the control stick and pedals while simultaneously decreasing the engine thrust so as to bring the aircraft into a level flight without changing the airspeed.

147. When accomplishing banked turns at subsonic airspeeds, even comparatively small G-loads cause peculiar

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vibration of the aircraft. However, further increase of G-load will not result in spinning of the aircraft, $C_{y\ max.}$ considerably exceeding C_y at the moment the vibration started. The aircraft starts rocking from wing to wing only in case of pulling the control stick excessively. This being the case, let the control stick go slightly forward as further increase in G-load may bring the aircraft into a spin.

148. Banked turns at banks within 60 - 70° when flying at altitudes higher than 10,000 m at an airspeed corresponding to M ≥1.2 should be made with the control stick pulled to the extreme rear position. Under these conditions G-load will reach a value of 3 - 4, with the aircraft never experiencing vibration. However it should be remembered that during transition from the supersonic speed to the subsonic speed the aircraft energetically increases its rate of turn and reaches greater angles of attack due to the increased effectiveness of the stabilizer. To avoid reaching excessive G-loads, reduce deflection of the control stick starting from Mach numbers equal to M = 1.15 - 1.2.

149. When flying with the drop tank, the techniques used in making banked turns are practically the same as in the case of accomplishing banked turns without the drop tank.

Chandelle

150. Chandelle is allowed to be performed at the normal, maximum and augmented ratings at airspeeds not exceeding the maximum permissible values.

In the course of a chandelle made at the maximum rating at the entry airspeed equal to 900 - 950 km/hr IAS the aircraft gains an altitude of 3000 - 4000 m (the entry altitude being 4000 m). The recovery airspeed should be equal at least to 400 km/hr IAS.

151. Before entering a chandelle set the required rating, accelerate the aircraft to the assigned airspeed while in a level flight and smoothly move the control stick rearward and to the side in which the chandelle is to be made in order to bring the aircraft into a climb along the ascending spiral with the

initial bank being equal to 5 - 10°. See that the bank at the end of the second period of the chandelle (consisting of these periods) is not in excess of 65 - 70°.

After the aircraft has turned through 140 - 150°, gradually decrease the bank and angle of climb. To this end, simultaneously move the control stick diagonallically forward and to the side opposite to the turn and deflect the pedal to the same side. Then apply coordinated aircraft controls so as to roll out of the turn into a level flight (just after the aircraft has turned through 180°) at an indicated airspeed of at least 400 km/hr.

152. To perform the chandelle within the minimum possible time, irrespective of the amount of altitude to be gained, obtain the required airspeed, bank the aircraft by 15 - 20° and then by deflecting the control stick full way to the rear energetically perform the first half of the oblique loop. When the aircraft is short of the inverted position (which corresponds to the turn made through 160 - 165°) and its nose is 10 - 15° short of the horizon line, bring the aircraft into a level flight by a coordinated movement of the control stick and pedals, after which place the controls neutral.

Half-Roll

153. Half-rolls are allowed to be performed at altitudes from 5000 m to the aircraft ceiling.

Initially, when the flying personnel is trained in advanced flying, half-rolls should be performed at altitudes from 6000 to 10,000 m; under these conditions an altitude loss will amount to 3000 - 6000 m.

When entering the half-roll, the indicated airspeed should be as follows:

- not over 600 km/hr at an altitude of 5000 m;
- not over 700 km/hr at an altitude of 7000 m;
- not over 1000 km/hr at altitudes 10,000 m and higher.

At these altitudes and airspeeds it is allowed to perform half-rolls with the air brakes retracted or extended before entering the manoeuver.

154. Before entering the half-roll reach the assigned altitude and after attaining the required airspeed smoothly deflect the control stick rearward to reach a pitch angle of 10 - 15°. Deflect the control stick and the pedal to the side of the half-roll so as to bring the aircraft to the inverted flight position within 2 - 3 sec after which reduce the engine r.p.m. to the idle rating (at an altitude lower than 15,000 m).

When in the inverted flight position, discontinue rolling and without holding the aircraft in this position smoothly pull the control stick rearward so as to recover from the dive into a level flight at an indicated airspeed not less than 600 km/hr.

155. When recovering from the dive, avoid overpulling or too slow pulling of the control stick.

Overpulling of the control stick may result in heavy vibration of the aircraft or in its rocking from wing to wing. To discontinue vibration or rocking, reduce the control stick travel to the rear.

When the control stick is pulled too slowly, the airspeed rapidly increases with simultaneous loss in the altitude.

CAUTION. If no relay unit RP-4 is available in the directional system set, it is forbidden to perform half-rolls and half-loops because the readings of the directional system become changed through 180°.

Roll

156. It is allowed to perform snap and slow controlled rolls in the vertical and level planes at indicated airspeeds not less than 550 km/hr.

157. To perform the snap controlled roll with the training purposes, bring the aircraft into a level flight at an indicated airspeed of 600 - 700 km/hr; then bring it to pitching at an angle of 10 - 15° and after holding it in this position move smoothly the control stick to the side of the roll and rotate the aircraft about its longitudinal axis. The snap roll should be performed within 4 - 5 sec.

To perform the snap controlled roll at higher airspeeds, obtain a pitch angle of 15 - 20° depending on the airspeed. Then follow the procedure used for performing snap rolls at an airspeed of 600 - 700 km/hr.

158. The slow controlled roll is performed within 10 - 12 sec. One portion of the maneuver should be performed at positive angles of attack, the other one, at negative angles. In view of this the pilot experiences G-forces varying in their sign.

To make a slow roll when flying level at an indicated airspeed of 700 - 800 km/hr, bring the aircraft into pitching at an angle of 15 - 20° and hold it in this position. Then move the control stick smoothly to the side of the roll and rotate the aircraft about the fore-and-aft axis. While rolling, hold the aircraft nose from dropping by coordinated movements of the control stick and pedals. As soon as the aircraft assumes the attitude of a level flight, place the controls for recovery; after rolling discontinues, place the controls neutral.

159. Double (multiple) horizontal rolls are performed as a series of rolls (two or more). It is possible to make both snap and slow double (multiple) horizontal rolls. When making a double horizontal roll, the entry airspeed at medium altitudes should be at least 600 - 700 km/hr.

The technique used for performing a series of rolls is similar to that employed for making single rolls.

Nesterov's Loop

160. The loop should be started from altitudes not exceeding 5000 m with the engine operating at the maximum rating and from altitudes not exceeding 7000 m with the engine operating at the augmented rating.

When making a loop, the entry indicated airspeed should amount to 950 km/hr at least.

161. Before entering a loop obtain the required airspeed and then bring the aircraft into a climb by pulling the control stick rearward at a rate which will ensure obtaining G-forces equal to 4.5 - 5.5 by the moment the aircraft has reached a

pitch angle of 30 - 40° (G-force should be checked by reference to the G-meter); then without releasing the control stick keep the aircraft flying along the loop trajectory in the vertical plane.

Pulling the control stick rearward should be made in such a way as to maintain the angular rate constant while the aircraft is flying along the loop trajectory; by the moment the aircraft reaches the inverted flight position the indicated airspeed should be equal at least to 400 km/hr.

When at the top point of the loop with the aircraft nose somewhat below the horizon line, move the engine control lever smoothly as far as the idle rating stop, bring the aircraft into a dive and then into a level flight using the same techniques as in the case of a half-roll.

162. When making a loop, particularly at the maximum rating, operate the controls in accurate and commensurated movements. Overcontrolling with the stick as well as pulling it in too slow (noncommensurate) movements in the first half of the loop will lead to premature loss of the airspeed when approaching the top point.

Oblique Loop

163. The oblique loop should be performed while flying along the trajectory in the slanting plane at the same flying altitudes and airspeeds as when making Nesterov's loop.

Before entering an oblique loop select the reference point and obtain the required airspeed; then bank the aircraft through 15 - 45° and while maintaining this bank enter the oblique loop just in the same way as in the case of an ordinary loop. While on the trajectory, it is necessary to maintain the above bank by reference to the natural horizon and to the gyro horizon.

After the aircraft has entered a dive, maintain the direction during the recovery by slightly deflecting the pedal to the side opposite to the bank. When recovering for a level flight, restore the level position of the aircraft by eliminat-

ing the bank and place the pedals neutral. Recovery should be made in the same direction which has been selected for entering the dive.

The main difficulty experienced by the pilot when making an oblique loop will be maintaining the assigned bank while approaching the top point of the loop and particularly after crossing it.

At the initial stages of training it is advisable to perform oblique loops at a bank not exceeding 20°.

Half-Loop

164. The half-loop should be made starting from altitudes not higher than 5000 m with the engine operating at the maximum rating and starting from altitudes not higher than 7000 m with the engine operating at the augmented rating.

When entering a half-loop, maintain an indicated airspeed not less than 950 km/hr.

While making a half-loop from 5000 m at the maximum rating the aircraft will gain about 4000 m.

165. The technique used in making the first half of the half-loop is similar to that used when performing the first half of the loop, with all peculiarities remaining the same. When the aircraft nose reaches the horizon line with the aircraft in the inverted flight position (the airspeed should be at least 400 km/hr) smoothly deflect the control stick and the pedal to the desired side to roll the aircraft about its fore-and-aft axis through 180° (i.e. to accomplish a half-roll). Operate the aircraft controls so as to perform rolling within 3 - 4 sec.

To avoid losing the airspeed and to be able to maintain the required direction in the recovery after the aircraft has completed turning about the fore-and-aft axis through 90°, move the control stick to the side of the roll and simultaneously slightly forward. If the airspeed at the top point of the half-loop is less than 400 km/hr, complete the maneuver by making the loop.

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Zoom

166. The zoom can be performed within the entire altitude range at the normal, maximum and augmented ratings with the airspeed not exceeding the maximum permissible value for the given altitude. Depending on the entry altitude and airspeed the angle of zoom may vary from 15 to 80°.

167. After accelerating the aircraft to the assigned airspeed smoothly pull the control stick rearward in order to attain and then to maintain the required angle of climb. Make sure that the angle of climb is correct and that no banking of the aircraft takes place by reference to the gyro horizon. At an airspeed of at least 500 - 600 km/hr (depending on the zooming angle) bring the aircraft into a turn by coordinated movements of the control stick and pedals, lower the aircraft nose as far as the horizon line and then roll out of the turn.

Recovery from a zoom can be also performed by rolling about the fore-and-aft axis through 180° with simultaneous lowering of the aircraft nose as far as the horizon line and further rolling through another 180° (the latter being a half-roll made in a desired direction).

Zooming Half-Roll

168. A zooming half-roll performed with the training purposes should be made at altitudes from 5000 to 10,000 m with the entry speed being 800 - 850 km/hr IAS.

When at altitudes below 5000 m or higher than 10,000 m with the entry airspeeds exceeding 850 km/hr (up to the maximum permissible airspeed), a zooming half-roll is allowed only after training it at altitudes from 5000 to 10,000 m.

169. After accelerating the aircraft to the assigned airspeed it is necessary to pull the control stick smoothly rearward in order to attain and then to maintain an angle of climb whose amount will depend on the airspeed. Thus, with the airspeed of entry amounting to 800 - 850 km/hr, the angle of climb should be equal to 40 - 45°. On reaching an airspeed of 500 - 550 km/hr while in a zoom, smoothly deflect the controls to the desired side and roll the aircraft about its

fore-and-aft axis through 180° (i.e. perform a half-roll) and then, while watching the airspeed, deflect the control stick rearward to bring the aircraft nose to the horizon line (with the aircraft in the inverted flight position). This being the case, the airspeed should be at least 400 - 450 km/hr; depending on the altitude and the airspeed the half-roll may be completed by making the second half of Nesterov's loop or by making a half-roll followed by bringing the aircraft into a level flight.

At angles exceeding 45° start zooming half-rolls at an airspeed of at least 600 km/hr.

Spiral

170. The optimum conditions for making spirals are as follows: bank - 45°, airspeed - 500 - 550 km/hr, engine setting - idle.

With the landing gear and flaps extended the spiral should be made with increased engine r.p.m. at an indicated airspeed of 450 km/hr and at a rate of descent not over 25 - 30 m/sec.

When performing a spiral from an altitude of 5000 m the aircraft loses 1500 - 1600 m within one turn.

171. Basically, the spiral is performed using the same technique as in the case of the banked turn.

Before entering the spiral perform gliding at an airspeed of 500 - 550 km/hr and then bring the aircraft into a spiral by coordinated movements of the control stick and pedals.

When making a spiral, decrease or increase the airspeed by the corresponding change in the tilt angle of the aircraft fore-and-aft axis relative to the horizon line (i.e. by lifting or lowering the aircraft nose).

Recovery from the spiral is made by a coordinated movement of the control stick and pedal with the simultaneous increase in the engine r.p.m. when recovery is made to a level flight. Increase in the engine r.p.m. may be also made after recovering from the spiral when in a glide.

172. When recovering from a steep spiral with the aircraft fore-and-aft axis tilted relative to the horizon line at more than 30° it is necessary to remove the bank and then to recover from the dive.

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FLIGHTS IN WHICH ARMAMENT IS EMPLOYED

175. Before making a flight in which the aircraft armament is to be employed the pilot should listen to the report of the technician. The technician should report on the aircraft armament indicating the armament system prepared for the in-flight operation, amount of ammunition and available film for the camera gun.

174. During preflight inspection check the following:

(a) when the mission includes launching special missiles P-3c: the missile for secure locking on the launcher; position of the aileron stops; the APU-3c automatic launcher for presence of safety pin; the missile homing device for presence of protective caps; the proximity fuses for presence of safety bands; the operating contacts of the missile control surfaces for presence of protective casings;

(b) when the mission includes firing rocket missiles (O-5m; O-5k): load-carrying levers of shackle M3-57 for secure closing; launching unit (launcher) for being properly suspended from the load-carrying levers of the locks; position of the latch locking the rear fairing of the YB-16-57y rocket pod in the closed position.

CAUTION. Before taking his seat in the cockpit the pilot should make certain that all the required circuit breakers on the rear right-hand electrical switch panel are ON.

While preparing the cockpit for the flight, check the operation of the radar sight, the collimating sight and the camera gun.

Preparation and Check of Radar Set RL-9-21

175. Before switching on the radar set make sure that:

(a) the mode of operation selector switch is set to TRACKING (СОПРОВОЖДЕНИЕ);

(b) selector switch DAY - NIGHT (ДЕНЬ - НОЧЬ) is set to position depending on the time of the day;

(c) selector switch LOW ALTITUDE - ALTITUDE (МАЛАЯ ВЫСОТА - ВЫСОТА) (if available)is set to position ALTITUDE (ВЫСОТА);

(d) mode of measuring selector switch on the control panel is set to TM;

(e) knob LIGHTING (ПОДСВЕТ) on the front panel of the indicator is in the extreme right-hand position.

Flight Involving Launching Missiles P-3c

176. Launching single missiles P-3c is allowed to be made with intervals not less than 4 - 5 sec for ranges from 1 to 7.6 km and with target aspect angles from 0 to 3/4.

When launching missiles at altitudes up to 14,500 m, G-load should not exceed 2, while at altitudes higher than 14,500 m it should not exceed 1.6.

While launching missiles under the above conditions, warning light G-LOAD LIMIT (СИГНАЛ ПЕРЕГРУЗКИ) should not be burning.

The permitted launching range is determined:

(a) through the use of radar sight (when the range marks get within the permitted range zone);

(b) through the use of fighter's collimating sight ПКИ (visually or following the command of the flight control officer with allowance for flying altitude, own airspeed and rate of closure with the target).

Red indicating light BREAK-OFF (ВЫХОД ИЗ АТАКИ) on the sight indicator will become on:

(a) at altitudes up to 14,000 m with range being equal to 1.3 ± 0.3 km;

(b) at altitudes higher than 14,000 m with range being equal to 1.95 ± 0.45 km.

To avoid spontaneous cut-out of the engine, perform launching under the following flying conditions:

(a) at altitudes below 5000 m with Mach numbers not less than 0.8;

(b) at altitudes within 5000 - 15,000 m with Mach numbers not less than 1.0;

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(c) at altitudes higher than 15,000 m with indicated airspeeds not less than 500 km/hr.

Notes: 1. Launching of missiles P-3c at altitudes within 5000 - 15,000 m with Mach numbers ranging from 0.8 to 1.0 is allowed. However, it should be remembered that under these conditions spontaneous cut-out of the engine is possible sometimes.
2. Launching of missiles P-3c with Mach numbers less than 0.8 is forbidden because of poor controllability of the missiles launched under these conditions.
3. Salvo launching of missiles P-3c is allowed only in the exceptional cases.

CAUTION. With the engine operating unsteadily at the partially augmented rating, launching the missiles at altitudes higher than 15,000 m at indicated airspeeds less than 500 km/hr is possible within the entire altitude range, though such launching leads as a rule to spontaneous cut-out of the engine.

177. On entering the cockpit proceed as follows:

(a) give command to remove the protective caps from the homing device of the missiles and to withdraw the safety bands from the fuses;

(b) switch on circuit breakers SP. MSL HEATER (ОБОГРЕВ СС) and SP. MSL FILAMENT (НАКАЛ СС) (with the ground power source connected) and make sure that indicating lights RIGHT SP. MSL SUSPENDED (ПОДВЕШЕН СС ПРАВ.) and LEFT SP. MSL SUSPENDED (ПОДВЕШЕН СС ЛЕВ.) are burning;

(c) check (i.e. listen to) the audible signal indicating that the target has been locked-on by the special missile homing devices (after the technician points the beam of the flashlight to the homing devices of the missiles from a distance of 0.5 - 1.0 m, place switch SP. MSL LAUNCH., LEFT - RIGHT (ПУСК СС, ЛЕВЫЙ - ПРАВЫЙ) in turn to the required position) and adjust the signal volume by operating knob LOCK-ON, QUIETLY - LOUDLY (ЗАХВАТ, ТИШЕ - ГРОМЧЕ);

(d) place the launching variant switches depending on the assignment to SALVO (ЗАЛП) or SINGLE (ОДИНОЧНО); in the latter case place the switch to RIGHT (ПРАВЫЙ) or to LEFT (ЛЕВЫЙ);

(e) switch off circuit breakers SP. MSL HEATER (ОБОГРЕВ СС) and SP. MSL FILAMENT (НАКАЛ СС).

Note. Should the flight be postponed, put on protective caps on the missile homing devices and remove them only before starting the engine.

178. After the engine has been started switch on circuit breakers SP. MSL HEATER (ОБОГРЕВ СС), SP. MSL FILAMENT (НАКАЛ СС) and CAMERA GUN (ФКП). Before taxiing command the technician to remove the safety pins from automatic launchers АПУ-3с and to take off the casings from the operating contacts and from optical proximity fuses of missiles Р-3с.

After taking off switch on the radar sight completely by placing the selector switch on the control panel to HIGH VOLTAGE ON (ВЫСОКОЕ ВКЛЮЧЕНО) which will be indicated by flashing-up of the light on the control panel; this done, check the instrument on the radar sight control panel for correct reading. After checking place the mode of measuring selector switch to ТМ. Check the radar sight for changing over to operation under fixed beam conditions and check operation of instantaneous erasure button.

By placing the switch to ON (ВКЛЮЧЕНО) change over the radar sight to operation under preliminary switch-on conditions.

179. On being informed by the flight control officer that the fighter has reached the target area, switch on the radar sight completely, switch on circuit breakers LAUNCHING OF SP. MSL, RKT MSL (ПУСК СС, РС) and proceed to target scanning on the indicator screen.

180. After locating the target image manoeuvr the aircraft to bring the target image to the zero azimuth line and obtain a steady position of marks TOP (ВЕРХ) and BOTTOM (НИЗ).

As soon as the target image reaches within the target lock-on area while approaching the target, press button LOCK-ON (ЗАХВАТ) on the control stick in order to accomplish target lock-on. After the sighting mark (pip) has appeared on the indicator screen, release the lock-on button.

If the target failed to be locked, release the lock-on button, determine position of the target more accurately and, when at the lesser range than before, press the lock-on button again.

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131. After locking on the target perform aiming, for which purpose manouver the aircraft in order to move the centre of the sighting mark into the sighting (smaller) ring of the indicator scale. When the range marks of the pip get within the area covering the permitted launching range area provided that the audible signal has reached its maximum volume (the signal indicating that the target has been locked on by the missile homing device), perform launching of a missile (or missiles) by pressing the fire button for 2 sec. While doing this, warning light G-LOAD LIMIT (СИГНАЛ ПЕРЕГРУЗКИ) should not be burning.

Departure of the missile (missiles) from the launcher will be indicated by indicating light RIGHT (LEFT) MISSILE SUSPENDED (ПОДВЕШЕН ПРАВЫЙ (ЛЕВЫЙ) which should go out.

To launch the second missile, release the fire button and after obtaining the initial launching conditions press it again. After the departure of the first missile the second missile launching circuit gets energized automatically. Should it occur that the second missile launching circuit has failed to get switched on automatically or if the first missile has failed to depart, it is necessary to place manual switch SP. MSL LAUNCH., LEFT - RIGHT (ПУСК СС, ЛЕВЫЙ - ПРАВЫЙ) to the position for launching the second missile.

182. After launching the missiles break away from the enemy, switch off the radar sight by placing the switch to RADAR SET OFF (СТАНЦИЯ ВЫКЛЮЧЕНА) and circuit breakers LAUNCHING OF SP. MSL, RKT MSL (ПУСК СС, РС), SP. MSL FILAMENT (НАКАЛ СС), SP. MSL HEATER (ОБОГРЕВ СС) and GUNNERY GUN (СКП) to OFF.

Notes: 1. When launching special missiles P-3c at ground targets, do not switch on the radar sight, but perform aiming with the use of the ПКИ collimating sight; switch on circuit breaker LAUNCHING OF SP. MSL, RKT MSL (ПУСК СС, РС) on reaching an airspace indicated in the Firing Range Operating Instructions.

2. When landing with special missiles P-3c suspended, switch off circuit breakers SP. MSL HEATER (ОБОГРЕВ СС) and SP. MSL FILAMENT (НАКАЛ СС) after landing.

183. When the target resorts to radio interferences which make it impossible for the fighter to lock on the target, it is necessary to:

(a) approach the target under the conditions of scanning until it is visually observed;

(b) perform aiming using the ИКМ collimating sight while obtaining maximum volume of the audible signal indicating that the target has been locked on by the missile homing device;

(c) determine the permitted launching range visually or following the command from the flight control officer.

184. To perform emergency launching of the missiles, throw back the cap and press button EMERG. LAUNCH. OF SP. MSL. (АВАРИЙНЫЙ ПУСК СО). In this case both missiles will depart simultaneously, no target seeking will occur but the optical proximity fuse will remain operative. After the missiles have departed, the missile suspended indicating lights will go out.

For the time being, emergency launching of missiles is recommended to be performed under the flight conditions which correspond to those selected for tactical launching of missiles.

185. In order to drop automatic launcher АПУ-3с together with the missiles or without them, throw back the cap and press button АПУ EMERGENCY DROP (АВАРИЙНЫЙ СБРОС АПУ). After dropping the launchers together with the missiles the missile suspended indicating lights should go out.

It is recommended that emergency drop of automatic launcher АПУ-3с together with the missiles should be made in a level flight at an altitude of 5000 m and at an indicated airspeed from 700 to 800 km/hr.

Flight Involving Firing Rocket Missiles C-5м and C-5с

186. Firing rocket missiles С-5м and С-5с at altitudes up to 13,500 m should be made while flying at an indicated airspeed not in excess of 1000 km/hr; when firing at altitudes higher than 13,500 m, maintain an airspeed corresponding to Mach number not exceeding 1.6.

CAUTION. It is allowed to fly with rocket missiles under

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the flight conditions prescribed by the present Instructions and to build up relative G-loads only after receiving additional instructions.

187. On entering the cockpit proceed as follows:

(a) make certain that Indicating Lights LEFT SP. MSL SUSPENDED (ПОДВЕШЕН СО ЛЕВЫЙ) and RIGHT SP. MSL SUSPENDED (ПОДВЕШЕН СО ПРАВЫЙ) are burning;

(b) switch on circuit breaker RKT MSL (PO) with rocket pods UB-16-57y suspended and make sure that rocket missile zero position indicating lights are on;

(c) adjust brightness of the NKI collimating sight reticle lighting.

188. After taking off proceed as follows:

(a) perform preliminary switching-on of the radar sight;

(b) with rocket pods UB-16-57y suspended, set the assigned launching variant for rocket missiles PO, i.e., AUTOMATIC (ABTOMAT), 2 SALVOES (2 ЗАЛПА) or 1 SALVO (2 ЗАЛП);

(c) on receiving the relative command from the flight control officer after reaching within the target area perform switching-on of the radar sight completely and switch on circuit breaker LAUNCHING OF SP. MSL, RKT MSL (ПУСК СО, РО);

(d) locate the target (target image) on the screen of the radar sight indicator, approach the target till it can be located visually and attack it by firing the missiles. Aiming should be made visually through the use of the NKI collimating sight.

189. After firing withdraw from the attack, switch off the radar sight and circuit breakers RKT MSL (PO) and LAUNCHING OF SP. MSL, RKT MSL (ПУСК СО, РО).

Note. When firing at ground targets, do not switch on the radar sight. Circuit breaker LAUNCHING OF SP. MSL, RKT MSL (ПУСК СО, РО) should be switched on when on the combat course and switched off when firing has been discontinued.

190. To drop rocket pods UB-16-57y from the racks, it is necessary to throw back the cap bearing inscription EMERGENCY DROP OF APU (АВАРИЙНЫЙ СБРОС АПУ) and press the

button. After dropping the rocket pods indicating lights RIGHT MISSILE SUSPENDED (ПОДВЕШЕН ПРАВЫЙ) and LEFT MISSILE SUSPENDED (ПОДВЕШЕН ЛЕВЫЙ) should go out.

CAUTIONS: 1. In case of a forced landing, perform an emergency drop of the rocket missiles. Depending on the situation it is possible to drop missiles Р-3с either together with launcher АПУ-3с using the emergency drop system or making use of the emergency launching system.

2. It is forbidden to taxi to the parking site with ammunition on board the aircraft. When any ammunition remains in the aircraft, it is necessary to taxi to the assigned site to unload the armament.

FLYING UNDER ADVERSE WEATHER CONDITIONS

191. Instrument landing approach and judgement with the use of the ILS equipment may be performed using the following methods: landing approach from the estimated line, straight-in landing approach, landing approach in two 180°-turns and rectangular pattern landing approach. Landing approach from the estimated line is the main instrument landing approach used.

Approach and estimation for landing made in two 180°-turns and rectangular pattern landing approach are used when it is impossible to perform landing approach from the estimated line or straight-in landing approach, and with the training purposes.

Preflight Preparation

192. Before making a flight under adverse weather conditions listen to the technician's report and inspect the aircraft using the same procedure as in the case of a flight to be made under ordinary weather conditions.

When inspecting the aircraft, particular attention should be paid to the operation of the gyro horizon, autopilot, directional system, radio compass, radio set, stand-by gyro horizon ДА-300 (200) and other flight and navigation instruments.

CAUTION. Gyro horizon АГД-1 and directional system КУС should be ready for operation at least in 2 min since they have been switched on (which period is their starting time).

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deflecting from 0 to 180°. When flying over the outer homing beacon, start the stop-watch, turn the aircraft to the assigned course (through the correction turn angle) and proceed flying during the estimated time, after which perform a turn to the landing course. While turning decrease the altitude by 200 m and change the bank to accurately take the landing course.

Flying from the outer homing beacon to the moment the landing course is assumed should be made at an indicated airspeed of 600 km/hr.

202. After assuming the landing course extend the landing gear when performing a 30-sec level flight, obtain an indicated airspeed of 500 km/hr and then bring the aircraft into a descent.

When on the landing course, maintain the following rate of descent:

(a) 40 m/sec down to an altitude of 2000 m;

(b) 15 m/sec from 2000 to 1000 m;

(c) 10 m/sec from 1000 to 600 m;

(d) 5 m/sec from 600 to 300 m.

203. When at an altitude of 300 m, bring the aircraft into a level flight, reduce the airspeed to 450 km/hr and continue flying at this altitude (in the overcast or below the cloud base) until reaching within the outer marker beacon area. Flying over the outer marker beacon should be made at an altitude of 300 m.

204. When flying over the outer marker beacon, as soon as the radio compass gets automatically switched over from the outer marker beacon frequency to the inner marker beacon frequency, turn the aircraft to obtain Radsta RB (KYP) = 0, extend the flaps, start descending at a vertical rate of descent equal to 5 - 7 m/sec. Then, while maintaining Radsta RB (KYP) = 0, approach the inner marker beacon at an altitude of 80 - 100 m and at an airspeed of 360 - 380 km/hr. After flying over the inner marker beacon finalize the landing approach and estimation visually and perform landing.

In addition to the above said flying over the outer and inner marker beacons should be checked by operation of the aircraft light and sound signalization system.

Note. Should the radio compass fail to switch over automatically to the inner marker beacon frequency, switch it over to that frequency manually by placing selector switch OUTER - INNER (ДАЛЬНЯЯ - БЛИЖНЯЯ) to INNER (БЛИЖНЯЯ).

Approach and Estimation for Landing from Estimated Line

205. After accomplishing the mission establish radio contact with the flight control officer (ILS ground facilities), report the flying altitude and proceed to the descent starting line with a course assigned by the flight control officer.

On reaching the descent starting line turn the aircraft (following the command given from the ground) to assume the assigned course and then bring it into a descent while maintaining the assigned rating. In the course of descending follow the commands from the ground and correct the course and vertical rate of descent accordingly.

Note. The direction of descending (i.e. course) should be given to the pilot so that he can bring the aircraft to an altitude of 2000 m just to a point where the turn to the landing course should be started. The flight conditions under which the descent is to be made are established by the flight control officer. When flying with the training purposes, descending to an altitude of 2000 m should be performed at an indicated airspeed of 500 km/hr and a rate of descent equal to 40 m/sec.

206. On reaching an altitude of 2000 m bring the aircraft into a level flight and then perform a correction turn at a bank of 30° to take the landing course. To bring the aircraft on the landing course accurately, change the bank, if required, follow all the commands sent by the ground flight control post and request radio bearings.

207. When on the landing course (while flying during 30-sec level), obtain an indicated airspeed of 500 km/hr, extend the landing gear and start descending using the same procedure as in the case of a straight-in landing.

208. If it ap[illegible] descending through the overcast (due to excessively high airspeed, inaccurate approach for landing, etc), perform a go-around procedure and request clearance for visual landing approach below the overcast or for instrument landing approach (when in the overcast or below) made in two 180°-turns depending on the weather conditions and terrain relief.

Landing Approach and Estimation Made in Two 180°-Turns

209. When making a go-around procedure in order to approach for landing in two 180°-turns, accelerate the engine to maximum r.p.m., start the stop-watch at the moment of flying over the inner marker beacon, turn the aircraft to take the landing course and then, when flying at an airspeed of 500 km/hr at the vertical rate of descent equal to 5 - 10 m/sec, gain the assigned altitude (500 m). While gaining the altitude, retract the landing gear and flaps.

210. One minute after flying over the inner marker beacon (or 1 min 30 sec after flying over the outer marker beacon) perform a turn at a bank of 30° to assume the course reverse to the landing one. If required, after turning correct the course for drift. Two minutes after leaving the beam of the outer marker beacon while flying level perform a turn for the landing course maintaining a bank of 30°. When in the second half of the turn make efforts to accurately assume the landing course by changing the amount of bank.

211. When making a 30-sec level flight after assuming the landing course, extend the landing gear, decrease the airspeed down to 450 km/hr and bring the aircraft into a descent with the rate of descent amounting to 5 m/sec. Then follow the procedure used for a straight-in landing approach.

Landing Approach and Estimation by Flying Rectangular Traffic Pattern

212. When going around in order to perform a landing approach by flying the rectangular traffic pattern, increase the engine r.p.m. to the maximum value, start the stop-watch

208. If it appears impossible to make a landing just after descending through the overcast (due to excessively high airspeed, inaccurate approach for landing, etc), perform a go-around procedure and request clearance for visual landing approach below the overcast or for instrument landing approach (when in the overcast or below) made in two 180°-turns depending on the weather conditions and terrain relief.

Landing Approach and Estimation Made in Two 180°-Turns

209. When making a go-around procedure in order to approach for landing in two 180°-turns, accelerate the engine to maximum r.p.m., start the stop-watch at the moment of flying over the inner marker beacon, turn the aircraft to take the landing course and then, when flying at an airspeed of 500 km/hr at the vertical rate of descent equal to 5 - 10 m/sec, gain the assigned altitude (500 m). While gaining the altitude, retract the landing gear and flaps.

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211. When making a 30-sec level flight after assuming the landing course, extend the landing gear, decrease the airspeed down to 450 km/hr and bring the aircraft into a descent with the rate of descent amounting to 5 m/sec. Then follow the procedure used for a straight-in landing approach.

Landing Approach and Estimation by Flying Rectangular Traffic Pattern

212. When going around in order to perform a landing approach by flying the rectangular traffic pattern, increase the engine r.p.m. to the maximum value, start the stop-watch

when flying over the inner marker beacon, make a correction turn to assume the landing course and start climbing after reaching an airspeed of 500 km/hr. In the course of the climb retract the landing gear and flaps. At an altitude of 500 m bring the aircraft into a level flight. After the inner marker beacon has been flown over and the estimated time (1 min) has elapsed make a turn through 90°.

With the radio station relative bearing being 240° (120°) perform the second turn at a bank of 30° to assume the course reverse to the landing one. Proceed flying with this course and report over the radio when flying abeam of the inner marker beacon; with the radio station relative bearing being equal to 230° (130°), make the third turn through 90°. Having made the turn and as soon as the radio station relative bearing has become equal to 285 - 290° (75 - 80°), start turning in the level plane to assume the landing course. By changing the bank obtain accuracy in assuming the landing course.

213. On the landing course, while making a 30-sec level flight, reduce the airspeed to 450 km/hr and bring the aircraft into a descent at a vertical rate of 5 m/sec. Then use the same procedure as in the case of a straight-in landing approach performed from an altitude of 500 m.

FLYING IN NIGHT-TIME

214. Inspection of the aircraft before a night flight should be performed in the same sequence and scope as when inspecting it before a day-time flight.

Besides, prior to entering the cockpit make sure that circuit breakers L.G. WARNING, NAVIGATION LIGHTS (СИГН. НАСОН, АНО), LAMPS, LANDING GEAR EXTERNAL SYGNAL. (ФАРЫ, ВНЕШН. СИГН. НАСОН), RED LIGHT (КРАСНЫЙ СВЕТ) and OXYGEN EQUIPM. SET - HEATER, EXTENSION LAMP RMO (ОБОГРЕВ КИО, ПЕРЕНОСНАЯ ЛАМПА МИО) on the rear right-hand electrical switch panel are on.

On entering the cockpit proceed as follows:

(a) obtain the required brightness of the red lights illuminating the cockpit by adjusting the rheostats;

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(b) check the emergency lighting of the instrument board, for which purpose switch off the instrument board illumination by operating the rheostat and turn on switch STAND-BY RED LIGHT (АВАРИЙНЫЙ КРАСНЫЙ СВЕТ); the check over, switch off the stand-by lights and obtain the required brightness of the instrument board illuminating lights through the use of the rheostat;

(c) switch on the extension lamp and check it for proper operation;

(d) close the blinds of the indicating lights on the instrument board and panels until the required intensity of light is obtained; set the blinds of both the light panels and of the ILS indicator to the night flying position;

(e) obtain the required illumination of the scale by operating the rheostat on the radio compass control panel;

(f) switch on the navigation lights, check them for proper operation and set the selector switch to the assigned position, i.e. to one of the following positions: LOW (НИЗКИЙ), MEDIUM (СРЕДНИЙ) or FULL (ПОЛНЫЙ);

(g) place the lamp selector switch to LANDING (ПОСАДОЧНАЯ) and then to TAXIING (РУЛЕЖНАЯ) and make sure that the lamps are sound and their beams are directed properly; after checking place the selector switch to RETRACTED (УБРАНО).

Engine start and test should be made using the same procedure as in the case of a day-time flight.

215. Before taxiing slave directional system КОИ.

After being cleared for taxiing brake the wheels, command the technician TAKE OFF CHOCKS (УБРАТЬ КОЛОДКИ) by blinking with the navigation lights. Having made sure that the chocks are removed and that no obstacles are present in front of the aircraft start taxiing. When starting taxiing, switch on the taxiing lamp. Taxiing in the night-time is performed in the same way as in the day-time, except that in the night-time it is necessary to keep looking around particularly well and to periodically switch on the taxiing lamp.

216. The techniques used by the pilot when taking off at night are the same as when taking off in the day-time. In taking off maintain the direction by reference to the runway lights.

Under the light-night conditions position of the aircraft nose in the course of the take-off run should be determined by reference to the horizon line and the runway lights, while under the dark-night conditions only by reference to the runway lights.

217. After the aircraft has become airborne shift your look (without changing position of the controls) to the lights on the left side of the runway and continue gaining airspeed while gradually increasing the distance between the aircraft and the ground; at an altitude of 15 - 20 m retract the landing gear and at an altitude of 200 m retract the flaps.

218. Flying technique used by the pilot under the light-night conditions does not differ from that used under the day-time conditions. When the natural horizon cannot be observed, perform flying by reference to the instruments.

219. Flying the landing pattern, sequence of actions when flying the landing pattern and making landing approach are similar to those used in the day-time flying. The turn to the base leg should be made somewhat later than when on the beam of the outer marker beacon, i.e. when the radio station relative bearing becomes equal to 260° (in case of a counterclockwise flow of traffic) or 100° (in case of a clockwise flow of traffic).

220. When flying at night under adverse weather conditions, ILS landing approach methods are similar to those used when flying under adverse weather conditions in the day-time.

It is characteristic of flying at night in the overcast that there appears reflected-light screen when the aircraft navigation lights are burning. This indirect light widely varies due to the varying density of the clouds, which interferes with the pilot concentrating on flying by reference to the instruments.

221. At night when making estimation for landing and while landing on the floodlit runway, use the same flying technique and procedure as in the day-time. The roundout point is to be selected 75 - 100 m short of the near end of the runway within the strip illuminated by the floodlights.

222. Landing with the use of the landing lights on the runway which is not illuminated with the floodlights is more complicated and requires from the pilot particular attention and skill in determining the height above the ground when making roundout and floating.

Gliding after turning to final approach should be made so as to bring the aircraft to the roundout point. Selected as a roundout point in this case are the runway threshold markings.

At an altitude of at least 100 m switch on the lamps by placing the selector switch to LANDING (ПОСАДКА). From an altitude of 30 - 20 m shift the look to the ground illuminated with the light of the landing lamps and concentrate on determining the distance to the ground to start the roundout. At an altitude of 10 - 12 m start rounding out by smoothly moving the control stick rearward so as to finish it at an altitude not over 1 m above the ground and then perform floating and landing on the two main wheels.

The landing roll completed place the lamp selector switch to TAXIING (РУЛЕНИЕ) and taxi the aircraft to the parking site.

AIRCRAFT FLIGHT TESTING

223. The purpose of testing aircraft in flight is to check operation of the aircraft engine, airframe units and systems, radio communication system, radio and navigational equipment as well as to evaluate the aircraft performance characteristics.

224. When in service, the aircraft is to be subjected to:

(a) annual check flight testing;

(b) flight testing after performing the routine maintenance operations on the aircraft;

(c) flight testing performed after assembling the aircraft, replacing its engine or fuel pump governor as well as after eliminating the defects which hamper the aircraft controllability and stability.

Note. When performing flight testing of the aircraft, no drop tank should be carried.

225. Annual check flight testing should be made in conformity with Items 230 - 239 of the present Instructions (Item 235 should be omitted).

After every 50-hour and 100-hour routine maintenance operations perform flight testing of the aircraft using procedure set forth under Items 230 "a", "b", "c", "d"; 234 "b", "c", "d"; 235 "a" (for the second flight) and 236 of the present Instructions.

After replacing the engine fly the aircraft at low ratings for 30 min within the airfield area and then perform flight testing according to Item 235.

Flight testing of the aircraft after replacing the engine fuel pump governor HP-2102 should be made according to Item 235 "a", "d" (for the first flight) and after replacing fuel pump governor HP-2202 according to Item 235 "d" (for the first flight) and "a" (for the second flight).

226. Flight check of the aircraft for proper balancing should be made according to Items 231, 232 and 233 in the following cases:

(a) after assemblying the aircraft accepted in disassembled condition;

(b) after replacing or repairing the aircraft stabilizer, aileron, rudder or flap;

(c) after replacing the aircraft spring-loaded mechanism, the actuating mechanism for controller AFU-3B, the trimming effect mechanism, booster BU-45A or BU-51MC;

(d) when there are complaints on the part of the pilot about the aircraft abnormal behaviour in flight.

Before flying for aircraft balancing the pilot should get acquainted with the balancing card.

227. If the pilot detects abnormal behaviour of the aircraft or improper operation of the engine, separate units or instruments when in a test flight, he must report this immediately over the radio, discontinue the mission and perform landing. After eliminating the defects it is necessary to make another flying test.

228. When performing a test flight follow the Instructions on Aircraft and Engine Operation, the present Instructions and the pertinent Bulletins. When making a testing flight, all entries should be made as prescribed by the assignment.

After each testing flight inspect the aircraft in the scope of a postflight inspection.

229. In every unit 5 - 8 pilots in the post not lower than flight commander should be appointed to carry out flight testing. These pilots should be instructed in the methods used when testing the aircraft in flight.

Annual Check Flight Testing

230. In the course of the testing flight it is necessary to check the following:

(a) synchronous and effective braking and unbraking of the aircraft wheels, controllability of the aircraft during taxiing, operation of the stand-by brake system;

(b) behaviour of the aircraft during the take-off run, after becoming airborne and in the course of climb (stability and controllability), operation of controller APY-3a and the trimming effect mechanism;

(c) proper functioning of the booster and main hydraulic systems, for which purpose operate the hydraulic system units and watch the pressure drop and increase by the pressure gauge; the landing gear, flaps and air brakes for proper retraction (after their retraction the relative indicating lights should flash up); besides, check should be made of the aircraft control surfaces and air brakes for effectiveness of operation; the check should be made while flying the traffic pattern at an altitude of 5000 - 6000 m;

(d) engine for steady operation and engine parameters (i.e. r.p.m., exhaust gas temperature and oil pressure) for meeting the specifications at steady and transient ratings;

(e) longitudinal, lateral and directional balancing.

231. Longitudinal balancing of the aircraft should be performed while climbing to an altitude of 3000 m at the engine maximum rating at an indicated airspeed of 450 ± 100 km/hr making use of the trimming effect mechanism when required.

If the aircraft fails to get balanced normally, accelerate it to an indicated airspeed of 1000 - 1050 km/hr at an altitude up to 4000 m. When accelerating the aircraft, pulling forces on the control stick should not exceed 4 kg. If pulling forces greatly exceed 4 kg while accelerating the aircraft, the balancing should be discontinued and the aircraft should be landed. After landing the "drift" of the stabilizer control system should be increased.

If the pilot made use of the trimming effect mechanism in order to balance the aircraft longitudinally at an indicated airspeed of 750 ± 100 km/hr, he should not use the mechanism after the aircraft has been balanced till the end of the flight. After landing it is necessary to perform additional adjusting of the trimming effect mechanism in order to place the stabilizer to the trimmed position.

Note. When performing aircraft longitudinal balancing, pressing forces on the control stick are not limited.

232. Lateral balancing of the aircraft should be checked with the aileron boosters switched on and then off and in each case with autopilot KAN-2 switched off and then switched on under damping conditions.

When checking lateral balancing of the aircraft with the aileron boosters on, flying should be performed at an altitude up to 4000 - 5000 m and at an indicated airspeed of 1000 - 950 km/hr.

It is allowed to start lateral balancing of the aircraft with the aileron boosters off if not more than 1/4 of the control stick full travel is required to counteract the aircraft banking.

If it requires more than 1/4 of the control stick full travel to counteract the aircraft banking, it is necessary to adjust the aileron misalignment after landing; this done, perform another checking of the aircraft lateral balancing with the aileron boosters on.

To check lateral balancing of the aircraft with the aileron boosters off, switch off the boosters when at an altitude of 4000 - 5000 m and at an indicated airspeed of 600 km/hr; then, while descending (at a small angle of descent) to an

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altitude of 2500 - 3500 m with the engine operating at the maximum rating, accelerate the aircraft to an indicated airspeed of 1000 - 950 km/hr; when flying under these flight conditions, the control stick forces required to counteract the aircraft banking should not exceed 15 kg; after reducing the indicated airspeed to 750 km/hr switch on the aileron boosters.

At the initial stage of aircraft acceleration the control stick forces required to counteract the aircraft banking should be minimum; but as soon as the airspeed is gained, they may increase and change the sign.

If the control stick forces exceed 15 kg, remember the indicated airspeed, flying altitude, direction of banking, control stick force and travel required for counteracting the aircraft banking; this done, reduce the indicated airspeed to 750 km/hr and switch on the aileron boosters. After landing check to see that the trailing edges of the ailerons and flaps are not deformed and adjust the tab bending of the port aileron.

If the aileron tab has been bent with the adjusting purposes, it is necessary to check the lateral balancing of the aircraft in flight with the aileron boosters off.

Having checked the aircraft for lateral balancing with autopilot KAП-2 switched off, perform checking of the aircraft for lateral balancing with the autopilot switched on to operate under damping conditions.

CAUTION. Lateral balancing of the aircraft should be made with the autopilot switched off.

When on the ground before making a flight for balancing the aircraft laterally, it is recommended that servo unit PAY-107 be set exactly neutral to avoid influence of aircraft banking on balancing. To this end, prior to taxiing, with the engine operating and the aileron boosters switched off, switch on circuit breaker AUTOPILOT (АВТОПИЛОТ) and tumbler DAMPER (ДЕМПФЕР) on the left-hand panel; wait for 2 - 3 minutes and then switch off circuit breaker AUTOPILOT (АВТОПИЛОТ) and then tumbler DAMPER (ДЕМПФЕР). This being the case, the servo unit will come just to the

neutral position where it will be locked by the electromagnetic stop.

233. Directional balancing of the aircraft should be checked when accelerating the aircraft to the maximum permissible indicated airspeed and Mach number.

When flying at an indicated airspeed exceeding 1000 km/hr and with Mach number exceeding 0.95, smooth drifting of the ball in stand-by gyro horizon ДА-200 (200) is allowed by an amount up to ±1 diameter of the ball (while flying level without any acceleration with the pedals not applied). This being the case, the pilot should be able to counteract the aircraft turning by applying the pedals with suitable force. Sharp spontaneous turns of the aircraft are not permissible.

If the aircraft is not balanced directionally at any of the engine ratings, the pilot should remember the following parameters while flying at this engine rating: indicated airspeed or Mach number, flying altitude, direction and amount of travel of the ball in stand-by gyro horizon ДА-200 (200) with the pedals not applied, and approximate amount of pedal force required to counteract the aircraft turning.

Having landed the aircraft, make sure that the jet nozzle shutters are symmetrical at all engine ratings and adjust the bending of the tab on the rudder.

After bending the tab it is necessary to perform additional checking of the aircraft directional balancing in flight.

234. In addition to the above it is necessary to check the following:

(a) operation of the cone control system; when increasing the flying airspeed or decreasing the engine r.p.m. with the airspeed remaining constant, the pointer of indicator УПЗС-3 should smoothly travel to the right; when decreasing the airspeed or increasing the engine r.p.m. with the airspeed remaining constant, the pointer should smoothly travel to the left;

(b) functioning of the flight and navigation instruments, the oxygen, high-altitude, and electrical equipment throughout the entire flight;

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(c) behaviour of the aircraft in gliding and in landing (its stability and controllability), steadiness of the engine operation; operation of the landing gear and flaps control system (to make sure that no banking is present when extending the flaps);

(d) operation and functioning of the drag chute system, effectiveness of the wheel brakes in the course of landing roll.

Test Flight after Replacing Engine

235. When making a test flight after replacing the engine, check the following:

During the first flight:

(a) engine control by smoothly shifting the engine control lever (in the same direction for 15 - 20 sec) from the idle rating to the maximum rating and back (be sure that the engine r.p.m. are not "lagging" behind the engine control lever while it is being moved); this check should be made when flying at an altitude of 8000 - 10,000 m at an indicated airspeed of 450 - 500 km/hr;

(b) functioning of the limiter for the high-pressure rotor r.p.m., which is determined by a drop of the low-pressure rotor r.p.m. (by some 0.5 - 1%) when increasing Mach number; in this case the high-pressure rotor r.p.m. should be constant and equal to 103.5 ± 0.5%; the check should be performed while accelerating the aircraft to Mach number equal to 1.17 - 1.2 at an altitude of 13,000 m with the engine operating at the full augmented rating;

(c) operation of the engine at the augmented rating and with the afterburner off; to this end, accelerate the aircraft, then set the engine to the minimum augmented rating and execute a zoom with the indicating airspeed decreasing to 550 - 600 km/hr; when at an altitude of 16,000 - 17,000 m at the indicated airspeed of at least 500 km/hr, switch off the afterburner by shifting the engine control lever to MAXIMUM (МАКСИМАЛ);

(d) acceleration of the engine while flying at an indicated airspeed of 350 km/hr by moving the engine control lever for 1.5 - 2 sec within the range from idling to the maximum rating; proper switching-on of the afterburner and controllability

of the engine within the range from minimum to full augmented rating while flying at an indicated airspeed of 500 - 550 km/hr; the check should be performed after descending to an altitude lower than 15,000 m.

During the second flight:

(a) change in the high-pressure rotor r.p.m. and low-pressure rotor r.p.m. depending on Mach number, fluctuation in the high-pressure rotor r.p.m. and low-pressure rotor r.p.m. with the engine operating at the high-pressure rotor r.p.m. limiter, exhaust gas maximum temperature and high-pressure rotor maximum r.p.m.; the check should be made at an altitude of 13,000 m while accelerating the aircraft to maximum permissible Mach number;

(b) engine operation for steadiness in climbing when reaching the static ceiling and at the static ceiling; the climb to the static ceiling should be made by zooming during which see to it that Mach number is not less than 1.75 - 1.8; when at the static ceiling, check operation of the engine while flying with Mach number equal to 1.35.

Note. When performing a test flight after replacing the engine, check operation of the intake cone automatic control system and fuel consumption throughout the entire flight.

Checking Operation of Radio and Radar Equipment

236. As far as the radio and radar equipment is concerned, check the following:

(a) operation of command radio set RSHV-5r to make sure that it ensures proper communication both between the aircraft and the ground and between the separate aircraft in flight at maximum ranges (according to the specifications);

(b) operation of the ARK-10 automatic radio compass to make sure that it accurately indicates the radio station magnetic bearing or the aircraft magnetic bearing at the maximum ranges according to the specifications; accuracy in reading the bearings by reference to indicator UKI-2 should be within ±2° at an altitude of 10,000 m and at a distance of 200 - 300 km from station NAP-3B and at a distance of up to 600 km from station NAP-7;

(c) operation of the automatic unit for retuning radio compass ARK-10 from the outer marker beacon to the inner marker beacon when making a landing approach and from the inner marker beacon to the outer marker beacon when making a go-around procedure;

(d) aircraft transponder CPO by watching response marks appearing on the plan position indicator (PPI) of the ground radar stations;

(e) target location and lock-on ranges at which the radar sight can operate when controlled by the ground radar station.

Flight Testing of Remote-Indicating Gyro Horizon AГД-1

237. The remote-indicating gyro horizon AГД-1 should be checked in flight under ordinary weather conditions once every three months and each time after replacement of its units or after eliminating defects found in it.

Final conclusions as to the operation of gyro horizon AГД-1 should be made after accomplishing the following maneuvers while in the test flight: 180°-turns (one to the right and one to the left at a bank of 18 - 20° and then one to the right and one to the left at a bank of 65 - 70°), left and right rolls, left and right half-loops, chandelles (one to the left and the other to the right).

238. Errors in the gyro horizon indications should be determined using the following procedure:

(a) after executing each of the above maneuvers level off the aircraft (as far as the pitch is concerned) by reference to the vertical speed indicator and remove the bank by reference to the gyro horizon; this done, the miniature aircraft should be aligned with zero readings of the bank scale;

(b) by observing the reference marks in the direction of flight and by watching the indications of the compass and the turn indicator determine the aircraft attitude (i.e. whether the aircraft is in a level flight or in a turn); if the

aircraft is in a turn, level it out until the turn discontinues; in this case the ball of the gyro horizon should remain between the notches (in the centre);

(c) by deflecting the miniature aircraft off the zero reading of the bank scale determine the error of gyro horizon AГД-1 in bank; after making the turns with the above banks the error should not exceed 3° (sometimes the error may reach 5 - 6°); after each aerobatic manouver the error should not exceed 5°;

(d) in the course of the test flight it is necessary to determine error in pitch that may be present after taking off; to this end, perform taking off and accelerate the aircraft (without turning) to an airspeed that will be the best climbing airspeed, after which make a turn through 90°; when on a new course, bring the aircraft into a level flight avoiding any bank (by reference to stand-by gyro horizon ДА-200 (200), the compass and visually); after turning through 90° the accumulated error in pitch will come to an error in bank; this error should not exceed 3°.

239. When checking autopilot КАП-2, proceed as follows:

(a) check behaviour of the aircraft under DAMPING (ДЕМПИРОВАНИЕ) and STABILIZATION (СТАБИЛИЗАЦИЯ) conditions at an altitude of 5000 - 7000 m while accelerating the aircraft to an indicated airspeed of 650 - 900 km/hr and while decelerating it from 900 km/hr to 400 - 500 km/hr;

(b) at an indicated airspeed of 800 - 900 km/hr (when in acceleration) check ATTITUDE (ПО ПОЛОЖЕНИЮ) control at a bank of 36° and bringing the aircraft to a zero bank position from the bank angles of 40 - 50° when placing the control stick neutral;

(c) with the engine operating at the maximum rating, climb to an altitude of 10,000 m and while flying with Mach number M = 0.85 check ATTITUDE (ПО ПОЛОЖЕНИЮ) control, switch off STABILIZATION (СТАБИЛИЗАЦИЯ) operating duty (to be checked by indicating light STABILIZATION going out) and check the autopilot for bringing to a zero bank angle from angles up to 150° by switching on STABILIZATION operating duty;

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(d) switch on the afterburner, climb to an altitude of 12,000 m and accelerate the aircraft to Mach numbers of 1.8 - 1.9 with STABILIZATION (СТАБИЛИЗАЦИЯ) operating duty on; by the end of the acceleration check ATTITUDE (ПО ПОЛОЖЕНИЮ) control and bringing the autopilot to a zero bank angle from angles of 40 - 50°;

(e) switch off the afterburner and when at the engine maximum rating, switch off STABILIZATION (СТАБИЛИЗАЦИЯ) operating duty and check the aircraft behaviour under damping conditions.

Note. When flying at an indicated airspeed of 650 - 850 km/hr at altitudes ranging from 0 to 10,000 m with the engine operating at the ratings up to the maximum rating (inclusive), periodical fluctuations in bank with a frequency of 1 c.p.s. and an amplitude of 3 - 5° make no influence on the flying technique.

[redacted]

Chapter XX

PILOT'S ACTIONS IN EMERGENCY CASES

240. Whether the flying personnel are ready to meet and cope with any emergency or abnormal situation in flight is of a paramount importance as far as flying safety is concerned.

Any failure that has occurred on the aircraft should be reported by the pilot over the radio to the flight control officer. The pilot should tell the nature of failure and then proceed as instructed by the flight control officer and depending on the situation.

In any emergency situation when the pilot needs help, he should switch on signal EMERGENCY(SELCTBHE) in the identification system.

FAILURE OF ENGINE, AIRCRAFT SYSTEMS AND INSTRUMENTS IN FLIGHT

Aircraft Power Plant Surge

241. The air intake surge can be known by repeated pops in the nose portion of the aircraft while the engine surge can be known by a single pop or repeated pops in the tail portion of the aircraft.

If the engine surge is the result of the air intake surge, the pilot may not be aware of the pops.

In most cases the air intake or engine surge is accompanied by a spontaneous engine stop which can be determined by a sharp drop in the engine r.p.m. and the exhaust gas temperature.

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In some cases the air intake or engine surge is not accompanied by the engine stop. This results in a sharp drop of the low-pressure rotor r.p.m. to 60 - 80% and an intense rise in the exhaust gas temperature.

242. In case of the air intake surge that did not cause spontaneous stop of the engine, proceed as follows:

(a) when flying at Mach numbers lower than 1.7, open manually the antisurge shutters or extend the cone until the surge discontinues; check operation of the engine by reading the indications of r.p.m. and exhaust gas temperature;

(b) when flying at Mach numbers exceeding 1.7, cut off the engine, open manually the antisurge shutters and reduce the airspeed until the surge discontinues; descend to an altitude at which the engine can be started for sure, close the antisurge shutters and start the engine.

Should the engine surge occur, cut off the engine, open manually the antisurge shutters, descend to an altitude where the engine can be started for sure, start it, close the antisurge shutters, discontinue the mission and proceed to the airfield.

Spontaneous Engine Stop

243. Spontaneous stop of the engine can be known by the aircraft deceleration, change in the engine operation sound and by the drop in the engine r.p.m. and the exhaust gas temperature.

In case of a spontaneous stop of the engine proceed as follows:

(a) place the engine control lever to STOP (STOM);

(b) if the engine has stopped spontaneously during the surge of the power plant, decrease the flying speed until the surge discontinues and then, with Mach number being not over 1.3, close the antisurge shutters;

(c) should the engine stop spontaneously when flying in the stratosphere, descend to an altitude of 10,000 m in the direction of the own or the nearest airfield and start the engine.

In-Flight Engine Start

244. Reliable engine start with the use of the in-flight oxygen feed system is possible up to an altitude of 10,000 m when flying at an indicated airspeed of 450 - 650 km/hr. When flying at altitudes from 11,000 to 12,000 m, it is possible to start the engine at an airspeed of 500 - 650 km/hr. If no oxygen is present in the engine feed line, engine start should be made when flying at altitudes lower than 8000 m at an indicated airspeed of at least 450 km/hr.

Engine start is allowed in the course of gliding when slight pops and air turbulence are present in the intake.

245. To start the engine, use the following procedure:

(a) obtain the required airspeed depending on the flying altitude;

(b) turn on switch IN-FLIGHT ENGINE START (ЗАПУСК В ВОЗДУХЕ) and check to see that the engine start system has become switched on by reference to indicating light SWITCH OFF IGNITION (ВЫКЛЮЧИ ЗАЖИГАНИЕ) on light panel T-10y (the indicating light should be burning);

(c) shift the engine control lever to the idle rating stop; within 15 - 20 sec the engine should reach the idle rating r.p.m. corresponding to the flying altitude.

Checking of the engine for proper starting should be made by reference to the r.p.m. that should increase and by hearing the engine operation sound. The exhaust gas temperature grows slowly being not a sign indicative of the engine operation.

246. After the engine has accelerated to the idle rating r.p.m. turn out switch IN-FLIGHT ENGINE START (ЗАПУСК В ВОЗДУХЕ) and, while smoothly moving the engine control lever, make sure that the engine r.p.m. are growing (the r.p.m. will start rising only after the engine control lever has been shifted from IDLE beyond the idling zone for the given flying altitude). When no rise in the r.p.m. occurs, shift the engine control lever as far as STOP (СТОП) and in 15 - 30 sec repeat the procedure for starting the engine.

Note. The engine oxygen feed system is rated for five engine starts with switch IN-FLIGHT ENGINE START (ЗАПУСК В ВОЗДУХЕ) being switched on for not longer

[redacted]

Restart [illegible]

[illegible] with the use of the in-flight [illegible] up to an altitude of 10,000 m [illegible] speed of 450 - 650 km/hr. Be[illegible] 10 to 12,000 m, it is possible [illegible] speed of 500 - 650 km/hr. If [illegible] the feed line, engine start [illegible] [illegible] lower than 8000 m at an [illegible] /hr.

[illegible] the course of gliding then [illegible] are present in the [illegible], use the following procedure: [illegible] speed depending on the flyi[illegible]

[illegible] ENGINE START (switch [illegible] engine start system has been [illegible] indicating light switch on) [illegible] light panel P-107 (the [illegible]

[illegible] lever to the idle rating [illegible] should reach the idle [illegible] the flying altitude.

[illegible] proper starting should be [illegible] should increase and by hand[illegible] exhaust gas temperature grow[illegible] of the engine operation.

[illegible] accelerated to the idle rating [illegible] ENGINE START (switch [illegible] the engine control lever, [illegible] growing (the r.p.m. will not [illegible] trol lever has been shifted [illegible] for the given flying altitude [illegible] shift the engine control [illegible] in 15 - 30 sec repeat the

[illegible] system is rated for five [illegible] IN-FLIGHT ENGINE START [illegible] switched on for not longer

than 30 sec. To switch it on for a period longer than 40 sec is not allowed otherwise the ignition coils may fail.

247. When all attempts to start the engine in flight are in vain, stop trying to start it at an altitude not lower than 2000 m. This being the case take a decision to bail out or to perform a dead-engine landing.

Dead-Engine Landing

248. The dead-engine landing should be made on the airfield or on a preselected site provided that the landing site is visually observed from an altitude not less than 5000 - 6000 m.

Approach for landing should be performed only with the engine autorotating.

249. On coming to a decision to perform a dead-engine landing proceed as follows:

(a) when in a glide, obtain an airspeed of 440 - 450 km/hr;

(b) place the engine control lever to STOP (СТОП);

(c) switch off the fuel pumps and press button EMERGENCY VALVE (ЭКСТРЕННЫЙ КРАН) that has been switched off for the time being;

(d) disconnect electric power consumers that are not required;

(e) switch off the autopilot;

(f) jettison the drop tank, missiles, if any;

(g) make sure that circuit breaker PUMPING UNIT (НАСОСНАЯ СТАНЦИЯ) is switched on.

Note: If the canopy becomes misted when descending with the dead engine from a high altitude, depressurize the cockpit at an altitude of 5000 - 6000 m to eliminate misting.

250. To maintain pressure in the hydraulic systems and to ensure normal operation of the aircraft controls, proceed as follows:

(a) fly the aircraft smoothly without sharp or unnecessary movements of the control stick;

(b) when the engine autorotating r.p.m. are too low and when pressure in the hydraulic systems is insufficient, switch off the aileron boosters;

[redacted]

(c) do not make use of the air brakes and flaps;

(d) extend the landing gear using an emergency procedure;

(e) when approaching for landing, watch the pressure in the hydraulic systems.

251. Make approach to the airfield so as to reach the near end of the runway at an altitude of 5000 - 5500 m with a course close to the landing one or at an altitude of 4200 m so as to be on the beam of the near end of the runway at a distance of 5 - 6 km away from it while flying with a course reverse to the landing one.

252. Estimation for landing should be made by reference to the following check points: the first check point will be the near end of the runway, the second check point will be the beam of the runway near end (at a distance of 5 - 6 km away from it), the third check point will be the beam of the outer marker beacon (where turning to the base leg should be made) and the fourth check point will be over the outer marker beacon (where the turn to final approach is to be completed).

The pilot should remember the second and the third check points by reference to the ground landmarks.

When making estimation for landing, take the following initial points: the first check point when approaching the airfield with the landing course, the second or third check point when approaching it with a course reverse to the landing one.

253. When approaching the first check point with the landing course at an altitude of 5000 - 5500 m, perform a 180°-turn at a bank of 30 - 40° while flying at an indicated airspeed of 450 - 470 km/hr.

Should it occur that the altitude over the first check point is more than 5500 m, perform turning somewhat later when the difference between the actual and the assigned altitudes becomes reduced by half.

254. When flying over the second check point, the altitude should amount to 4200 m. If the flying altitude is 4200 m or higher, extend the landing gear (following the emergency procedure); if it is less than 4200 m, do not extend the landing gear until the third check point is reached.

255. Flying over the third check point should be made at an altitude of 3000 m. This being the case, extend the landing gear (if retracted) and make a turn to the base leg; if an altitude over the third check point is higher than 3000 m, perform turning to the base leg somewhat later when the difference between the actual and the assigned altitudes decreases by half.

256. After making the turn to the base leg, perform gliding at an angle somewhat less than 90^0 relative to the runway; make the turn to the final approach so as to complete it over the outer marker beacon at an altitude of 1200 - 1300 m (the outer marker beacon being 4 km away from the runway).

Maintain a gliding speed not less than 450 km/hr (i.e. within 450 - 470 km/hr) throughout the entire glide till the moment the roundout is to be started.

CAUTION. When making landing not on the airfield but on a preselected site, it is necessary to jettison the canopy when at an altitude of 1500 - 1000 m.

257. When making approach for landing under head wind conditions with the wind blowing at a velocity of 8 - 10 m/sec, maintain an altitude of 3200 - 3300 m over the third check point and 1400 - 1600 m over the fourth check point.

258. After turning to the final approach the aircraft should be glided to a point which is 200 - 300 m away from the near end of the runway. The pilot should not be too quick in finalizing the landing approach, for under these conditions it usually seems to every pilot that he is overshooting.

When at an altitude of 200 - 300 m, perform the first (preliminary) roundout by decreasing the glide angle to a normal one. After descending to an altitude of 6 - 10 m perform the second roundout. By the moment the second roundout is to be made the airspeed becomes reduced to 350 - 360 km/hr.

259. If undershooting has occurred when on final approach, land the aircraft at greater pitch angles than usually required by pulling the control stick full way to the rear.

If overshooting has occurred, perform landing and after lowering the nose wheel apply fully the wheel brake lever holding it in this position till the end of the landing roll with the control stick in the extreme forward position. At an altitude of 280 km/hr release the drag chute.

260. When making estimation for landing with the engine throttled down with the training purposes, gliding should be made with the air brakes extended and the engine control lever shifted to the extreme back position. Under these conditions the glide path will be similar to that flown by the aircraft when making a dead-engine landing (with the engine autorotating).

Failure of Both Hydraulic Systems
(with engine operating)

261. Failure of the aircraft hydraulic systems can be determined by flashing-up of two red lights on the light panel and by steady drop of pressure in both hydraulic systems below 165 kg/sq.cm with pumping unit NN-27 operating.

Should the hydraulic systems fail to operate proceed as follows:

(a) discontinue the mission;

(b) switch off the autopilot (first stabilization and then damping operating duties);

(c) reduce the flying speed;

(d) switch off the aileron boosters while flying at an indicated airspeed of 1000 km/hr or with M≤1.4;

(e) descend to 6000 m if pressure in the hydraulic system is sufficient to control the aircraft.

Should it occur that at an altitude of 6000 m the pressure in the hydraulic systems is not still restored or failure of both hydraulic systems has taken place at an altitude lower than 6000 m, the pilot should resort to the bailout procedure.

Note. As soon as pressure in the hydraulic systems has dropped below 70 kg/sq.cm, the autopilot gets automatically de-energized; this being the case, it is not obligatory for the ailerons to be in the neutral position when the control stick is neutral.

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Failure of Booster Hydraulic System
(with engine operating)

262. When the booster hydraulic system fails to operate, proceed as follows:

(a) discontinue the mission;

(b) make sure that the booster hydraulic system has failed; this being the case red indicating light NO PRESSURE IN BOOSTER SYSTEM (НЕТ ДАВЛ. БУСТ. СИСТ.) on the light panel is burning and the pressure is below 165 kg/sq.cm and continues dropping;

(c) check to make certain that the circuit breaker of pumping unit НН-27 is on;

(d) check pressure in the main hydraulic system;

(e) switch off pumping unit НН-27 if it takes more than 15 minutes to reach the airfield; switch it on when approaching the airfield.

Should it be the case that after switching on pumping unit НН-27 the pressure is maintained within 165 - 195 kg/sq.cm, extend the landing gear, flaps and air brakes during the landing approach using the normal procedure. If the pressure cannot be maintained within these limits, extend the landing gear using the emergency procedure and perform landing with the flaps and air brakes retracted.

Failure of Main Hydraulic System
(with engine operating)

263. If the main hydraulic system fails to operate proceed as follows:

(a) discontinue the mission;

(b) make sure that the main hydraulic system has failed; this being the case red indicating light NO PRESSURE IN MAIN SYSTEM (НЕТ ДАВЛЕН. ОСН. СИСТ.) on the light panel is burning and the pressure is steadily dropping below 165 kg/sq.cm;

(c) check the position of the cone; if the cone is extended, do not increase the engine r.p.m. in excess of 85%;

(d) when approaching for landing, extend the landing gear using the emergency procedure and keep the air brakes and

flaps retracted (trying to extend the air brakes and flaps will be in vain).

Failure of Booster Hydraulic System
(with inoperative autorotating engine)

264. If the booster hydraulic system fails to operate, proceed as follows:

(a) make sure that the booster hydraulic system has failed; this being the case red indicating light NO PRESSURE IN BOOSTER SYSTEM (НЕТ ДАВЛ. БУСТ. СИСТ.) is burning and the pressure is steadily dropping below 165 kg/sq.cm;

(b) check to see that the circuit breaker of pumping unit НН-27 is switched on;

(c) switch off the autopilot (first stabilization and then damping operating duties);

(d) perform descending without any sharp manuevers;

(e) go on trying to start the engine until reaching an altitude of 2000 m.

If all attempts to start the engine are in vain and an altitude is not higher than 2000 m, the pilot should resort to the bailout procedure.

Failure of Main Hydraulic System
(with inoperative autorotating engine)

265. When the main hydraulic system fails, proceed as follows:

(a) make sure that the main hydraulic system has failed; this being the case the red indicating light of the main hydraulic system is burning and the pressure is steadily dropping below 165 kg/sq.cm;

(b) check to make sure that there is pressure in the booster hydraulic system; if the pressure is within 165 - 195 kg/sq.cm, it is allowed to perform landing;

(c) switch off the autopilot (first stabilization and then damping operating duties);

(d) go on trying to start the engine only down to an altitude of 2000 m;

flaps retracted (trying to extend the air brakes and flaps will be in vain).

Failure of Booster Hydraulic System
(with inoperative autorotating engine)

264. If the booster hydraulic system fails to operate, proceed as follows:

(a) make sure that the booster hydraulic system has failed; this being the case red indicating light NO PRESSURE IN BOOSTER SYSTEM (НЕТ ДАВЛ. БУСТ. СИСТ.) is burning and the pressure is steadily dropping below 165 kg/sq.cm;

(b) check to see that the circuit breaker of pumping unit НН-27 is switched on;

(c) switch off the autopilot (first stabilization and then damping operating duties);

(d) perform descending without any sharp manoeuvers;

(e) go on trying to start the engine until reaching an altitude of 2000 m.

If all attempts to start the engine are in vain and an altitude is not higher than 2000 m, the pilot should resort to the bailout procedure.

Failure of Main Hydraulic System
(with inoperative autorotating engine)

265. When the main hydraulic system fails, proceed as follows:

(a) make sure that the main hydraulic system has failed; this being the case the red indicating light of the main hydraulic system is burning and the pressure is steadily dropping below 165 kg/sq.cm;

(b) check to make sure that there is pressure in the booster hydraulic system; if the pressure is within 165 - 195 kg/sq.cm, it is allowed to perform landing;

(c) switch off the autopilot (first stabilization and then damping operating duties);

(d) go on trying to start the engine only down to an altitude of 2000 m;

(e) when making approach for landing, extend the landing gear using the emergency procedure and keep the air brakes and flaps retracted (trying to extend them will be in vain).

Engine Seizure

266. In case of engine seizure resort to the bailout procedure. If it is impossible to bail out, it should be remembered that the booster hydraulic system ensures landing with the engine seized.

When landing under those conditions it is necessary to do the following:

(a) make sure that there is pressure in the booster hydraulic system; this pressure should be equal to 165 - 195 kg/sq.cm;

(b) make sure that the circuit breaker of pumping unit NN-27 is switched on;

(c) switch off the autopilot (first stabilization and then damping operating duties);

(d) switch off the aileron boosters;

(e) perform descending avoiding sharp manoeuvres;

(f) when making landing approach, extend the landing gear using the emergency procedure; do not extend the flaps and the air brakes.

Failure of Jet Nozzle Control Follow-Up System

267. Failure of the jet nozzle control follow-up system when flying at the engine augmented ratings can be known by the absence of any changes in the engine thrust when shifting the engine control lever within the range from the minimum to the full augmented rating and by the sharp rise or sharp drop in the engine thrust.

268. If the follow-up system has failed, it is necessary to turn on switch SHUTTER EMERGENCY SWITCHING-ON, AUGMENTED, MAXIMUM (АВАРИЙНОЕ ВКЛЮЧЕНИЕ ОТБОРОК, ФОРСАЖ, МАКСИМАЛ) and change over to operating the jet nozzle two-position control system; this being the case, it is possible to use only full augmented and non-augmented ratings of the engine.

269. Should it be the case that after switching off the afterburner (by shifting the engine control lever to MAXIMUM) the thrust becomes insufficient, the exhaust gas temperature becomes too low (not over 400°C) and the difference between the high-pressure rotor r.p.m. and the low-pressure rotor r.p.m. is more than 8 - 10%, this will be indicative of the shutters remaining in position AUGMENTED (ФОРСАЖ); to place the shutters to position MAXIMUM (МАКСИМАЛ), it is necessary to turn on switch SHUTTER EMERGENCY SWITCHING-ON, AUGMENTED, MAXIMUM (АВАР. ВКЛЮЧ. ОТВОРОК, ФОРСАЖ, МАКСИМАЛ).

If the shutters failed to change over to position MAXIMUM (МАКСИМАЛ), i.e. the thrust failed to become restored, switch off circuit breaker AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ).

If the engine thrust failed to get restored (the jet nozzle shutters failed to become closed) after switching off circuit breaker AUGMENTED, MAXIMUM (ФОРСАЖ, МАКСИМАЛ), jettison the drop tank and other external stores and proceed to the airfield using the shortest way possible being aware that the engine thrust (even without any external stores) is not sufficient for a level flight at high altitudes. The landing gear should be extended only in those cases when the pilot is sure that he can land the aircraft safely on the airfield.

Engine on Fire

270. The following are signs indicative of fire:

(a) warning light FIRE (ПОЖАР) on light panel is lit and burning;

(b) smoke trail behind the aircraft tail unit (which is observed during the turn).

271. Having made sure that the engine is on fire, it is necessary to do the following:

(a) place the engine control lever to STOP (СТОП);

(b) press button SHUTOFF VALVE (ПЕРЕКРЫВНОЙ КРАН);

(c) reduce the flying speed as far as possible by bringing the aircraft into climbing;

(d) press button FIRE EXTINGUISHER (ОГНЕТУШИТЕЛЬ) in the fire-fighting system;

(e) switch off autopilot КАП-2 stabilization and damping operating duties.

The fire extinguished, do not start the engine and take a decision whether to perform landing or resort to the bailout procedure depending on the situation.

CAUTION. Should it occur that light FIRE (ПОЖАР) is burning while no other indications of fire are present, it is necessary to discontinue the mission and proceed to the airfield.

Drop of Fuel and Oil Pressure in Systems

272. Drop of fuel pressure aft of the booster pump occurs due to the failure of the booster pump and is determined by the burning of light SERVICE PUMP (РАСХОДНЫЙ БАК) on light panel T-10y. When the fuel booster pump has failed at an altitude exceeding 15,000 m, proceed as follows:

(a) discontinue the mission;

(b) switch off the afterburner by shifting the engine control lever as far as stop MAXIMUM (МАКСИМАЛ);

(c) descend to an altitude below 15,000 m at the maximum vertical rate possible and throttle down the engine to the normal rating;

(d) perform further descending and proceed flying to the airfield at an altitude not over 6000 m if the fuel tanks contain fuel, grade T-1 or TC-1, or at an altitude not over 4000 m if the fuel tanks contain fuel, grade T-2.

Note. Avoid negative G-loads when flying with the booster pump inoperative.

273. When oil pressure has dropped below 3.5 kg/sq.cm at altitudes up to 15,000 m, proceed as follows:

(a) discontinue the mission;

(b) reduce the engine r.p.m. to the minimum possible value ensuring a level flight to the nearest airfield.

Should the oil pressure drop below 3.0 kg/sq.cm when flying higher than 15,000 m, it is necessary to:

(a) discontinue the mission;

(b) switch off the afterburner by shifting the engine control lever as far as stop MAXIMUM (МАКСИМАЛ);

(c) descend to an altitude below 15,000 m at the maximum vertical rate possible, throttle down the engine to obtain the minimum possible r.p.m. ensuring a level flight to the nearest airfield.

Note. A short-time drop of the oil pressure (lasting not longer than 17 sec) down to zero is allowed at all altitudes under the conditions of negative and zero G-loads.

Failure of Generator

274. Failure of the generator when in flight can be known by flashing-up of light GENERATOR OFF (ГЕНЕРАТОР ВЫКЛЮЧЕН) on light panel T-10y, by reference to the voltmeter (the voltage drops from 28 - 29 V to 21 - 22 V) and by the drop of the aircraft storage battery capacity (the pointer of integrating ampere-hour meter MCA travels to zero).

When the generator fails, the following units get automatically disconnected: the radar sight, system P-3c, the fuel pump of fuel tank group 1, inverter NO-1500ст-2п, exciter of A.C. generator CTO-8-Ser.2.

275. In case of generator failure, proceed as follows:

(a) discontinue the mission;

(b) obtain the engine r.p.m. not in excess of normal value;

(c) report the generator failure over the radio.

Under the conditions of generator failure with the aircraft electric power consumers operating from the aircraft storage batteries, the time of safe flying both in the day-time and in the night-time will amount to 15 min.

When flying under these conditions, the voltage in the aircraft mains (as measured by voltmeter B-1 in the course of discharge of the aircraft storage batteries) should equal 21 V and the residual capacity of one storage battery at the end of the discharge (according to integrating ampere-hour meter MCA) should be not less than 11 A-hr.

CAUTIONS: 1. To increase the safe flight time it is allowed to additionally switch off the power consumers

unnecessary in the flight performed. After warning light 550 LTT OF FUEL REMAINDER (ОСТАЛОСЬ 550 Л) becomes on, switch off the pump of tank group 2 (provided that more than 15 min are required to continue the flight).

2. If the voltage in the aircraft mains has dropped below 20 V, extend the landing gear using the emergency procedure. This being the case, do not forget that the drag chute may fail to release and the automatic brake system will fail to operate.

Failure of Inverter ПО-750а

276. When in flight, failure of inverter ПО-750а will be indicated by the following: no radio communication (via all channels), no response of the radio compass to any deviation of the aircraft from the course and the fuel flowmeter pointer remains motionless.

277. On discovering that inverter ПО-750а has failed switch on circuit breaker INVERTER EMERGENCY SWITCH-OVER (АВАР. ПЕРЕКЛ. ПРЕОБР.) located on the right-hand horizontal panel in the cockpit. Following this the above consumers will change over to operation from inverter ПО-1500ВТ-2Н (which will be determined by their functioning in 1 - 1.5 min) and the radar sight will get de-energized.

Failure of Air Intake Cone Automatic Control System

278. The following are indications of the air intake cone automatic control system failure:

(a) the air intake cone fails to extend after taking off and retracting the landing gear (indicating light CONE EXTENDED (КОНУС ВЫПУЩЕН) on light panel Т-4 is not burning and the pointer of the cone position indicator reads zero);

(b) the cone fails to extend (which is determined by reference to the cone position indicator) while accelerating the aircraft at a constant engine rating or while decreasing the engine r.p.m. with the airspeed remaining constant;

(c) the cone fails to extend (which is determined by reference to the cone position indicator) while decelerating the aircraft or increasing the engine r.p.m.

Should the cone automatic control system fail to operate when flying at supersonic speeds, surge in the air intake may take place.

279. In case of failure of the cone automatic control system proceed as follows:

(a) discontinue the mission;

(b) switch off the afterburner by shifting the engine control lever to position MAXIMUM (МАКСИМАЛ);

(c) open manually the antisurge shutters;

(d) decrease the airspeed to Mach number less than 1.3;

(e) by turning the rack align the wide pointer of the cone position indicator with the slim pointer;

(f) place the cone mode of operation switch to MANUAL (РУЧНОЕ);

(g) as the airspeed decreases, rotate smoothly the rack counterclockwise to move the pointers of the cone position indicator as far as zero; while doing this, the cone will get retracted alongside with the movement of the pointers. Prior to landing retract the cone fully.

When gliding at the idle rating at an altitude below 7000 m, vibration of the power plant may occur. To eliminate this vibration, it is necessary to extend the cone manually.

Should it be the case that the cone fails to get retracted manually, turn off switch CONE CONTROL (УПРАВЛЕНИЕ КОНУСОМ) and then change the engine operating conditions by moving the engine control lever smoothly avoiding increase in the low-pressure rotor r.p.m. in excess of 85%.

Note. If required (e.g. when making a go-around procedure), the engine r.p.m. may be increased to their maximum value. While doing this, be sure to move the engine control lever smoothly.

280. If the cone automatic control system fails under combat conditions, it is possible to continue accomplishing the mission while controlling the cone manually. To this end, proceed as follows:

(a) place the pointer of the cone position indicator to a position corresponding to flying Mach number (See Table 2); this should be done by making use of the rack;

(b) set the MODE SELECTOR to MANUAL (PYTHON).

When further accomplishing the mission, control the cone manually each time placing it to a position corresponding to flying Mach number (according to Table 2).

Table 2

Flying Mach number	1.5	1.6	1.7	1.8 and over
Position of cone indicator pointer, %	50	60	70	80

Smoke in Cockpit

281. On discovering smoke in the cockpit proceed as follows:

(a) start breathing with pure oxygen having placed the air-dilution switch on remote-control panel AV-2 to position "100% O_2";

(b) disconnect the cabin pressurization system by placing the cabin supply valve on the right-hand panel to the extreme rear position and then descend to an altitude lower than 12,000 m.

If the smoke in the cockpit persists, decrease the air-speed and altitude and act depending on the situation (jettison the canopy, if required).

Failure of Controller AFV-3b

282. The signs indicating that controller AFV-3b has failed are as follows:

(a) when flying at high airspeeds, the aircraft responds too energetically to the deflections of the control stick (which means that controller AFV is set to position LOW SPEED);

(b) when flying at high altitudes, the aircraft is too slow in responding to the control stick deflection;

(c) readings of the AFV controller arm position indicator do not correspond to the indicated airspeed and flying altitude;

(d) when flying at indicated airspeeds exceeding 850 km/hr

at altitudes from 5000 to 10,000 m, indicating light STABILIZER FOR LANDING (СТАБИЛИЗАТОР НА ПОСАДКУ) is burning.

283. In case of failure of controller APY discontinue the mission, reduce the airspeed to 500 - 550 km/hr and change over to manual control of the actuating mechanism of controller APY. To this end, proceed as follows:

(a) shift the mode of operation switch of controller APY from AUTOMATIC (АВТОМАТ) to MANUAL (РУЧНОЕ);

(b) using the pressure-type switch place the rod of controller APY (the indicator pointer) to a position corresponding to the indicated airspeed and flying altitude.

When operating controller APY manually, avoid sharp maneuvers in flying the aircraft. See that the indicated airspeed does not exceed the airspeed according to controller APY by more than 150 km/hr.

Note. When controller APY fails there is no correction of autopilot KAP-2 transmission ratio, which may cause spontaneous oscillations of the aircraft when the autopilot is switched on and hamper control of the aircraft. This being the case, switch off the autopilot (first stabilization and then damping operating duties) and circuit breaker AP (AP).

284. If controller APY fails when flying at altitudes up to 7000 m at the indicating airspeed of 800 km/hr and more (the pointer of the APY controller indicator remaining at the left stop or near it), the pilot may spontaneously oscillate the aircraft longitudinally with negative and positive accelerating forces growing sharply.

To discontinue these oscillations make no attempts to counteract separate longitudinal oscillations but pull the control stick rearward to bring the aircraft into a climb and simultaneously place the engine control lever at the idle rating stop. This done, the oscillations will discontinue.

Having dissipated the indicated airspeed to 550 - 600 km/hr, discontinue the mission.

285. Before making approach for landing place the pressure-type switch to position LOW SPEED (МАЛАЯ СКОРОСТЬ) and bring the rod of the actuating mechanism of controller APY to the greater arm until indicating light STABILIZER FOR LANDING (СТАБИЛИЗАТОР

НА ПОСАДКУ) flashes up and the pointer of the APY controller indicator reaches the left stop. In this case ootination for landing and landing proper should be made as usual.

286. If it is impossible to change over the rod of controller APY to the take-off-and-landing position by operating the pressure-type switch, perform landing with the rod of controller APY remaining at the smaller or intermediate arm. Under these conditions the glide after the turn to the final approach should be made at a lesser angle of descent and at an airspeed increased by some 20 - 30 km/hr. With the rod of controller APY being set to the smaller arm, the stabilizer maximum deflection angles will be half as great as when the rod is set to the greater arm. With the controller APY set to the smaller arm, landing will require high skill and concentration on the part of the pilot. When making landing under these conditions, control stick forces will increase 2 - 2.5 times, being equal to 20 - 25 kg.

CAUTION. Should the mode of operation selector switch be set to position MANUAL (РУЧНОЕ) in case of failure of controller APY when in flight, never set it to position AUTOMATIC (АВТОМАТ) until controller APY is repaired.

287. Should it occur that controller APY fails to operate when carrying out a combat mission, it is allowed to continue flying with controller APY operated manually. In this case the pilot should set the rod (the indicator pointer) of controller APY to a position corresponding to the indicated airspeed and flying altitude by using the pressure-type switch. This being the case, the pilot should avoid sharp maneuvering and excessive indicated airspeeds, i.e. the indicated airspeed corresponding to the position of the APY controller indicator pointer should not be exceeded by more than 100 - 150 km/hr.

Failure of Autopilot KAП-2

288. Failure of the servo unit of autopilot КАП-2 (the rod of the servo unit has been jammed not in the neutral position) can be known by the aircraft banking when the control stick is neutral.

289. If autopilot KAN-2 fails to operate properly (auto-oscillations and spontaneous banking are taking place), it is necessary to switch off the autopilot stabilization and then damping operating duties and finally circuit breaker AP (AII). If this fails to bring the rod of the servo unit to the neutral position, it is necessary to discontinue the mission and counteract the bank which occurs in landing by deflecting the control stick.

Failure of Oxygen System

290. The following are the indications of failure of the aircraft oxygen system:

(a) sharp drop of oxygen pressure as read by the pressure gauge of oxygen-flow indicator MK-18;

(b) no oxygen flows to the pressurized helmet or to the oxygen mask, this being determined by the blinkers of the oxygen-flow indicator remaining motionless when closed (i.e. the blinkers fail to open during inhalation);

(c) when the cabin is depressurized at altitudes higher than 12,000 m, no oxygen flows to the bladders of G-suit (which the pilot can feel) and no excessive pressure is built up in the pressurized helmet or in the oxygen mask (which is determined by reference to pressure gauge M-2000).

291. If one of the above indications of the failure of the oxygen system is found it is necessary to do the following:

(a) switch on oxygen supply from the parachute apparatus;

(b) descend at the maximum vertical rate possible down to an altitude of 4000 m;

(c) while descending, make sure that the air-dilution switch on remote-indicating panel AY-2 is set to MIXTURE (CMECb); this is necessary to obtain dilution of air flowing through the aircraft oxygen regulator if oxygen supply from the parachute oxygen apparatus is not sufficient for breathing;

(d) when at an altitude of 4000 m, remove the transparent face-pieces of the pressurization helmet and switch off the heater.

Depressurization of Cabin at High Altitudes

292. When the cabin becomes depressurized not due to the damage of the canopy glass or the break-off of the canopy sliding portion, decrease the flying altitude down to a cabin altitude below 12,000 m.

293. If it is necessary to make a prolonged flight in the unpressurized cabin at an altitude within 10,000 - 12,000 m, be careful not to spend too much oxygen. With the purpose of saving oxygen cut off manually the continuous oxygen flow by shifting the switch on the ДУ-2 remote-indicating panel from NEUTRAL (Н) to AUTOMATIC CUT-OUT (ВЫКЛ. АВТ.) because the automatic supply of oxygen to the suit will get cut out only after descending to an altitude of 8000 - 9000 m. After the automatic oxygen flow has been cut out the pressure in the bladders of G-suit is bleeded.

If it is necessary to increase the flying altitude in the course of further flight (the cabin altitude being over 12,000 m), set the oxygen supply control to NEUTRAL (Н) beforehand.

294. If the canopy glass has become damaged or the canopy sliding portion has been broken off, it is necessary to decrease the flying altitude and airspeed immediately. Flying with the canopy glass damaged or with the canopy sliding part off is possible if the pilot is wearing a crash helmet and maintains an indicated airspeed of 500 km/hr or if he is wearing a pressurization helmet and maintains an indicated airspeed of 700 km/hr.

Failure of Automatic Cabin-Air Temperature Controller

295. If the temperature of the cabin air starts rising, it is necessary to set the pressure-type switch of the cabin-air heater to COLD (ХОЛОДНЫЙ). If no drop in the cabin-air temperature occurs within 2 - 3 min, reduce the engine r.p.m. and descend to an altitude of 4000 m. If the cabin-air temperature remains too high, cut off the flow of air to the cockpit by

placing valve CABIN SUPPLY (ПИТАНИЕ КАБИНЫ) to CUT OFF (ЗАКРЫТО) and depressurize the cockpit when at an altitude not higher than 4000 m.

296. If the temperature of the cabin air starts dropping, place the pressure-type switch of the cabin-air heater to HOT (ГОРЯЧИЙ); the cabin-air temperature should start rising within 1 - 1.5 min.

Misting of Cockpit Canopy Glass

297. Usually the canopy glass becomes misted when descending from high altitudes with the engine operating at low power ratings.

Should the canopy glass become misted, it is necessary to:

(a) check whether the cockpit air supply valve is open;

(b) make sure that the canopy is properly sealed;

(c) increase the engine r.p.m.;

(d) reduce the rate of descent;

(e) place the switch of the cabin-air temperature controller to HOT (ГОРЯЧИЙ).

Misting of Transparent Face-Piece of Pressurization Helmet

298. Should the pressurization helmet transparent face-piece become misted in flight, it is necessary to turn the knob of the heater rheostat clockwise as far as the stop.

After the misting has disappeared set the rheostat knob index as required by shifting it somewhat to the right relative to the initial position.

299. When the rheostat of the transparent face-piece heater fails (misting persists), it is necessary to periodically make use of button PRESSURIZATION HELMET FAST HEATING (БЫСТРЫЙ ОБОГРЕВ ГЕРМОШЛЕМА) by pressing it for 1 - 2 min each time.

This being the case discontinue the mission and descend to an altitude of 4000 m.

300. If misting of the transparent face-piece persists in spite of using the rheostat and heater button, it is necessary to:

(a) bring the aircraft into a descent;

(b) shift the emergency oxygen supply control from NEUTRAL (H) to G-SUIT ON (ВКЛЮЧЕНИЕ КОСТЮМА);

(c) turn the excessive pressure handwheel to the left as far as it will go. After descending to an altitude of 4000 m remove the face-piece of the pressurization helmet and secure it on the parachute harness lock; place the emergency oxygen supply control and the excessive pressure handwheel to the initial position.

If misting of the pressurization helmet face-piece occurs in the depressurized cabin with the cabin altitude not exceeding 12,000 m, the pilot should act as indicated above. With the cabin altitude exceeding 12,000 m in addition to the above said it is necessary to descend to an altitude lower than 12,000 m.

If the face-piece of the pressurization helmet persists getting misty after switching on the emergency oxygen supply system, remove it when the cabin altitude is not over 12,000 m and keep it against your face so that the upper edge of the face-piece is somewhat lower than your eyes while covering your nose. Holding the face-piece in this position will allow you to observe the instruments. After descending to an altitude of 4000 m take the transparent face-piece off your face and place the knob for switching on the emergency oxygen supply system and the handwheel for building up excessive pressure to the initial position.

Note. In the exceptional cases it is possible to make a level flight at an altitude within 8000 - 12,000 m with the emergency oxygen supply system on both when the pressurization helmet face-piece is attached to the helmet and when it is detached. In both cases the pilot should be at any moment aware of the remaining amount of oxygen (which should be equal at least to 30 kg/sq.cm).

Aircraft Icing

301. If the aircraft and the cockpit canopy become covered with ice while penetrating through the overcast in an ascending flight, go on climbing and when above the clouds bring the aircraft into a level flight and then switch on the de-icer; the switching-on should be made in pulses lasting 2 - 3 sec at intervals lasting 10 - 15 sec.

If icing occurs when descending through the overcast, do not change the flight condition; switch on the canopy de-icer when at an altitude of 1000 m.

302. To remove ice formed on the aircraft, increase the flying airspeed (if it is possible under the flight conditions) to 700 km/hr IAS when flying at medium altitudes and to 800 - 900 km/hr TAS when flying at high altitudes.

Failure of Airspeed Tubes ПВД-7 and ТП-156

303. Failure of the total pressure line due to the failure of pitot-static tube ПВД-7 is determined by erroneous indications of the airspeed indicator and Mach number indicator as well as by failure of controller АРУ-3в. Failure of the static pressure line or failure of the static and total pressure lines due to the failure of pitot-static tube ПВД-7 can also be determined by erroneous indications of the altimeter and stand-by gyro horizon ДА-200 (200).

304. In case of failure of both these instruments it is necessary first of all to make sure that the heater of pitot-static tube ПВД-7 is switched on. If the failure is due to the heater being off, then the instruments should read properly in 2 - 3 min after switching on the heater.

305. If the total pressure line fails due to the failure of pitot-static tube ПВД-7, it is necessary to switch over the power supply to stand-by pitot tube ТП-156 and make sure that its heater is on; pitot tube ТП-156 being sound, the readings of the airspeed indicator and Mach number indicator will be restored and controller АРУ-3в will start operating.

306. If all mentioned instruments fail to operate simultaneously or their operation fails to be restored after

switching them over to operation from stand-by pitot tube ПВД-156, the pilot should check his flight conditions by reference to the gyro horizon in combination with the turn indicator and the engine r.p.m.; flying altitude should be checked by reference to cabin altitude and pressure differential gauge УЗПД-20 (when flying at altitudes over 2000 m, cabin altitude amounts approximately to half the flying altitude; when flying lower than 2000 m, cabin altitude is approximately equal to the flying altitude). If landing approach is made using ILS system, the pilot should check his flight conditions after obtaining the required data from the ground radar stations.

Presented in Table 3 are pitch angles and low-pressure rotor r.p.m. for different flight conditions in case of failure of pitot-static tube ПВД-7.

307. In all cases when pitot-static system fails, it is necessary to discontinue the mission and perform landing on the home or auxiliary airfield.

In the course of flying to the airfield, check whether the indicated airspeed corresponds to the indications of controller АРУ. Change over controller АРУ to manual control, if required. Before making approach for landing change over controller АРУ manually to LOW SPEED (МАЛАЯ СКОРОСТЬ).

Failure of Gyro Horizon

308. When in flight, failure or erroneous indications of the gyro horizon in any flight condition can be determined by comparing the indications of the whole group of flight and navigation instruments as well as by reference to the indicating light on the indicator of remote-reading gyro horizon АГК-1.

309. Should it occur that the gyro horizon starts reading erroneously, cage the instrument while in a straight and level flight by pressing the button for a short time. This will cause the indicating light to burn for not longer than 15 sec. If the instrument persists reading erroneously, this means that the gyro horizon is out of order.

Flight condition	Pitch angle as read by gyro horizon, deg	T.P.R. 3 positions	Airspeed, km/hr	Vertical rate, m/sec	Flaps
1	2	3	4	5	6
Climb:		Maximum rating			
aerodrome of 2000 m	15		850 (TAS)	35 - 45	Ig and flaps re-tracted
altitude of 4000 m	10	Ditto	850 (TAS)	35 - 45	Ditto
Level flight, altitude of 5000 m	3		600 (TAS)	0	Ig and flaps re-tracted
Glides:					
up to altitude of 2000 m	6	80	500 (IAS)	40	
from 2000 m to 1000 m	5	85	500 (IAS)	15	Ig down, flaps re-tracted
from 1000 m to 600 m	2	88	500 (IAS)	10.	
from 600 m to 300 m	0	88	450 (IAS)	3 - 5	
Traffic pattern level flight, altitude of 500 m	2	90	500 (IAS)	0	Ditto
Glide from altitude of 300 m after turning to final approach	-	65 - 70	400 - 360 (IAS)	-	Ig and flaps extended

With the gyro horizon being out of order, fly the aircraft by reference to stand-by gyro horizon ДА-200 (200) in combination with the airspeed indicator, the altimeter and directional system КСИ.

Failure of Directional System КСИ

310. Failure of the directional system КСИ is determined by the following:

(a) the scale of indicator УКИ-2 is immovable or moves by jerks when the aircraft is being turned;

(b) the scale oscillates when the aircraft is in a steady straight flight.

311. In case of failure of directional system КСИ discontinue accomplishing the mission and approach the landing airfield by reference to the radio compass with simultaneous checking the flight direction through obtaining the required data from the radio direction finder.

Note: If the directional system fails due to the failure of the gyro unit or gyro horizon, the aircraft course can be determined when flying level at a constant airspeed after pressing button SLAVING КСИ (СОГЛАСОВАНИЕ КСИ).

Failure of Radio Compass

312. Failure of the radio compass can be determined by:

(a) the pointer of the radio compass on instrument УКИ-2 remaining stationary while changing the flight direction or by the pointer uniform travel while in a straight flight;

(b) the absence of audible signals from the homing radio station.

313. In order to check the radio compass for operation it is necessary to:

(a) check operation of inverter ПО-750а (i.e. make sure that radio communication can be established);

(b) make certain that the mode of operation selector switch on the radio compass control panel is set to COMPAS (КОМПАС) and selector switch WIDE - NARROW (ШИР. - УЗК) is set to WIDE (ШИР.);

(c) make sure that the stops on the range and coarse tuning knob are locked;

(d) check the position of selector switch OUTER - INNER (ДАЛЬНЯЯ - БЛИЖНЯЯ);

(e) request the flight control officer whether the homing station is operating;

(f) check operation of the radio compass through other fixed channels.

314. Should the radio compass fail to operate, approach the airfield by reference to the directional system КСИ. Request periodically for radio bearings to make sure that the approach is made correctly.

If the radio compass fails to operate when flying in the overcast or above the overcast, perform landing approach by reference to the directional system; simultaneously obtain the necessary data from the radio direction finder and follow the commands of the flight control officer.

Failure of Radio Communication

315. Whenever radio communication has been interrupted suddenly, proceed as follows:

(a) make sure that selector switch RADIO - COMPASS (РАДИО - КОМПАС) on the radio station control panel is set to RADIO (РАДИО);

(b) make certain that the proper channel is selected;

(c) check the head phones (pressurization helmet) cord for proper connection;

(d) check the volume control for proper setting;

(e) switch off the noise suppressor by placing its switch to OFF (ВЫКЛЮЧЕНО);

(f) check position of the power selector switch and place it to position FULL POWER (МОЩНОСТЬ ПОЛНАЯ), if required;

(g) check radio communication on other channels.

If radio communication has not been restored after the above check, discontinue accomplishing the mission and make approach for landing while not interrupting radio transmission where it is required according to the flight rules.

316. If a homing radio station is provided with special equipment which enables the flight control officer to communicate with the aircraft in flight, it is necessary to make use of the automatic radio compass receiver to follow the commands of the flight control officer. This being the case, proceed as follows:

(a) set selector switch RADIO - COMPASS (РАНЕО - КОМПАС) on the control panel for radio set РСИУ to position COMPASS (КОМПАС);

(b) place the mode of operation selector switch on the radio compass control panel to ANTENNA (АНТЕННА);

(c) make certain that selector switch NEW - VOICE (ТЛГ - ТЛФ) is set to VOICE (ТЛФ).

On receiving commands from the flight control officer place periodically the mode of operation selector switch on the radio compass control panel to position COMPASS (КОМПАС) in order to be able to check the flight direction.

Forced landing outside Airfield

317. Landing outside the airfield is allowed on a site permitting landing with the landing gear extended and on condition that the pilot is sure of a safe landing.

318. In case of landing outside the airfield, proceed as follows:

(a) report the case to the flight control officer indicating the selected site;

(b) jettison the drop tank if it contains fuel;

(c) resort to emergency drop of the missiles and rocket pods УБ;

(d) extend the landing gear and flaps;

(e) lock the safety harness;

(f) jettison the canopy when flying at an altitude of 1500 - 1000 m at an indicated airspeed of 400 - 450 km/hr (when at a lower altitude, come to a decision on jettisoning the canopy depending on the situation);

(g) cut off the engine before the touchdown;

(h) release the drag chute and switch off the storage battery after the touchdown;

(1) when in a landing roll, apply the brakes taking into consideration the hardness of the soil and presence of obstacles.

At all times the forced landing should be made with the landing gear extended.

Damage of Tire or Wheel of One or Both Landing Gear Main Struts

319. The following are the signs indicating damage of one of the tires of the landing gear main wheels when in take-off run: severe vibration of the aircraft, turning moment and aircraft banking in the direction of the damaged tire.

320. If the tire or wheel of the landing gear main strut has been damaged during the first half of the run, it is necessary to:

(a) discontinue the take-off;

(b) hold the aircraft from turning;

(c) release the drag chute;

(d) cut out the engine.

If it is impossible to hold the aircraft from turning, switch off the automatic brake system and maintain the direction by pressing the brake lever (even if it causes tear-off of the tire).

321. In case of failure of the tire or wheel of the landing gear main strut before the aircraft has become airborne do as follows:

(a) continue taking off;

(b) immediately after the take-off brake the wheels without retracting the landing gear (when making a combat flight, it is allowed retracting the landing gear);

(c) perform landing approach and estimation for landing using a standard procedure. Before making approach for landing switch off the wheel brake automatic system. Perform landing on a concrete runway; after touchdown switch off the engine, release the drag chute and perform normal braking of the wheels; counteract the aircraft tendency to turning by deflecting the rudder.

The amount of fuel remaining in the tanks under these conditions should be minimum.

Failure of Landing Gear when Extending It in Usual Procedure

322. If the landing gear fails to extend or extends only rtially when in flight, with operating pressure existing in e main hydraulic system, it is necessary to place the landing ear valve control first to RETRACTED (УБРАНО) and then without lding it in the neutral position to EXTENDED (ВЫПУЩЕНО).

Make sure that the landing gear is extended by reference the landing gear warning system.

If it appears that the landing gear has failed to extend has extended only partially, repeat the above procedure - 3 times. While doing this, build up some accelerating force pending on the situation and flying conditions.

Note. Should it occur that all three struts of the landing gear fail to extend which is indicative of failure of the landing gear control circuit (e.g. failure of the selector switch, landing gear solenoid-operated valve, electric wiring), extend the landing gear using the emergency procedure.

Landing Gear Emergency Extension Procedure

323. If it is impossible to extend the landing gear using e standard procedure (due to the absence of pressure in the in hydraulic system), it is necessary to resort to the ergency procedure. To this end, proceed as follows:

(a) reduce the airspeed to 500 km/hr;

(b) place the landing gear control valve switch to NEUTRAL (НЕЙТРАЛЬНО);

(c) open the landing gear emergency control valve.

Make sure that the wheels are down by reference to the nding gear warning light and to the nose strut position chanical indicator which should come out completely.

Failure of One of Landing Gear Main Struts

324. If one of the landing gear main struts fails to tend, with the main hydraulic system being under pressure, is necessary to make two or three attempts to extend it and en, if the strut persists, retract the landing gear. This

being the case do not use the emergency procedure to extend the landing gear. Landing should be made on a soft runway on the nose leg (which should have been extended by operating the autonomous extension control) and the empty drop tank (if any). After the touchdown release the drag chute.

325. Landing approach and estimation should be made in the usual way. Be sure that the amount of fuel remaining in the tanks is minimum. Before turning to the base leg look the safety harness. Prior to touchdown switch off the engine. When making landing, avoid rounding out and floating too high.

Landing Roll under Conditions of Brake System Failure

326. Failure of the automatic wheel brake system is determined by the absence of braking at all or by intensive braking of one of the wheels after pressing the brake lever.

If this is the case, it is necessary to:

(a) release the drag chute (at a predetermined airspeed) and retract the flaps;

(b) release fully the brake lever, switch off the automatic brake system and perform manual braking by pressing smoothly the brake lever;

(c) switch off the engine.

327. Should it occur that after the automatic brake system has been switched off no braking of the wheels takes place (which means that the entire brake system has failed), release the drag chute, switch off the engine and in case of emergency apply the emergency brake system. To obtain the required braking, smoothly pull rearward the emergency brake lever.

EMERGENCY ESCAPE FROM AIRCRAFT

Escape when in Flight

328. In order to be able to escape from the aircraft as quickly as possible when in flight, the pilot should be thoroughly trained on the ground.

As a rule emergency escape from the aircraft should be made using the bailout procedure with canopy protection and sometimes with the canopy previously jettisoned.

329. When bailing out using canopy protection it is necessary to:

(a) reduce the airspeed and assume an attitude required for ejection, if possible (if it is necessary to bail out as quickly as possible, taking attitude is not obligatory);

(b) take hold of the arm rests of the ejection seat and press both seat ejection handgrips;

(c) push off the ejection set arm rests with your hands after the harness restraint locks have got opened.

The entire ejection procedure including the parachute opening is made automatically without any interference of the pilot.

If the canopy has not come off the ejection seat after 1,5 sec have passed since the moment of ejection, the pilot should pull the emergency handle located on the front side of the seat pan. This done, the firing mechanisms will operate and release the pilot from the seat harness and detach the canopy from the ejection seat.

The pilot should make use of the emergency handle when the locks fail to open as well.

The minimum altitude at which the pilot can be safely ejected while in a level flight is equal to 110 m; the maximum indicated airspeed for safe ejection is 1100 km/hr.

330. If the pilot has jettisoned the canopy and then he confronts the situation which presses him to resort to ejection, he should:

(a) reduce the airspeed, if possible;

(b) press the body against the seatback and the head against the headrest;

(c) press tightly the arms against the seat arm rests, and while holding the arms tight against the body, strain the muscles of the body;

(d) without changing the attitude press the seat ejection handgrips on the arm rests.

After being ejected and released from the harness the pilot should push off the seat with the hands.

If the harness failed to release the pilot in 1.5 sec since the moment of ejection, the pilot should pull the emergency handle for opening the locks of the restraint harness.

The minimum level-flight safe ejection altitude when bailing out under the above conditions will be 150 m; safe indicated airspeed for ejection under the above conditions will be 700 km/hr.

331. If no ejection occurs after pressing both seat ejection handgrips, the pilot should:

(a) reduce the airspeed, if possible;

(b) switch on the parachute apparatus oxygen supply;

(c) disconnect common connector OPK-2;

(d) jettison the canopy by throwing back and pulling the red handle located on the cockpit right side; while doing this, the pilot should bend as close to the instrument board as possible;

(e) pull the emergency handle located on the front side of the seat pan; this will cause the firing mechanism to operate and the pilot will become released from the seat harness;

(f) escape from the aircraft.

332. When ejecting at altitudes below 500 m, the pilot should pull the pull ring and open the parachute immediately after being detached from the seat.

When ejecting at altitudes higher than 10,000 m, the pilot should go on falling until the parachute becomes opened by parachute release control unit KAP-3u; the parachute gets opened at the altitude to which the unit has been set or in 2 sec since the moment the pilot was detached from the seat provided that the ejection altitude is lower than that to which the KAP-3u unit is set.

If the parachute has not been opened by unit KAP-3u, the pilot should open it by pulling the pull ring at an altitude not lower than 1000 m above the ground.

333. Should it become necessary to open the parachute at an altitude exceeding that which is set on unit KAP-3u (in case of excessive roll, ear ache, ejection above

mountains), the pilot should open it after 5 sec have passed since the moment the pilot was detached from the seat. It should be remembered, however, that this altitude should not exceed 9000 m. When ejecting at an altitude higher than 9000 m, open the parachute after 10-sec delay for every 1000 m (See Table 4).

Notes: 1. When descending at a high rate, under emergency conditions the pilot should take a decision for bailing out before reaching an altitude not less than 2000 m.

2. After ejecting the pilot should remove the face-piece of the pressurisation helmet at an altitude not over 4000 m.

334. Should it become necessary to jettison the canopy without resorting to the bailout procedure, the pilot should reduce the airspeed (if possible) to 400 - 500 km/hr IAS, bend closer to the instrument board and jettison the canopy by throwing back and pulling the red handle located on the right side of the cockpit. When flying at high altitudes, it is necessary to depressurize the cabin before pulling the handle.

Escape when on Ground

335. In order to leave the aircraft as quickly as possible when on the ground, use the following procedure:

(a) open the cockpit canopy (if it would not open, bend close to the instrument board and jettison using the emergency procedure);

(b) remove the face-piece of the pressurisation helmet;

(c) disconnect common connector OPK-2;

(d) get released from the safety harness of the ejection seat using the emergency handle located on the front side of the seat pan;

(e) disconnect the cord of unit KAN-3M from the seat and leave the aircraft without taking off the parachute.

336. If the aircraft is furnished with oxygen equipment set KKO-3 provided with pressure ratio controller POД-3M, it is possible to use another escape procedure. In this case the pilot should make use of the handle of the emergency group connector

(the handle being located on pressure ratio controller РОД-3м) to disconnect the high-altitude suit communicating lines from the aircraft equipment, then open the master lock of the parachute harness and escape from the aircraft having left the parachute inside the cockpit.

Table 4

Ejection altitude, m	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000
Parachute-opening delay time, sec	10	20	30	40	50	60	70	80	90

14,000	15,000	16,000	17,000
50	60	70	80

Chapter IV

DESCRIPTION OF AIRCRAFT, ITS SYSTEMS AND EQUIPMENT

GENERAL INFORMATION

Data on Aircraft Dimensions and Weight

Length	12.287 m
Wing span	7.15 m
Wing area	23 sq.m
Sweepback angle (for wing leading edge)	57°
Stabilizer area	3.94 sq.m
Stabilizer nose deflection angles:	
up	13 ± 1°
down	20 ± 1°
Vertical tail area	4.45 sq.m
Rudder area	0.965 sq.m
Rudder angles of deflection	± 25°
Area of flaps	1.87 sq.m
Flap deflection angle	25 ± 1°
Aileron deflection angle	± 20°
Area of ailerons	1.10 sq.m
Area of three air brakes	1.23 sq.m
CG limits (when carrying drop tank)	29.5 - 36.2 % MAC
Aircraft take-off weight with two rocket missiles S-3:	
without drop tank	7750 kg
with drop tank	8280 kg

Power Plant

Engine

Installed on the aircraft is two-shaft turbojet engine P1102-300 consisting of the following main parts and systems:

(a) axial six-stage two-rotor compressor;
(b) ten independent combustion chambers;
(c) two-stage axial gas turbine;
(d) afterburner provided with controllable jet nozzle;
(e) engine fuel supply and automatic control system;
(f) autonomous oil system;
(g) engine automatic start system.

The main engine ratings are presented in Table 5.

Table 5

Engine rating	Thrust, kg	Low-pressure rotor r.p.m., %	Jet nozzle dia., mm
Full augmented	6200	100 ± 0.5	680
Minimum augmented	4900	100 ± 0.5	610
Maximum	3900	100 ± 0.5	530
Normal	3100	93 ± 0.5	530
Idle	170	Depending on atmospheric pressure	680

Notes: 1. The table indicates the thrust obtained with the engine operating on the ground under standard atmospheric conditions.
2. When operating at intermediate engine rating between full and minimum augmented ratings, the diameter of the jet nozzle will be variable, depending on the engine control lever position.

When on the ground, the thrust of engine P1102-300 operating at the augmented rating exceeds that obtained at the maximum rating by some 59%. In this case the specific rate of fuel consumption will get increased by 2.2 or 2.3 times.

With the increase of the airspeed the engine thrust is increased too.

To provide steady operation of the compressor in a two-shaft engine while changing its operating conditions (i.e. airspeed, flying altitude, ambient air temperature, engine r.p.m.), self-regulation of low-pressure rotor and high-pressure rotor r.p.m. is used. This being the case, the axial speeds of airflow as well as the low-pressure rotor and the high-pressure rotor r.p.m. are set automatically so that the inlet airflow incidence angles are considerably lesser than the stall angles.

To regulate the operation of engine P1102-300 a combined principle of regulation is used. With the airspeed increasing up to M = 2, the low-pressure rotor r.p.m. are maintained constant, while the high-pressure rotor r.p.m. grow up to 104%. As soon as the high-pressure rotor r.p.m. reach the maximum permissible value equal to 104%, further increase of the airspeed will keep the high-pressure rotor r.p.m. constant while the low-pressure rotor r.p.m. will decrease.

Increase of the flying altitude to 11,000 m, with the airspeed remaining constant, will cause reduction of the high-pressure rotor r.p.m.; when flying at altitudes over 11,000 m, the value of the high-pressure rotor r.p.m. will not change due to the constant ambient temperature.

<u>The engine compressor</u> comprises a stator provided with inlet guide vanes and two rotors (the low-pressure rotor and the high-pressure rotor). Both of the rotors have three stages.

To increase the compression ratio, the first four stages of the compressor are made supersonic.

The stator of the compressor consists of separate housings used as guide vane assemblies of the compressor stages.

The low-pressure rotor of the compressor consists of a shaft and three discs provided with blades. The rear end of the shaft is connected with the shaft of the second-stage turbine.

The high-pressure rotor also consists of three discs and a hub whose shank is connected with the shaft of the first-stage turbine.

Provided on the rear housing of the compressor are two side units and one upper unit for attachment of the engine on the aircraft.

50X1-HUM

Straight-flow, cylinder-shaped combustion chambers of the engine are located within the circular space between the compressor and the turbine. There are ten of them in the engine.

Inserted in the front portion of each combustion chamber (i.e. in the swirler) is the main burner. The combustion chambers are connected by interconnecting tubes used for equalising pressure in the combustion chambers and for flame propagation when starting the engine on the ground and in flight.

Located on the interconnecting tubes of the combustion chambers (between chambers 1 and 2, 9 and 10) are two starting units used for inflaming air-fuel mixture in the combustion chambers when starting the engine on the ground or in flight. When starting the engine, kerosene and oxygen are delivered to the starting units (oxygen being delivered only for the in-flight start) and high voltage is supplied to the spark plug.

Located on the rear flange of the housing of the combustion chambers are two rear attachment fittings for the engine.

The engine turbine is an axial, two-stage jet-type turbine.

Each turbine stage is provided with an operating wheel furnished with blades and a turbine nozzle.

The outer shaft of the rotor of the turbine first stage is rigidly connected with the high-pressure compressor. The inner shaft of the turbine second stage rotor is connected with the low-pressure compressor.

The engine afterburner chamber consists of a diffuser and a pipe provided with variable area jet nozzle.

The diffuser houses the following units: thermocouple transmitters, two manifold rings provided with burners, two flame holder rings and igniter.

Control of the variable jet nozzle (i.e. changing its diameter) is accomplished through the use of all-rating electro-hydraulic system SRCY-1, the latter changing the position of the jet nozzle shutters depending on the engine rating (i.e. depending on position of the engine control lever).

When starting the engine and when the engine operates at the idle rating the jet nozzle shutters should remain in the augmented position (in which case the jet nozzle diameter is

maximum and amounts to 680 mm). With the high-pressure rotor r.p.m. increased to 66%, the shutters should be placed to a position corresponding to the maximum rating (in which case the jet nozzle diameter is minimum and equals 530 mm).

When the engine control lever is shifted to MINIMUM AUGMENTED (МИНИМАЛЬНЫЙ ФОРСАЖ), the shutters will open to make the jet nozzle diameter equal to 610 mm. When shifting the engine control lever from this position as far as stop FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ), the shutters will be smoothly opening while following the engine control lever and on reaching position FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ) they will settle in a position corresponding to the augmented rating (680 mm). This system of control makes it possible to control the jet nozzle at all engine ratings and to obtain controllable thrust with the engine operating at the augmented ratings.

If the all-rating electro-hydraulic system of the jet nozzle control fails, the pilot may change over to operation of the two-position jet nozzle control system by turning on selector switch EMERGENCY SWITCHING-ON OF SHUTTERS, AUGMENTED, MAXIMUM (АВАРИЙНОЕ ВКЛЮЧЕНИЕ СТВОРОК, ФОРСАЖ, МАКСИМАЛ). This being the case, the afterburner will become switched on only after placing the engine control lever to FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ). Under these conditions no change in engine thrust will take place at the augmented rating.

To ensure operation of the engine and aircraft systems, mounted on the engine bottom are the following main units driven by the engine rotors:

(a) main fuel regulating pump НР-21Ф2;

(b) afterburner regulating pump НР-2202;

(c) auxiliary centrifugal fuel pump ДЦН-13х8;

(d) oil system pumps;

(e) two hydraulic pumps НП-34 for the main and booster hydraulic systems;

(f) starter-generator ГСР-СТ-12,000 W;

(g) A.C. generator СГО-8- Ser.1;

(h) tachometer generator of the low-pressure rotor and high-pressure rotor r.p.m.

Lubrication system. Engine P1082-300 is provided with a closed-circuit lubrication system for lubricating bearings and drives. All the units of the oil system are installed on the engine. The oil tank, fuel-oil cooler and fuel filter are assembled as one fuel-oil unit 1675. The delivery pump, three scavenge pumps (pumping the fuel out of the middle and rear supports of the rotors and out of the drive gear box) and the fine filter make up one oil unit as well. One more pump is used for scavenging oil out of the front bearing.

The delivery pump takes oil from the oil tank and then feeds it under pressure to the front bearing of the low-pressure rotor, to the bearings of the middle and rear supports of the engine rotors, to the bearings and gears of the gear drive box, to the pressure gauge transmitter.

The scavenged oil is delivered to the fuel-oil cooler (of unit 1675) to be cooled by the fuel supplied to the engine. From the oil cooler the oil is delivered to the oil tank.

Used for lubrication is oil, grade MK-8, with antioxidant additive ionol or without it. The oil tank filled to capacity should contain 10.5 - 11.5 lit of oil (with the engine oil system filled up). The oil level in the tank should be checked with a dipstick provided for the purpose. Oil consumption is not more than 1.2 lit/hr.

Air Inlet Duct

The inlet duct of the aircraft is provided with:

(a) supersonic air intake;

(b) automatically controlled cone provided with boundary layer bleeds;

(c) automatically controlled antisurge shutters located on both sides of the air intake front portions;

(d) noncontrolled take-off shutters located on the fuselage sides in front of the engine inlet.

On entering the air intake, the air is directed into two ducts located along the fuselage sides, which merge to form one duct at the engine inlet.

When in flight, the position of the cone is automatically changed as the airspeed, flying altitude and engine speed change. If the airspeed increases or the engine speed decreases (in which

case mass air flow through the engine and compressor pressure ratio decrease), the intake cone gets extended. With the increase in the engine speed or decrease in the airspeed, the cone is retracted.

By changing the position of the cone the amount of the air entering the air intake is changed so as to be brought in correspondence with the engine compressor capacity. In this case the stageless system of cone control will provide for minimum loss of total pressure in the inlet duct, minimum drag of the air intake and steady operation of the engine and inlet duct under all flight conditions and with the engine operating at steady or intermediate ratings.

The pilot should change over to the automatic control of the cone after retracting the landing gear. With the landing gear extended, the cone automatic control system is switched off and the cone is fully retracted, which makes it possible to reduce losses in the effective thrust during take-off.

The travel of the air intake cone is accomplished through the use of a stageless automatic control electrical system which operates depending on the change in the air pressure ratio of the engine compressor and stabilizer deflection angle.

If the cone automatic control system fails, the pilot may accomplish control of the cone manually.

If the pressure in the aircraft hydraulic system drops, the cone will remain in the position it occupied at the moment of pressure drop.

The cone position is checked by reference to the indicator both when using the automatic and manual control. Zero position of the indicator pointer will correspond to the retracted position of the cone. When the cone travels by 3 - 6 mm forward of the retracted position, the CONE EXTENDED(КОНУС ВЫНУТЕН) indicating light on light panel T-4 comes on.

To ensure steady operation of the air intake when changing the aircraft angle of attack, provision is made for additional extension of the cone and opening of the antisurge shutters depending on the stabilizer angle of deflection.

Besides, to obtain steady operation of the air intake, the antisurge shutters open when throttling down the engine at the augmented rating at Mach numbers more than 1.35.

When the antisurge shutters are open, the air is partially vented to the atmosphere from the air intake. Due to this it is possible to maintain steady flow of the air at the air intake inlet.

If the antisurge shutter automatic control system fails, the pilot can control the shutters manually.

To reduce losses at the engine inlet during take-off, the intake duct of the aircraft is furnished with the non-controlled take-off shutters which operate due to the difference between the ambient air pressure and the pressure inside the inlet duct. When the engine operates on the ground or at low airspeeds (during take-off), the take-off shutters are open, for the pressure in the inlet duct is below the atmospheric one. When increasing the airspeed, the pressure in the inlet duct increases and the take-off shutters are closed.

Engine Control

Control of the engine is accomplished through the use of the engine control lever located on the cockpit left-hand control panel. Movement of the engine control lever of regulating pump НР-21Ф2 is transmitted through the system of rods and rockers.

The engine control lever has the following fixed positions: STOP (СТОП), IDLE (МАЛЫЙ ГАЗ), MAXIMUM (МАКСИМАЛ), MINIMUM AUGMENTED (МИНИМАЛЬНЫЙ ФОРСАЖ), FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ). The engine control lever mounts two buttons. The rear button is used for shifting the engine control lever from STOP (СТОП) to IDLE (МАЛЫЙ ГАЗ) and back, the front button is used for shifting the engine control lever to MINIMUM AUGMENTED (МИНИМАЛЬНЫЙ ФОРСАЖ), FULL AUGMENTED (ПОЛНЫЙ ФОРСАЖ) and back.

Checking the engine operation is performed by reference to the indications of the two-pointer r.p.m. indicator (the first pointer showing the low-pressure rotor r.p.m., the second pointer showing high-pressure rotor r.p.m.), the exhaust gas temperature

indicator and the oil pressure gauge. Besides, for checking the engine start and afterburner switching-on, there are special indicating lights on light panel T-10y.

Fuel System

The purpose of the fuel system is to supply the engine with fuel at all altitudes and engine ratings. The aircraft fuel system consists of the main fuel system and the engine fuel system.

Main Fuel System

The consumable capacity of the aircraft fuel system without the drop tank is 2780 lit, with drop tank - 3270 lit.

The fuel system comprises:

(a) six fuselage bag tanks with a total capacity of 2110 lit (tanks 1 through 6);

(b) one fuselage top metal tank with a capacity of 170 lit (tank 7);

(c) four wing fuel cells (wing tanks) with a capacity of 560 lit;

(d) one drop tank of a 490-lit capacity;

(e) vent system and system for pressurizing the fuselage, wing and drop tanks;

(f) fuel transfer system for supplying fuel into the service tank and for fuel transfer from the service tank to the engine;

(g) system of control pressure provided with a special valve as well as with drain and float valves to ensure definite sequence in fuel consumption;

(h) system which allows checking fuel consumption rate, amount of fuel remaining in the tanks and operation of the pumps.

According to the sequence of fuel consumption and signalization the fuel tanks are divided into the following groups:

(a) tank group 1 including tanks 1, 2, 7 and wing fuel cells (pump 1 being located in tank 2);

(b) tank group 2 (service tank group) including tank 3, the latter consisting of two halves (the top half and the bottom one);

(c) tank group 3 including tanks 4, 5 and 6 (pump 3 being located in tank 4);

(d) the drop tank.

To ensure normal operation of the fuel system particularly at high altitudes, a constant excessive pressure of 0.21 - 0.23 kg/sq.cm should be maintained inside all fuselage fuel tanks. The vent system is provided with an impact pressure scoop for rapid equalising of pressure in the fuel tanks during dive.

Transfer of fuel from each group of fuel tanks is accomplished by the pumps.

To transfer fuel from tank group 1 to the service tank, pump 1 is used (unit 422A); fuel may also flow to the service tank by gravity.

Fuel from tank group 3 is transferred by the pump (unit 495A2) via the float valve located in the top portion of tank 3 to the service tank.

Consumption of fuel from the wing fuel cells is accomplished without any pumps; it is possible due to an excessive air pressure of 0.19 - 0.2 kg/sq.cm (over the pressure in the fuselage tanks).

Consumption of fuel from the drop tank is accomplished under an excessive pressure of 0.6 kg/sq.cm (as compared with the pressure in the fuselage tanks).

Thus, fuel is transferred from all the tanks into service tank 3 in whose bottom portion pump 2 is installed. This pump supplies fuel along the fuel delivery line via the shutoff valve and the fuel flow transmitter to the engine booster pump.

To make it possible to feed fuel to the engine when flying with negative G-loads, the bottom half of the service tank is made constructionally as an inverted-flight section with a reserve of fuel sufficient for flying during 15 sec at any engine rating but the augmented one (when at the augmented rating, this time will be equal to 5 sec).

To check the amount of fuel remaining in the system, the pilot should watch the readings of fuel flow indicator FRI-16. Besides, the cockpit is provided with a light indicating system for checking sequence of fuel consumption.

(c) tank group 3 including tanks 4, 5 and 6 (pump 3 being located in tank 4);

(d) the drop tank.

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To check the amount of fuel remaining in the system, the pilot should watch the readings of fuel flow indicator PRC-15a. Besides, the cockpit is provided with a light indicating system for checking sequence of fuel consumption.

Sequence of fuel consumption. To keep CG position within the permissible limits, the sequence in which fuel is consumed from the tanks is maintained automatically through the use of the float valves installed in tanks 7 and 3, the special valve installed in tank 2, the drain valves and the fuel control pressure taken off aft of pumps 2 and 3.

Presented in Table 6 is sequence of fuel consumption and fuel consumption signalization (with the drop tank suspended).

Table 6

No.	Tank group	Fuel consumption signalization	Fuel remainder as read by fuel flowmeter, lit
1	2	3	4
1	50 lit from fuselage top tank 7	-	-
2	Drop tank	Green light on instrument board becomes on	-
3	30 lit from fuselage top tank 7	-	-
4	Wing rear tanks	-	-
5	Wing front tanks	-	-
6	Tank group 1	Green light TANK GROUP 1 (1 FP. BAKOB) becomes on	900 ± 1200
7	Top sections of tanks 3, 4, 5 and 6	Red indicating light 550 LIT FUEL REMAINDER (OSTATOK 550 L) becomes on	450 ± 90
8	Tanks 4, 5 and 6 (emptied completely)	Green indicating light TANK GROUP 2 (2 FP. BAKOB) becomes on	280

1	2	3	4
9	Service tank (emptied completely)	Indicating light SERVICE TANK (РАСХОДНЫЙ БАК) becomes on	0

Sequence of fuel consumption when flying without the drop tank differs from that mentioned above in that about 80 lit of fuel are consumed first from the fuselage top tank and then from the wing fuel cells. Further sequence of fuel consumption and signalization is the same as presented in Table 6.

Note. The above sequence of fuel consumption and signalization involves level flying with the engine operating at the ratings not higher than the maximum rating.

Filling all fuel tanks with fuel is accomplished through the filler neck of the fuselage top tank. The drop tank is fueled through its own filler neck.

Drainage of fuel from all fuel tanks should be made through the drain cock with the pumps being switched on. Besides, there are drain plugs in the wing fuel cells and drain cocks on the pumps and connecting pipelines.

Engine Fuel System

The fuel system and automatic control equipment of the engine make it possible to start the engine on the ground and in flight and to control the amount of fuel supplied to the main and afterburner chambers when changing the engine rating.

The engine operates on kerosene T-1 or TC-1. This kerosene is also used for starting the engine on the ground and in flight.

Pump 2 delivers fuel from the service tank to auxiliary centrifugal pump ДЦН-13Д where from the fuel is supplied through the fuel-oil cooler (unit 1675) to governing pumps НР-2102 and НР-2202.

Governing pump НР-2102 feeds fuel to the main burners of the combustion chambers (the burners being supplied from two manifold rings) and ensures:

(a) automatic starting of the engine (in combination with other starting units);

(b) control of r.p.m. of the engine rotors when operating at the idle rating;

(c) changing and maintaining the assigned engine ratings;

(d) control of the low-pressure rotor maximum r.p.m. value;

(e) restriction of the high-pressure rotor maximum r.p.m. value (in combination with pump NP-2202);

(f) engine acceleration when rapidly shifting the engine control lever;

(g) engine shutoff.

Governing pump NP-2202 supplies fuel to the burners of the engine afterburner.

When the engine operates at the augmented rating, pump NP-2202 controls fuel supply to the afterburner by maintaining a constant ratio of the air pressure aft of the compressor to the exhaust gas pressure at all altitudes and airspeeds as well as when changing the diameter of the jet nozzle.

With the increase in the airspeed and decrease in the flying altitude, the air pressure aft of the compressor will increase. This being the case, to maintain a constant pressure ratio, governing pump NP-2202 will increase the amount of fuel supplied to the afterburner until the assigned pressure ratio is obtained due to the increase in the gas pressure.

The fuel flow through the burners of the afterburner is also automatically increased with the increase of the jet nozzle diameter, due to which the engine thrust at the augmented rating gains momentum.

When switching on the afterburner, ignition of fuel in the afterburner is accomplished through the use of a special flame igniter, the latter operating within 7 - 12 sec.

During its operating time, the flame igniter is supplied with carburated mixture and high-voltage electric current (the latter being fed to the spark plug). Jet flames formed in the igniter "light off" the afterburner fuel.

The engine is started automatically; when on the ground, the engine is started with the aid of starter-generator TGP-OT-12,000 W which is supplied from ground power sources

АПА-2М or ЭГУ-1 (the aircraft storage batteries used for starting the engine autonomously).

Oxygen Feed System

To make in-flight engine start more reliable, particularly at high altitudes, the aircraft is provided with an automatic oxygen feed system for supplying oxygen to the starting igniters of the main combustion chambers.

When using the oxygen feed system, reliable engine start in flight is provided up to an altitude of 10,000 m.

When placing the switch to IN-FLIGHT ENGINE START (ЗАПУСК В ВОЗДУХЕ) the oxygen contained in the oxygen cylinder will be supplied to the igniters through the reducer which decreases the pressure down to 9 - 10.5 atm and through the electropneumatic valve. Simultaneously with this, starting fuel is supplied and ignition is switched on. The amount of oxygen is sufficient for five starting cycles, each lasting 30 sec.

The amount of oxygen is checked by reference to the pressure gauge located in the cockpit (the pressure should be as high as 9 - 10.5 atm).

When the engine is started on the ground with the aid of button ENGINE GROUND START (ЗАПУСК НА ЗЕМЛЕ) oxygen is not supplied to the igniters.

Fire-Fighting Equipment

The aircraft fire-fighting equipment is used for extinguishing fire in the engine compartment; it consists of a fire-fighting system and a warning system. Used as a fire-fighting substance is a special compound contained in a 2-lit bottle provided with an electrically-operated discharge bonnet.

Fire-warning system МС-2мс includes two semi-circular heat-resistant metal pipes (i.e. ionization warning units) arranged in a semi-circle at the fuselage tail portion bulkhead. The pipes are attached to the fuselage by brackets through ceramic insulators.

It is characteristic of fire-warning system МС-2мс that it sends warning signals only after fire has appeared but not when

the temperature starts rising. When flame appears, the air gap between the aircraft body and the warning unit becomes current-carrying due to the ionised air and warning light FIRE (ПОЖАР) on light panel T-10y becomes on.

Ring manifold sprayer is located in the front portion of the fuselage engine compartment and is connected with the bottle by a pipeline.

In order to extinguish fire, it is necessary to press button FIRE EXTINGUISHER (ОГНЕТУШИТЕЛЬ) located on the left-hand panel of the instrument board. On pressing the button the discharge bonnet operates and the fire-extinguishing compound is forced from the bottle through the manifold sprayer to the engine compartment.

Hydraulic System

The aircraft hydraulic system comprises two independent systems: the booster hydraulic system and the main hydraulic system.

The amount of fluid АМГ-10 contained in both these systems when filled to capacity is equal to 37.5 lit. The maximum pressure in the systems with the units inoperative and the temperature of the hydraulic fluid being as high as 20 ± 5°C is equal to 215_{-12} kg/sq.cm. With the hydraulic units operating, the operating pressure range will be from 180 to 215 kg/sq.cm.

To ensure reliable operation of the systems at higher altitudes, air pressurization is provided for the hydraulic tanks, the air being fed from the engine compressor under an excessive pressure of 1.6 - 2.55 kg/sq.cm.

The booster system is used to operate the aircraft control system. It actuates one chamber of booster БУ-51ПС of the stabiliser and two boosters БУ-45А of the ailerons.

The main hydraulic system is designed for retracting and extending the landing gear, flaps, air brakes, for control of the engine jet nozzle shutters, the cone and the antisurge shutters of the air intake as well as for supplying fluid to the second chamber of booster БУ-51ПС and for actuating the cylinder of the automatic wheel brake when retracting the land-

ing gear. The main booster system is at the same time a stand-by system for aileron boosters BY-45a.

Variable-capacity plunger pump HH-34-1s is used as a source of hydraulic power in each hydraulic system.

The capacity of each pump under a pressure of 180 kg/sq.cm is not less than 34 lit/min, while under a pressure of $215^{}_{-12}$ kg/sq.cm the pump has zero capacity. In both hydraulic systems the assigned pressure is maintained by the regulators included in the pumps.

The control of the units in the hydraulic systems is accomplished through the use of the solenoid-operated valves which are remote-controlled from the cockpit. The pressure in the systems is measured by the remote-indicating two-pointer electrical gauge installed in the cockpit on the instrument board. Both hydraulic systems are provided with the pressure drop indicating light system. When the pressure drops down to 165^{+10}_{-5} kg/sq.cm, the red indicating lights on light panel T-10y will become on, when it rises as high as 195 kg/sq.cm, they will go out.

The booster system is provided with stand-by pumping unit HH-27T which is used in case of a dead engine landing or failure of the booster system pump. The pumping unit is operated by the electric motor fed from the aircraft mains. The maximum capacity of the stand-by pumping unit under a pressure of 185 kg/sq.cm is at least 1.6 lit/min at the rated voltage of 27 V.

When the booster and main hydraulic systems operate normally, the chambers of the stabilizer booster are supplied with power from both systems simultaneously, while the aileron boosters are actuated only from the booster system. If the booster system fails to operate and the pressure in this system drops to a value not exceeding half of the pressure in the main system, the aileron boosters will automatically change over to operation from the main hydraulic system, while the stabilizer booster will have only one chamber operating from the main system. This being the case, the force developed by the booster will be decreased by half.

When the pressure in the booster system rises to a value which is approximately equal to half of the pressure in the

main system, the aileron boosters will automatically change over to operation from the booster system.

Boosters BU-45a can be disconnected from both systems by operating the switch located over the instrument board at its left side. If this is the case, the ailerons will be controlled mechanically and the whole pressure will be spent for supplying hydraulic power to booster BU-51ms.

The stand-by pumping unit should be switched on when the pressure in the booster system drops down to 165^{+10}_{-5} kg/sq.cm. In this case the red indicating light on light panel T-10y flashes up. The pressure built up by pumping unit NN-27s is used for charging the hydraulic accumulators, the booster system, and for feeding booster BU-51ms and aileron boosters BU-45a (if they are switched on).

With pumping unit NN-27s operating and all hydraulic lines sound, the pressure in the booster system is maintained within 160 - 195 kg/sq.cm. With the pressure increasing in excess of 195 kg/sq.cm, the pumping unit will get disconnected automatically. This will be indicated by the red light on panel T-10y going out.

Air System

The aircraft air system comprises the main system and the emergency system.

The main air system is furnished with air bottles each having a 10.4-lit capacity, while the emergency system has air bottles each of a 2.6-lit capacity. The pressure in both systems is maintained within 110 - 130 kg/sq.cm. Besides, provided on the aircraft is an air bottle having a 2-lit capacity which is used for emergency removal of the canopy. This air bottle is separated from the main air system by a nonreturn valve. Therefore, when no air is present in the main system, a pressure of 110 - 130 kg/sq.cm is maintained in the bottle.

The drag chute control system is provided with an air bottle whose capacity is 1.9 lit; the pressure inside the bottle is equal to 50 Kg/sq.cm. This bottle is used to supply air for release and drop of the drag chute only.

The maximum operating pressure in the main wheel brakes is equal to $19^{+1.0}$ kg/sq.cm, in the nose wheel brake - 9.5 ± 0.5 kg/sq.cm, and in the emergency brake system - 17.5 ± 0.5 kg/sq.cm.

The pressure in the main brake system should be checked by reference to the two-pointer pressure gauge located on the instrument board. The pressure in the emergency brake system is not checked at all.

The main air system is used for: braking the wheels, opening and sealing the canopy, emergency removal of the canopy, releasing and dropping the drag chute, actuating the de-icer system, emergency closing of the shutoff fuel valve, and for control of the pneumatic valves in the system for cooling the fuselage front compartments.

The emergency air system is designed for emergency extension of the landing gear and emergency braking of the landing gear main wheels.

To check pressure in the main and emergency air systems, use should be made of the two-pointer pressure gauge installed on the right-hand panel in the cockpit.

Take-Off and Landing Devices

Landing Gear

The aircraft is provided with a tricycle retractable landing gear. The main struts are of a cantilever type, the nose strut being of a lever-and-straight-line type.

The landing gear extension and retraction is performed with the aid of the main hydraulic system. Operation of the landing gear control valve is accomplished through the use of a lever located on the left portion of the instrument board.

The main struts of the landing gear are retracted into the wing, while the wheels, turning relative to the struts, are retracted into the wells provided in the fuselage. The nose strut and its wheel are retracted into the well provided in the fuselage nose portion (in the flight direction). The pilot can check the landing gear for proper retraction and extension by reference to the indicating lights, the nose strut mechanical

indicator and by the pressure in the main hydraulic system which should reach its maximum value. When extended, the landing gear struts are held in position by mechanical and hydraulic locks; when retracted, they are held by mechanical locks.

Emergency extension of the landing gear is accomplished with the aid of the emergency air system. The lever of the landing gear control valve is located on the right-hand panel in the cockpit. There is also an autonomous mechanical extension system for the nose strut. Mounted on the landing gear main struts are brake wheels KT-92 measuring 800x200B and furnished with disc brakes. The operating pressure inside the wheel tires is 7.5 - 8 kg/sq.cm. The deflection of tire should be approximately equal to 50 - 60 mm.

Mounted on the nose strut is wheel KT-38 measuring 500x180A and provided with two pneumatic brakes. The operating pressure in the nose wheel tire is equal to 7 - 7.5 kg/sq.cm (the tire deflection being 30 mm).

The shock absorbers of all the three struts are of a hydro-nitrogen type, all of them located inside the struts. The initial pressure in the shock absorber of the main strut is 24 ± 1 kg/sq.cm, while in the shock absorber of the nose strut - 37 ± 1 kg/sq.cm.

The aircraft is provided with an automatic unbrake system to preclude skidding of the wheels. If skidding of any of the main wheels occurs, it is necessary to unbrake the skidding wheel and the nose wheel. If skidding of the nose wheel takes place, only the nose wheel should be unbraked.

Switching-on of the automatic wheel brake should be made by placing circuit breaker AUTOMATIC WHEEL BRAKE (АВТОМ. ТОРМОЗ. КОЛЕС) on the cockpit left side to ON (ВКЛЮЧЕНО). With the automatic wheel brake switched off, the system is operated manually. Before take-off the nose wheel brake should be switched on by operating the control valve lever located at the top of the instrument board; it should be switched off at the end of the take-off run.

Emergency braking (of the main wheels only) should be made by making use of the handle located at the top left-hand portion of the instrument board. In this case the emergency air system is employed.

Pulling the handle causes the valve to open, as a result of which the air flows into the wheel brakes. Pressure inside the brakes will depend on the amount of travel of the handle when pulled and on the reducing valve adjustment. Under emergency braking conditions the maximum pressure in the brakes should amount to 17 - 18 kg/sq.cm. The braking effect of the emergency brake system is lower than that of the main brake system with the automatic wheel brake switched on.

Drag Parachute

To shorten the landing roll length, use should be made of the drag chute provided on the aircraft. The drag chute is stowed in a special container arranged in the bottom left-hand portion of the fuselage tail unit. The parachute container has two shutters that should be closed. To release the drag chute, the pilot should press the button located on the top left-hand portion of the instrument board. The parachute drop button is located on the cockpit left-hand control panel. Parachute release and drop are accomplished with the aid of the electropneumatic system.

Flaps

To improve the aircraft take-off and landing performance characteristics, the wings of the aircraft are provided with floating flaps. When the flaps are in the take-off or landing position the flap angle equals 25°. When retracted, the flaps are held by the ball locks in the hydraulic cylinders and by the operating fluid pressure; when extended, they are held only by the operating fluid pressure. Due to this, retraction of the flaps under the action of the aerodynamic load begins as soon as the airspeed has reached 340 km/hr as read by the wide pointer while at an airspeed of 700 km/hr they will be retracted completely with the fluid being forced out of the cylinders into the delivery line.

The flaps are controlled by valve PA-184 with the aid of two buttons located on the cockpit left-hand control panel. When both flaps are extended, indicating light FLAPS EXTENDED

(ЗАКРЫЛКИ ВЫПУЩЕНЫ) on the flight and landing warning panel comes on. Should one of the flaps be extended only partially the indicating light will not become on.

Air Brakes

The aircraft is provided with three air brakes (two side flaps and one rear flap) which should be used for dissipating airspeed when flying under different flight conditions. The air brakes are controlled by means of two valves PA-184 one of which is used for control of the side flaps and the other for control of the rear flap. The rear flap valve is interlocked with the fuel drop tank by means of the limit switch. With the drop tank suspended, the rear air brake cannot be extended.

Control of the air brakes is accomplished by operating the switch on the engine control lever. When the switch is in the ON (ВКЛЮЧЕНО) position, the air brakes remain extended.

When pressure in the main hydraulic system drops, the air brakes are held retracted by the nonreturn valve, the latter precluding the fluid against flowing from the retracting chamber.

The lines for retracting and extending the side air brakes are connected with the pipeline provided with a cross-feed valve. With the cross-feed valve open, no retraction or extension of the side air brakes is possible by using the pressure in the hydraulic system.

Checking of the air brakes for proper extension is accomplished by reference to indicating light AIR BRAKES EXTENDED (ЩИТКИ ВЫПУЩЕНЫ) on the flight and landing control panel.

Aircraft Control System

The aircraft control system includes the stabilizer and aileron manual control system and the rudder control system (with the rudder being controlled by application of pedals).

Stabilizer Control

The stabilizer is controlled by operating the aircraft control stick. The stabilizer control system includes rigid rods, rockers and two-chamber booster БУ-5Ме, the latter operating in an irreversible cycle. The chambers of the booster are fed with

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Included in the stabilizer control system is controller APY-3B which changes automatically transmission ration between the control stick and the stabilizer and simultaneously between the control stick and the spring-loaded mechanism depending on flying altitude and airspeed.

The spring-loaded mechanism builds up efforts on the control stick in proportion to the control stick deflection from the neutral position and to the position of the APY-3B controller actuating mechanism.

Included in the system is also the trimming effect mechanism whose purpose is to remove continuous efforts from the control stick by changing the tension of the springs in the spring-loaded mechanism. Control of the trimming effect mechanism is accomplished through the use of a pressure-type switch located on the control stick.

Controller APY-3B consists of a control unit, an actuating mechanism and an indicator. With controller APY-3B operating, the amount of control stick travel (from stop to stop) remains unchanged, while deflection range of the stabilizer and efforts on the control stick are changing. The law of control according to which controller APY-3B operates depends on the airspeed and flying altitude; with the controller operating properly, no interference of the pilot is required. When flying at altitudes below 5000 m, control will be dependent on the airspeed only.

With the increase in the airspeed when flying at subsonic speeds, effectiveness of the stabilizer is increasing and, with the stabilizer-to-control stick transmission ration remaining unchanged, may grow excessively. During transition to supersonic airspeeds there intensively grows the aircraft longitudinal stability, while effectiveness of the stabilizer decreases to a certain extent. Consequently, to keep the aircraft control and maneuverability within allowable limits, the pilot should first increase stabilizer deflection angles and then discontinue increasing the angles of deflection as soon as the aircraft reaches supersonic airspeeds.

All above will be performed by controller APY-3D as follows:

(a) with the indicated airspeeds being less than 450 km/hr and corresponding to the take-off, landing and traffic-pattern flight airspeeds, the actuating mechanism of controller APY-3D is set to the larger arm (low speed) which corresponds to great angles of deflection of the stabilizer and to small efforts on the control stick;

(b) with the increase in the indicated airspeed from 450 to 1010 km/hr the stabilizer deflection angles decrease while the effort on the control stick increases;

(c) with the airspeed increasing in excess of 1010 km/hr the actuating mechanism of controller APY-3D remains set to the smaller arm, which corresponds to stabilizer minimum deflection angles and to maximum efforts on the control stick;

(d) when flying at altitudes from 5000 to 10,000 m, operation of the controller depends both on the impact pressure and flying altitude; for each flying altitude from 5000 to 10,000 m there is quite a definite indicated airspeed approaching a sonic speed; further increase in the indicated airspeed does not require any additional increase in the stabilizer deflection angles; with the increase in the flying altitude there decreases the range within which the controller is dependent on the impact pressure; the efforts on the control stick are decreasing while the stabilizer deflection is increasing by the amount of control stick deflection;

(e) when flying at altitudes over 10,000 m, the transmission ratios of the controller remain constant irrespective of the flying speed and altitude.

Checking the operation of controller APY-3D is accomplished by reference to the indicator installed in the top left-hand corner of the instrument board and to indicating light STABILIZER FOR LANDING (СТАБИЛИЗАТОР НА ПОСАДКУ) located on light panel T-4.

Controller APY-3D operates independently by taking up dynamic and static pressures from the aircraft airspeed tube system. Under normal operation conditions no interference of the pilot is required. If the controller fails, the pilot can

exercise control of the actuating mechanism of controller AFV-5D manually. To this end, the pilot should use the mode of operation selector switch and the pressure-type selector switch for manual switch-over of the controller to low and high speeds, both of the switches being located in the top left-hand corner of the instrument board.

Aileron Control

Control of the aircraft ailerons is accomplished through the use of the control stick. The aileron control system includes rigid rods and rockers as well as two boosters BU-45D operating in an irreversible cycle and located just next to the ailerons, a nonlinear mechanism and roll-stabilization autopilot KAP-2.

It is only the spring-loaded mechanism that creates some effort on the control stick when the latter is deflected with the aileron boosters operating. When switched off, the aileron boosters will operate as rigid rods. When deflecting the control stick the efforts on it will grow due to counteracting the aerodynamic load on the ailerons.

The transmission ratio nonlinear change mechanism is used to provide normal lateral stability of the aircraft at high indicated airspeeds when the ailerons are excessively effective and the lateral control of the aircraft is extremely responsive.

The nonlinear transmission mechanism provides for more easy control of the ailerons when the control stick is only slightly deflected from the neutral position with the boosters inoperative as well as for proper lateral control of the aircraft when flying at high airspeeds with the boosters operative.

The decreased effectiveness of the ailerons when flying at high Mach numbers or at low airspeeds, requires greater deflection of the control stick and consequently greater deflection angles of the ailerons.

Autopilot KAP-2 is used for improving aircraft stability and controllability in rolling. The autopilot has two operating duties: damping and stabilization.

When switched to damping, the autopilot will dampen the lateral oscillations of the aircraft while responding to the

angular rate of the roll. This facilitates flying considerably (the number of control stick movements required to maintain the assigned bank will be greatly reduced).

After pressing the stabilisation button the autopilot will bring the aircraft to zero bank from any initial bank (including the inverted flight), with pitch angles being ±30° and the aircraft control stick being neutral.

By deflecting the control stick laterally from the neutral position by ±70 mm, with the autopilot switched on to stabilisation, the pilot can change the bank angle from 0 to 36° while flying by reference to the control stick. In this case, with the control stick held deflected, the aircraft controlled by the autopilot will maintain the assigned bank.

Deflection of the control stick by more than ± 70 mm will lead to usual control of the aircraft by reference to the angular rate. In this case maintaining the assigned bank (in excess of 36°) should be made by the pilot. It is characteristic of flying with the autopilot switched on to stabilisation that maintaining the assigned bank requires holding the control stick deflected with some effort.

When the control stick is placed to the neutral position, the aircraft recovers to zero bank.

Used as a servo unit in autopilot КАП-2 is an electromechanical extension rod (РАУ-107) installed in the aileron control system. If the autopilot is switched off, the extension rod operates as usual rigid rod. When the autopilot is switched on, the length of the extension rod varies depending on the angular rate of the aircraft in roll. This being the case, the ailerons will be deflected to dampen the lateral oscillations without any interference of the pilot.

The gyro unit of gyro horizon АГД-1 is used in the autopilot as a bank angle transmitter. Gyro transmitter ДУС-М is installed for measuring angular rate of roll.

Full travel of the servo unit rod will cause the ailerons to deflect by 5.5°. This enables the pilot to continue flying and to perform landing while counteracting the aircraft banking, by deflecting the control stick in case of failure of the autopilot (e.g. when extension rod РАУ-107 has become jammed).

In order to switch on the autopilot, the pilot should cut in circuit breaker АГД, ДА-300 (200), АГД and АП. After these circuit breakers have been switched on horizon АГД-1 and gyro transmitter ДУС-К start operating. The pilot determines whether the autopilot is ready for the required operating duty (damping or stabilization) to be switched on after making sure that gyro horizon АГД-1 is ready for operation (the latter is ready for operation after at least 2 min have passed since the moment of switching-on of circuit breaker АГД).

Prior to switching on the autopilot it is necessary to switch on the aileron boosters and build up pressure in the hydraulic system, otherwise the autopilot will fail to get switched because of the pressure interlock.

For switching on the damping operating duty switch BANK DAMPER (ДЕМПФЕР КРЕНА) should be used.

For switching on the stabilization operating duty it is necessary to press the button on the control stick. After switching on the stabilization operating duty indicating light AP SWITCHED ON (АП ВКЛЮЧЕН) on the instrument board should become on.

To switch off the stabilization operating duty, the pilot should press the left-hand button located on the aircraft control stick.

Switching-off of the autopilot in flight on an aircraft balanced laterally may cause banking. This is due to the fact that switching-off of the autopilot brings servo unit РАУ-107 to the neutral position within ± 1.5 mm in the direction of the rod travel, which corresponds to $\pm 0.5^{\circ}$ in bank.

The above mentioned banking is permissible and is not subject to elimination.

Rudder Control

The rudder control system is rigid, consisting of rods, rockers and a mechanism for transmission ratio nonlinear change (no boosters are included in the rudder control system).

The mechanism for transmission ratio nonlinear change provides small deflection angles of the rudder with the pedal travel being great. This improves the rudder response at high

airspeeds and decreases the efforts on the pedals. The mechanism is mounted in the fin.

Pressurized Cabin

The aircraft pressurized cabin is of a ventilation type, being provided with pressurization from the engine compressor.

The cabin is furnished with a canopy. The canopy consists of a collapsible hood, a rear hood, a transparent armoured shield with side flaps and a pressurization partition.

When opening the cockpit, the collapsible hood is lifted forward (in the direction of flight) while turning about the axle located at the armoured shield. Lifting of the collapsible portion of the canopy is made through the use of pneumatic cylinders. The canopy is sealed after it has been lowered and its locks have been closed. The seal is provided with the help of sealing hose laid on the fuselage. Depressurization is made either automatically when the canopy locks open or by means of a special button provided for the purpose.

The canopy control handle and the canopy pressurization button are located on the left side of the cockpit. When placing the control handle to the vertical position as far as retainer STOP (СТОП), the air is bleeded from the canopy actuating cylinders and the canopy is lowered. To close the canopy locks the canopy control handle should be pushed to the extreme forward position where it should remain in the slot of the panel. Having made sure that the locks are closed (the indicating pins of the side locks should come out), it is necessary to pressurize the canopy by placing the pressurization button to the forward position.

Opening and closing of the canopy from the outside is made with the aid of the external canopy control handle located in the recess provided in the fuselage left side.

CAUTION. When the canopy is lifted, a ground safety pin should be installed in the hole of the actuating cylinder rod.

For jettisoning the canopy the pilot should operate the canopy jettison handle located on the fuselage right side.

The canopy jettison locks are opened through the use of the explosive charge system. Canopy tossing is accomplished by the canopy actuating cylinders which are fed with the air pressurized to 130 kg/sq.cm.

The hooks of the rods of the right and left actuating cylinders are provided with red marks to make it possible for the pilot to check visually whether the canopy jettison system is in the closed position. With the system closed, the red marks on the hooks should be covered with the forks of the two-arm bellcranks so that they cannot be seen.

The air supplied for pressurization, ventilation and heating of the cockpit is taken behind stage 6 of the engine compressor. For supplying air into the cockpit the pilot should open valve COCKPIT SUPPLY (ПИТАНИЕ КАБИНЫ) by placing it to the forward fixed position. The assigned pressure in the cockpit is maintained automatically by pressure regulator АРД-57Д which regulates airflow from the pressurized cabin.

The pressure regulator located on the cabin left side is provided with a valve which should always remain locked in the ON (ВКЛЮЧЕНО) position.

Pressure regulator АРД-57Д ensures free ventilation of the cockpit up to an altitude of 2000 m. At altitudes from 2000 to 10,000 m the pressure regulator permits smooth build-up of excessive pressure in the cockpit up to 0.29 - 0.31 kg/sq.cm; this pressure remains constant in spite of further increase in altitude. Pressure differential and cabin altitude are checked by reference to the indicator of cabin altitude and pressure differential gauge УВПД-20.

In case of failure of the pressure regulator the air excess in the cockpit will be bleeded through the safety valve to the atmosphere. The safety valve is set to an excessive pressure of 0.327 kg/sq.cm (240 mm Hg).

The assigned air temperature in the cockpit is maintained constant automatically. With the cockpit heating switch placed to AUTOMATIC (АВТОМАТ), the air supplied from the engine to the cockpit is divided by the distribution valve into two streams. One air stream runs through the air cooler and through the turbo-cooler in order to be cooled, the other stream (hot air) runs

through the pipeline to the pilot's cockpit. Before entering the cockpit both streams get mixed.

Amounts of hot and cooled air supplied to the cockpit are controlled automatically (depending on the temperature in the cockpit) by temperature controller ТРТВК-45М which controls the throttles of the air distribution valve.

If the automatic system fails, the pilot can control the air temperature in the cockpit manually. To this end, he should place the cockpit heating switch to COLD (ХОЛОДНЫЙ) or HOT (ГОРЯЧИЙ) depending on what is required.

Placing the switch to the neutral position will switch off the distribution valve, the throttles of the valve remaining in the same position as at the moment of switching-off.

The aircraft is provided with the system of cockpit forced ventilation to make it possible for the pilot to remain in the cockpit for a long time (in case of ground alert No.1) with the engine inoperative.

De-Icer System

The purpose of the aircraft de-icer system is to remove ice from the canopy front glass panel. For removing ice, alcohol is supplied to the front glass panel from the reservoir of a 4.5-lit capacity. The reservoir is located in the fuselage upper portion in front of the equipment compartment and connected with the manifold.

To switch the system on and off, the pilot should make use of button CANOPY DE-ICER (ПРОТИВООБЛ. ФОНАРЯ) on the left-hand panel of the instrument board. When pressing the button, valve ПУ-7 gets opened and the air flows from the main air system under a pressure of 3 kg/sq.cm to the reservoir thereby forcing the alcohol out of it, the alcohol being supplied to the canopy glass through the manifold.

To operate the system, the pilot should press the button several times, each pressing lasting 2 - 3 sec. The system allows to make 10 - 15 applications.

Aircraft Ejection System

The aircraft ejection system makes it possible for the pilot to abandon the aircraft safely under emergency conditions both at low and at high airspeeds.

Used for protecting the pilot from dangerous effects of the impact air is the canopy collapsible portion which is catched by the seat when ejecting. During ejection the canopy collapsible portion covers the pilot due to which it is possible to increase the airspeed of safe bailout.

The ejection system considerably decreases the time which is necessary for the pilot to prepare for ejection while in the cockpit, i.e. the time since the moment the pilot takes a decision for ejection till the moment he assumes the required attitude and presses the arm rests. It is not obligatory for the pilot to assume a definite attitude before ejection; he should only press the arm rests.

The ejection seat is provided with the harness automatic restraint mechanism. Ejection may be accomplished either with the canopy used for protection of the pilot or without the canopy which should be then jettisoned prior to ejection.

The ejection seat is a rigid construction consisting of the frame with the seat pan and of the control systems. The seat pan is electrically controlled. When in flight, it can be raised or lowered at the pilot's will. Clearance between the pressurized helmet (oxygen helmet) and the canopy glass should be equal to 50 mm.

The pilot is locked in the seat with the help of the safety harness having three locks, two of them being located at the waist belt and one at the shoulder straps. The tightness of the waist belts can be changed by operating the handle installed on the right side of the seat pan. The shoulder strap restraint mechanism is actuated by a special spring when in operation and by powder gases when ejecting. When in flight, the pilot can lean forward and get locked in this position. Control of the restraint locks is accomplished through the use of the handle located on the seat pan left side.

To unlock the shoulder stray restraint mechanism it is necessary to move the handle on the left-hand arm rest of the ejection seat.

The following are the main characteristics of the ejection system:

(a) the system provides for safe ejection when flying level at indicated airspeeds up to 1100 km/hr;

(b) the strength of the system component elements makes it possible to accomplish safe ejection up to the maximum airspeed values;

(c) G-force values built up during ejection are as high as 15 - 20;

(d) deceleration force at an indicated airspeed of 1100 km/hr is equal to 35 - 36;

(e) minimum safe ejection altitude in a level flight is equal to 110 m.

Employed in the system is life parachute C-3 provided with safety harness made of capron.

Ejection with canopy protection. Having taken a decision for ejection, the pilot should withdraw his feet from the pedal straps (ejection is also possible without removal of the feet from the pedal straps, for the latter are provided with detachable spring locks) and press the triggers of the ejection seat arm rests (either both of the triggers or one of them). This will cause operation of the safety harness restraint firing mechanism (which draws the pilot tight to the seatback and locks him in this position) and of the main firing mechanism. As a result of this the seat will start moving upward.

As the seat is moving upward, the following mechanisms operate automatically:

(a) the canopy rear engaging locks get closed on the seat trunnions while the canopy jettison locks get opened; the canopy, being disengaged from the fuselage, starts moving together with the seat;

(b) the stabiliser drogue firing mechanism operates and moves the drogue chute upwards; the drogue chute knocks the canopy hatch cover out and brings the main parachute into the airstream before the ejection seat has left the guide rollers;

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(c) the canopy supports get opened and locked in positions;

(d) safety harness automatic unlock mechanism AД-3 set to an operating time of 1.5 sec gets switched on;

(e) under the action of G-force the pilot's feet are lowered automatically onto the foot rests and get locked;

(f) the front portion of the canopy rolls off the windshield onto the opened supports and gets locked; then the seat engaged with the canopy separates from the aircraft and flies over the fin;

(g) in 1.5 sec since the moment of ejection automatic unlock mechanism AД-3 operates and actuates the canopy jettison firing mechanisms; these mechanisms open the canopy front engaging locks that connect the ejection seat with the canopy and the lock of the stabilizer drogue rod;

(h) the rod along with the stabilizer drogue becomes disconnected from the seat so as not to interfere with the canopy turning;

(i) then the canopy turns about the trunnions; the locks holding the canopy on the trunnions get opened and the canopy becomes separated from the seat;

(j) by the end of the travel of the firing mechanisms all safety harness locks become opened, the pilot's legs get released from the grips and the pilot gets separated from the seat. As soon as the pilot is separated from the seat, parachute release control unit КАП-3К installed inside the parachute pack gets engaged.

When ejecting at high altitudes, the pilot makes a delayed drop down to an altitude at which unit КАП-3К operates and releases the parachute. If the unit fails to operate, the pilot should open the parachute by pulling the parachute rip-cord ring at an altitude not lower than 1000 m above the ground.

If automatic unlock mechanism АД-3 fails, the pilot should pull the handgrip located on the seat pan. This will cause operation of the firing mechanisms which release the safety harness locks and the leg grips. Further movement of the handgrip may cause opening of the safety harness locks and the leg grips, after which the handgrip becomes disconnected.

Ejection without canopy protection. Ejection without canopy protection is possible when flying at an indicated airspeed up to 700 km/hr. When ejecting under these conditions, the pilot should previously jettison the canopy. To this end, he should throw down and pull back the canopy jettison handle located on the cockpit starboard side. When the canopy jettison handle is deflected down, there operates the diaphragm valve of the emergency air system for canopy tossing. This allows the air to be fed into the cylinder for opening the time delay lock and into the cylinder for canopy tossing. By deflecting the canopy jettison handle back the pilot engages the explosive charge mechanism for opening the canopy jettison locks (as a result of which the canopy is jettisoned) and opens the valve of the air-pressure bleeding device provided in the base plate of the firing mechanism to decrease G-forces during ejection which will follow (the canopy being already jettisoned).

Further actions of the pilot as well as travel of the ejection seat and operation of the mechanisms are quite similar to those as in the case of ejection with canopy protection, the procedure of separation of the canopy from the ejection-seat being excluded.

Aircraft Armament

The aircraft is equipped with rocket missiles and special missiles.

Main armament of the aircraft consists of two special missiles R-3s (suspended from the racks) with the use of launchers APU-3s.

Rocket armament consists of two sixteen-tube rocket pods UB-16-57y for rocket missiles C-5M or C-5K. Rocket pods UB-16-57 are suspended from shackles DG-57 of racks MDG-6U-21y.

Radar sight RP-9-21 and collimating sight PPK installed on the aircraft are used for aiming and launching missiles R-3s.

When launching missiles R-3s at ground targets or firing rocket missiles, aiming is performed with the aid of collimating sight PPK.

The reticle of sight PPK has two rings and a crosshair with divisions. The great ring has a 105-mil diameter, while the small

ring has a 70-mil diameter. The value of the crosshair greater division is 20 mils, the value of its smaller division is 10 mils. The dimmer located on the lower switch panel of the instrument board is used for control of reticle lighting.

Checking the results of launching missiles P-3c is accomplished through the use of radar camera NAY-473 which photographs the radar sight indicator scope.

Depending on the position of the selector switch on unit ECH-1 radar camera NAY-473 starts operating either with the radar sight high voltage switched on (in which case the selector switch should be placed to the HIGH VOLTAGE (ВКЛЮЧЕНО) position) or following the command from the ground.

When the radar sight operates under scanning or tracking conditions, radar camera NAY-473 operates under pulse conditions (1 frame per 2.5 sec); with the firing button depressed, it operates under cinema conditions (8 ± 2 frames per sec). When releasing the firing button, radar camera NAY-473 is changed over to operation under pulse conditions.

CAUTION. With missiles P-3c suspended, it is forbidden to check radar camera NAY-473 for operation by pressing the firing button.

Electrical Equipment

The aircraft electrical equipment consists of D.C. and A.C. power sources, current consumers and aircraft mains.

The main power source of direct current is starter-generator ГСР-СТ-12,000 W. When operating as a generator, it represents a D.C. generator with parallel excitation; when used as a starter, it represents a compound excitation motor.

Basic specifications for starter-generator ГСР-СТ-12,000 W are as follows: rated voltage - 28.5 V, rated current - 400 A, power (with voltage being 30 V) - 12,000 W and weight - 29 kg.

Connecting the starter-generator to the aircraft mains should be made with the high-pressure rotor r.p.m. equalling 31 - 34%; disconnecting should be made at a definite value of engine r.p.m. depending on the load and discharge extent of the storage batteries.

Two storage batteries 15-СЦС-45 are used as an additional source of D.C. electric power.

Basic specifications of these batteries are as follows: rated voltage - 22.5 V, capacity - 45 A-hr, weight of the battery filled with electrolyte - not over 16 kg.

To preserve the battery capacity at low ambient temperatures, the aircraft storage batteries should be installed on the aircraft in warm cases provided with electrical heaters. Electrical heating of the storage batteries is provided through the use of the ground power source; to switch on the electrical heating of the batteries, turn on switch STORAGE BATTERY HEATER (ОБОГРЕВ АККУМУЛЯТОРА) located on the right-hand control panel of the cockpit.

Checking the voltage across the aircraft mains should be made by reference to voltmeter B-1 installed on the instrument board. The voltmeter should read a voltage of 28 - 29 V with the generator operating and 26 - 27 V with the aircraft storage batteries operating without any load.

When in flight, storage batteries 15-СЦС-45 become charged slowly. This being the case, to preserve the capacity of the storage batteries, checking of the aircraft flight and navigation and radar equipment on the ground (when the engine is inoperative) should be made only from the ground power source.

On connecting the ground power source to the aircraft mains the generator and storage batteries get automatically disconnected from the mains.

The distribution busbars of the electrical switch panels are provided with two-way supply, being divided into sections which are connected by circuit breakers АЗР-60. Circuit breakers АЗР-60 (Bus 1, Bus 2, Bus 3) (ШИНА 1, ШИНА 2, ШИНА 3) are installed in the aircraft cockpit under protective covers and are always switched on.

The following units are used as A.C. power sources: generator СГО-8-Ser.2 and inverters ПО-1500 У-2М, ПО-750А, ПТ-500Э, ПАГ-1Ф. Generator СГО-8-Ser.2 is used for supplying the aircraft single-phase mains with an alternating current of a stabilized voltage and a varying frequency.

Basic specifications for generator СГО-8-Ser.2 are as follows: voltage - 115 V, frequency - 400 - 900 c.p.s., power - 8 kV, weight - 31 kg.

The generator is used for energizing the radar sight, system P-3c and transponder СРО.

Inverters ПО-1500W-2Н and ПО-750а convert direct current into a single-phase alternating current with a voltage of 115 V and a frequency of 400 c.p.s.

Inverter ПО-750а feeds current to radio station РСИУ-5Р, radio compass АРК-10, oil pressure gauge ДИМ-82, fuel flowmeter РТС-16а-4, cone control system УВД-2М, fire warning system ПС-2м and marker radio receiver МРП-56П.

Inverter ПО-1500W-2Н supplies power to radar sight РП-9-2Л.

If inverter ПО-750а fails, all its consumers may be switched over to inverter ПО-1500W-2Н by switching on circuit breaker INVERTER EMERGENCY SWITCH-OVER (АВАРИЙНОЕ ПЕРЕКЛЮЧЕНИЕ ПРЕОБРАЗОВАТЕЛЕЙ). This being the case, the radar sight will get automatically disconnected from inverter ПО-1500W-2М.

Inverters ПТ-500Ц and ПАГ-1Ф are used for converting direct current into a three-phase alternating current of a 36-V voltage and a 400-c.p.s. frequency.

Inverter ПТ-500Ц supplies power to autopilot КАП-2, directional system КСИ and gyro horizon АГД-1.

Inverter ПАГ-1Ф supplies power to stand-by gyro horizon ДА-300 (200).

For lighting the aircraft cockpit red light is used. Employed in the lighting system are incandescent lamps СМ-37 in which red-colour light filters are used.

The lamps are powered from the aircraft mains through circuit breaker RED LIGHT (КРАСНЫЙ СВЕТ) located on the rear right-hand switch panel.

Two dimmers РКД-45 mounted on the right-hand horizontal control panel in the cockpit are used for switching on the cockpit lighting system and for control of light intensity.

If the lighting system fails, the pilot should turn on switch STAND-BY RED LIGHT (АВАРИЙНЫЙ КРАСНЫЙ СВЕТ). In this case only the emergency group of instruments will be illuminated.

the rest of the instruments as well as the right-hand and left-hand control panels being not illuminated.

Aircraft Instruments

The aircraft instruments comprise three groups of instruments: flight and navigation instruments, engine instruments and instruments for checking the aircraft systems.

Flight and Navigation Instruments

Two-pointer airspeed indicator KUCH-2500: measuring range - from 200 to 2500 km/hr, division value up to 400 km/hr - 10 km/hr, division value starting from 400 km/hr - 50 km/hr.

Barometric altimeter VDM-30 is furnished with two dials. The outer dial has a measuring range from 0 to 1000 m with the division value being 10 m; the inner dial has a measuring range from 0 to 28 km with the division value being 1 km.

Stand-by gyro horizon DA-200 (200). Combined in the instrument body are a vertical speed indicator and a turn-and-slip indicator. Measuring range of the vertical speed indicator is from 0 to 300 (200) m/sec, division value up to 20 m/sec is 1 m/sec, division value for speeds over 20 m/sec is 20 m/sec.

Mach meter: measuring range - from 0.5 to 2.5 M; division value - 0.02 M.

Gyro horizon AGK-1. Basic specifications of the gyro horizon are as follows:

(a) starting time (i.e. time during which the instrument becomes ready for operation after being switched on) is equal to 1 - 2 min;

(b) errors in the instrument indications when determining bank angles in turns up to 360° are not in excess of ±3°;

(c) errors in bank and pitch angle indications after performing aerobatic maneuvers are not over ±5°;

(d) error after take-off is not in excess of ±3°.

Directional system NKI. The following are basic specifications of the system:

(a) starting time after energizing the system is not over 2 min;

(b) error in magnetic course reading when flying straight and level at a constant airspeed is not in excess of $\pm 2^{\circ}$;

(c) additional error due to azimuth drift of the gyro when flying by reference to the directional gyro is not in excess of $\pm 2^{\circ}$ within 30 min;

(d) error in radio station relative bearing readings at zero division is not in excess of $\pm 1^{\circ}$ while at the rest of the divisions it should not exceed $\pm 2.5^{\circ}$.

Accelerometer AM-10. Dial measuring range - from -5 to +10 g; division value - 0.5 g.

Aircraft clock AUK0.

Engine Instruments

Tachometer MTS-2. Measuring range - from 0 to 110%, division value - 1%. The tachometer indicator is provided with two pointers, the pointer with index "1" being used for measuring low-pressure rotor r.p.m. and the pointer with index "2" being used for measuring high-pressure rotor r.p.m.

Exhaust gas thermometer TM-11a. Measuring range - from 300 to 900°, division value - 10°.

Fuel flowmeter PTC-16a-4. Measuring range - from 0 to 4000 lit, division value - 100 lit. The indicator is provided with a rack used for setting the indicator pointer on a division corresponding to the amount of fuel filled. Setting the pointer should be made after the aircraft has been already fueled.

Oil pressure gauge MM-3a. Its measuring range is from 0 to 8 atm, its division value is 0.5 atm.

Instruments for Checking Aircraft Systems

Cabin altitude and pressure differential gauge UMD-20. Its measuring range is from 0 to 20 km, its division value is 0.5 km. Pressure differen-

tial measuring range is from -0.4 to +0.6 kg/sq.cm. Division value for positive range is 0.02 kg/sq.cm and for negative range is 0.01 kg/sq.cm.

Pressure gauge 2ДИМ-250a. Measuring range - from 0 to 250 kg/sq.cm, division value - 10 kg/sq.cm.

Pressure gauge 2M-150. Measuring range - from 0 to 150 kg/sq.cm, division value - 10 kg/sq.cm.

Pressure gauge MB-12. Measuring range - from 0 to 12 kg/sq.cm, division value - 1 kg/sq.cm.

Integrating ampere-hour meter MCA. Measuring range - from 0 to 100 A-hr, division value - 2 A-hr.

Cone position indicator УПК-3. Measuring range - from 0 to 100%, division value - 5%.

Voltmeter B-1.

Oxygen Equipment

Employed on the aircraft is oxygen equipment set KKO-3. The KKO-3 oxygen equipment set comprises:

(a) aircraft oxygen regulator KH-34;
(b) high-altitude pressure suit BKK-4 (BKK-3M);
(c) pressure ratio controller PCД-3M;
(d) pressurised helmet ГШ-4MC (ГШ-4M) or oxygen mask MH-32;
(e) parachute oxygen apparatus KH-27M;
(f) remote-control system ДУ-2;
(g) common connector OPK-2;
(h) reducer KP-26, valve KB-2MC and check instruments (MK-18 and M-2000).

Oxygen equipment set KKO-3 is used for supplying oxygen to the pilot under the following conditions:

(a) continuously - when flying in the pressurised cabin up to an altitude of 38 km and in the depressurised cabin up to an altitude of 12 km;

(b) for a short time - when depressurising the cabin at an altitude over 12 km;

(c) for a short time - when resorting to bailout at an altitude up to 38 km.

Operation of Oxygen Equipment Set

1. Up to an altitude of 38 km in the pressurised cabin and up to an altitude of 12 km in the depressurised cabin.

Under those conditions oxygen regulator KK-54 operates employing the principle of the breathing automatic apparatus. Checking the set for sound condition should be made by reference to oxygen-flow indicator MK-18.

Up to an altitude of 10 km (according to cabin altitude and pressure differential gauge VPDD) oxygen-air mixture is supplied to the pressurized helmet (or oxygen mask), percentage of oxygen in the mixture being regulated according to the altitudes by means of the air dilutor. Starting from 10 km only pure oxygen is supplied to the pressurized helmet (oxygen mask).

The air being sucked additionally from the atmosphere via the suction valve at altitudes up to 2 km, percentage of oxygen in the mixture supplied to the pilot for inhalation is not significant, due to which the blinkers of oxygen-flow indicator MK-18 may not respond to inhalations and exhalations.

To preclude oxygen starvation in case of poor seal of the pressurized helmet or oxygen mask at cabin altitudes from 6000 to 12,000 m, slight excessive pressure is maintained in the pressurized helmet (or in the oxygen mask).

2. At altitudes in excess of 12 km in case of cabin depressurization.

If this is the case, the bladders of pressure suit MK-4 (BKK-3M) are inflated within 1 - 2 sec and back pressure is built up on the pilot's body.

Oxygen is supplied in a steady flow to the pressurized helmet (or to the mask) just after the bladders of the pressure suit have been inflated. Steady flow of oxygen is interrupted automatically at an altitude of 8000 - 9000 m.

As soon as the bladders of the pressure suit have become inflated, the pilot should check the oxygen equipment set for sound condition by reference to pressure gauge M-2000, the latter indicating the amount of excessive pressure in the breathing system in mm of water.

3. When resorting to ejection at altitudes up to 20 km. When ejecting, common connector OPK-2 gets disconnected. The lower block of common connector OPK-2 remains on the aircraft, the middle block - on the seat and the upper block along with pres-

sure ratio controller РСД-3М remains on the hoses of the pressurised helmet.

Just as common connector ОРК-2 is being disconnected, parachute oxygen apparatus КП-27М is switched on and the oxygen hoses are automatically separated from the aircraft oxygen breathing apparatus. After the bladders of the pressure suit have become inflated, oxygen is supplied to the pressurised helmet (or to the mask) in a steady flow.

As the oxygen in the parachute oxygen breathing apparatus is being consumed, every inhalation made by the pilot opens the nonreturn valve provided on the upper block of common connector ОРК-2 to suck in additional air from the atmosphere.

Pressure suit НКК-4 allows the pilot to withstand G-loads up to 8. Pressurised helmet ГШ-4МС (ГШ-4М) protects the pilot's face from the impact pressure of the airstream at the moment of ejection at indicated airspeeds up to 1200 km/hr.

Checking Pilot's High-Altitude Equipment during Preflight Preparation

Before putting on pressure suit НКК-4 (НКК-3М) the pilot should check it for sound condition to make sure that the cloth, seams, bladders, anti-G devices, lacings and zippers are sound.

When inspecting the pressurised helmet, make certain that:

(a) no ruptures of the inner rubber helmet and the throat valve are present;

(b) the microphone is securely attached;

(c) the transparent face-piece is clean and sound;

(d) the heater wiring, communication lines and plug connectors are free of damage;

(e) the hoses, inhalation valves, exhalation valves and pressurised helmet body are free of damage; the rubber gaskets of the bayonet fasteners for the hoses are present and sound.

If the pilot is wearing the oxygen mask, it is necessary to check:

(a) the oxygen mask inhalation valve for proper airtightness. To this end, it is necessary to connect the bayonet fastener of the exhalation valve hose to the pipe union of the tensioner compensator hose and after pressing the oxygen mask tightly to

the face to make an exhalation. If it is impossible to make an exhalation, the inhalation valve should be considered airtight;

(b) the oxygen mask exhalation valve for proper airtightness. To this end, it is necessary to press the mask to the face tightly, then clamp the corrugated hose and make an inhalation. If it is impossible to make an inhalation, the exhalation valve should be considered airtight. Simultaneously it is necessary to check the mask for proper fitting the size of the face (i.e. for airtightness);

(c) the mask-to-face tightness compensator for proper airtightness. To this end, it is necessary to inflate the compensator through the hose by blowing air into it with the mouth, to clamp the hose with the fingers and then to make sure that there is no air leak.

After putting on the pressure suit check whether it fits properly. If no pressure exists in the bladders of the tensioner, the suit should fit the pilot's body closely but so that the pilot feels no pain due to excessive pressure and is not hindered in his movements. The pressure suit tensioner should be checked for airtightness with the use of oxygen test set KY-6 or instrument KIT by smoothly building up pressure in the bladders of the tensioner up to 1 kg/sq.cm (checking should be performed by a medical officer on duty or by a mechanic dealing with special equipment).

If the pilot is wearing a pressurized helmet, it is necessary to check the pressurized helmet for proper adjustment (so that it fits the face of the pilot closely) and for airtightness. This check should be made simultaneously with checking the suit tensioner for tightness.

Prior to placing the parachute into the cockpit it is necessary to check parachute oxygen breathing apparatus KK-27M for being properly packed into the pocket of the parachute container and for proper filling with oxygen. Besides, it is necessary to make sure that the engaging mechanism cotter pin is locked. See that rubber shock absorber is connected to the parachute container.

Aircraft Radio Equipment

The aircraft radio equipment includes the following:

(a) communication radio station РСИУ-5Т;

(b) automatic radio compass АРК-10;

(c) transponder СРО;

(d) radar sight РП-9-21;

(e) marker radio receiver МРП-56М.

The main units of the radar sight are mounted on a common frame installed on the extension cone of the air intake.

Receiver МРП-56М is installed in the fin fairing, the rest of the radio equipment being located in the upper nose compartment of the fuselage.

Radio station РСИУ-5Т is a voice transmitting-receiving VHF radio station with a quartz-stabilised frequency. It can be tuned (previous to operation) to 20 operating communication channels. To change over from one channel to another, turn control "CHANNEL" on the control panel to place it to a position corresponding to the assigned channel (the number of the selected channel is seen in the recess made in the cover of the control panel).

The radio station set includes: transmitter-receiver, control panel, amplifier УК-2М and antenna.

The radio set receiver employs a special noise-suppression circuit.

The radio station transmitter can operate under the conditions of full or reduced power.

Maximum range of radio communication is reached under full power conditions with the noise suppressor switched off.

The radio station operates within the wave range of 2 - 3 m (or frequency range of 150 - 100 c.p.s.). The range of radio communication with a ground radio station, type РАФ-УКВ, is at least 120 km when flying at an altitude of 1000 m, 230 km when flying at 5000 m and 350 km when flying at 10,000 m. When operating under reduced power conditions, the communication range is reduced 2.5 times.

Amplifier УК-2М installed on the left-hand control panel of the cockpit is used to ensure operation of the radio station from the throat phones or microphone (in the pressurized helmet)

When flying with head phones on, the selector switches on amplifier УК-2М should be placed to OXYGEN MASK (КМ) and THROAT PHONE (Д); when the pilot is wearing pressurized helmet, they should be placed to PRESSURE HELMET (ГШ) and MICROPHONE (М).

Automatic radio compass АРК-10 provides automatic tuning to a radio station (whose bearing is to be taken) when operating on any of the nine previously tuned channels (frequencies); if necessary, it can provide smooth tuning to the required frequency when in flight. Change-over from one frequency to another is accomplished by pressing a relative button on the control panel.

The radio compass has three operating duties: COMPASS (КОМПАС), ANTENNA (АНТЕННА) and LOOP (РАМКА).

When under COMPASS (КОМПАС) conditions, the radio compass automatically takes bearings of the homing radio stations; when under ANTENNA (АНТЕННА) conditions, there takes place only tuning of the radio compass and monitoring of the homing station signals; when under LOOP (РАМКА) conditions, the radio compass takes bearings of the homing radio station producing a sound signal (in case of failure of the compass portion of the radio compass).

The radio compass set includes: receiver, control panel, remote frequency control (ДРЧ), directional antenna (loop), nondirectional antenna (which is common with the antenna of radio station РСИУ-5Р), power supply unit, tuning indicator, course indicator (УКИ-2), radio compass automatic selector switch УАП-1 and manual selector switch OUTER - INNER (ДАЛЬНЯЯ - БЛИЖНЯЯ).

Selector switch УАП-1 is used for automatic switching-over of the radio compass from the outer homing beacon frequency to the frequency of the inner homing beacon when flying over the outer homing beacon (the switching-over taking place due to the signal sent by the marker beacon) and from the inner homing beacon frequency to the frequency of the outer homing beacon after flying over the inner homing beacon. When switching over automatically to the inner homing beacon frequency, indicating light АРК - INNER HOMING STATION (АРК - БНРС) flashes up. Selector switch УАП-1 operates only with the aircraft landing

gear in the extended position. When retracting the landing gear, the selector switch automatically brings the radio compass to operation at a frequency of the outer marker beacon.

When employing the APK radio compass, the following distribution of channels (buttons) according to their function is used: 1, 3, 5, 7 - frequencies of the outer marker beacon; 2, 4, 6, 8 - frequencies of the inner marker beacons; 9 - frequency of the broadcasting radio station; 0 - smooth tuning button. Adjacent buttons should be used for each of the assigned airfields, for instance: button 1 for outer marker beacon of the airfield, button 2 for the inner marker beacon of the same airfield, etc.

The radio compass operating frequency range (120 - 1240 ko/s) is divided into eight bands (in ko/s):

120 - 280	720 - 880
280 - 420	880 - 1020
420 - 580	1020 - 1180
580 - 720	1180 - 1240

Tuning the APK radio compass (on the ground). After switching on the radio compass and warming it up for 5 - 10 min the pilot should:

(a) make sure that selector switch OUTER - INNER (ДАЛЬНИЙ-ВНУТРЕННЯЯ) is placed to OUTER (ДАЛЬНЯЯ);

(b) place selector switch KEY - VOICE (ТЛГ - ГОЛ) to the position corresponding to the operating conditions of the homing radio station;

(c) place selector switch NARROW - WIDE (УЗК. - ШИР.) to WIDE (ШИР.);

(d) place the mode of operation selector switch to АНТЕННА (АНТЕННА);

(e) press button 1;

(f) unlock the range selector switch handle, set the hand corresponding to the first assigned frequency and lock the switch handle; the frequency marked on the range selector switch corresponds to the initial value of the band; thus, for band 280 - 420 ko/s it is necessary to place the selector switch to 280;

(g) unlock handle COARSE TUNING (ГРУБАЯ НАСТРОЙКА) and set the scale to the required value corresponding to the assigned

frequency using the following rule: the required value of the tuning scale division is equal to the assigned frequency in ko/s minus frequency to which the range selector switch is set.

Example. The assigned frequency of the homing radio station is 410 ko/s; the frequency set by the range selector switch is 280 ko/s.
S o l u t i o n. The required value of the tuning scale division will be: 410 ko/s - 280 ko/s = 130 ko/s.

(h) accomplish fine tuning; place selector switch WIDE - NARROW (ШИР. - УЗК.) to NARROW (УЗК.); by turning the volume control on the radio compass control panel coarse the sensitivity to 3 - 4 divisions according to the tuning indicators; fine setting of the scale division should be made with the help of handle SMOOTH TUNING (НАСТРОЙКА ПЛАВНАЯ). To this end, it is necessary preliminarily to press the handle forward as far as it will go;

(i) checking of proper tuning should be made by reference to the tuning indicator pointer (which should be deflected through a maximum angle) and by listening to the call signs; after tuning lock the retainer;

(j) place the mode of operation selector switch to COM-PASS (КОМПАС); in this case the pointer of indicator УКИ-2 should indicate direction to the homing radio station;

(k) place selector switch WIDE - NARROW (ШИР. - УЗК.) to WIDE (ШИР.).

For the rest of the buttons (channels) perform fixed tuning using the similar procedure.

To make call signs of the homing radio stations audible, switch on radio station РСИУ-5Г and place selector switch RADIO - COMPASS (РАДИО - КОМПАС) on the control panel to COMPASS (КОМПАС).

S m o o t h t u n i n g o f t h e АРК r a d i o c o m p a s s (w h e n i n f l i g h t) is tuning the radio compass to any range frequency in case of reaching the range of homing radio stations whose frequencies are not marked on the fixed buttons and in case of failure of the mechanism for switching on the fixed frequencies. To change over to smooth tuning conditions, press button П to disconnect the mechanism for auto-

matic change-over and tune the automatic radio compass using the same procedure as when tuning it to the fixed frequency. When doing this, use handles RANGE (ДИАПАЗОН) and COARSE TUNING (НАСТРОЙКА ГРУБАЯ) without unlocking them.

After using the radio compass under smooth tuning conditions it is possible to switch on the radio compass for operation on any of the fixed channels by pressing the relative button.

When tuning the radio compass, be sure to remember the following:

1. The radio compass is ready for operating normally in 5 - 7 min since the moment it has been energized at a positive temperature and in 10 - 15 min at an ambient temperature from -30° to -60°.

2. If the automatic change-over mechanism continues rotating and fails to stop after pressing the required button, it is necessary to switch on another button (except for button П). In this case the automatic change-over mechanism should stop rotating. If this is the case, switch on the required button again.

3. With the retainers of handles RANGE (ДИАПАЗОН) and COARSE TUNING (НАСТРОЙКА ГРУБАЯ) opened, it is forbidden to switch on the buttons.

4. To prevent shifting of the tuning scale, the pilot should first select the required band and then the frequency according to the tuning scale.

5. If the button switch fails, it is possible to perform smooth tuning when pressing any fixed button. In this case the handles should be unlocked.

6. For repeated setting of frequency with the help of the COARSE TUNING (НАСТРОЙКА ГРУБАЯ) handle when under smooth tuning conditions, it is necessary to pull handle SMOOTH TUNING (НАСТРОЙКА ПЛАВНАЯ) back as far as it will go.

Using the automatic radio compass

When landing on the assigned airfield, proceed as follows:

1. Press the button corresponding to the frequency of the outer marker beacon of the landing airfield (one of the odd-number buttons).

2. Set the remote frequency selector switch to the figure corresponding to the number denoting the assigned airfield inner marker beacon button (the even number following the outer marker beacon button number). Within the region of this number place the selector switch to position:

(a) OFF (ВЫКЛ.) if the inner marker beacon frequency (as read in the scale divisions) is less than the outer marker beacon frequency or if the inner marker beacon frequency exceeds the outer marker beacon frequency by a value which is equal to or greater than 80 kc/s;

(b) ON (ВКЛ.) if the inner marker beacon frequency (as read in the scale divisions) exceeds the outer marker beacon frequency by a value which does not exceed 80 kc/s.

Example. Outer marker beacon - 362 kc/s (button 5); inner marker beacon - 748 kc/s (button 6). Frequency of range to which the range selector switch is set is 280 kc/s for the outer marker beacon (scale 82) and 720 kc/s for the inner marker beacon (scale 28). The remote-control selector switch should be placed to "6" in position OFF (ВЫКЛ.).

3. At the moment of flying over the outer marker beacon (and following the signal transmitted by the marker receiver) the pilot should check to make sure that the automatic radio compass has been switched over to the inner marker beacon frequency. Switching-over is indicated by indicating light АРК - INNER HOMING STATION (АРК - ВПРС) coming on.

Responder СРО produces and transmits identification signals. Flying with faulty responder СРО is forbidden.

Radar Station РЩ-9-21

The following are main tasks which can be solved by radar station РЩ-9-21 irrespective of visibility conditions in the day or night time under ordinary or adverse weather conditions:

(a) automatic scanning and location of aerial targets and determining their aspect angles and ranges to them relative to the aircraft longitudinal axis within the forward hemisphere and within the angles of $\pm 30^{\circ}$ in azimuth and $\pm 12^{\circ}$ in elevation with the radar range being up to 18 - 20 kms;

(b) target approach and taking initial position for attack;

(c) semi-automatic target lock-on at ranges of 8 - 10 km under ALTITUDE (ВЫСОТА) conditions within the angles of $\pm 5^{\circ}$ in azimuth and in elevation with further automatic tracking of the target by reference to the target present data and target range;

(d) aiming and automatic computing of data required for launching missiles P-3c by reference to the indicator of the radar sight.

The radar station comprises 15 units. Besides, it operates in conjunction with: altitude unit БВД-30-21, radar camera НАУ-473 and synchronization unit БСВ-2. Special control panel is provided for checking the radar sight on the ground.

Employed in the radar sight is one double-dish antenna which operates successively under scanning and then under aiming conditions. The antenna generates a narrow beam with a beam width of 4.7°. To decrease the time of scanning and to ensure rapid changing-over of the radar sight from the scanning conditions to the aiming conditions, the antenna beam is continuously scanning forming in the space a cone whose axis coincides with the antenna axis. When under scanning conditions this cone is displaced successively in azimuth and elevation in order to scan the assigned space.

When under aiming conditions, the beam (cone) is continuously tracking the target automatically in azimuth, elevation and range.

The radar sight is furnished with one radar target indicator operating under scanning and aiming conditions. When under scanning conditions, the indicator has a sweep, type AZIMUTH - RANGE (АЗИМУТ - ДАЛЬНОСТЬ), which permits determining target position in azimuth within $\pm 30^{\circ}$ and in range up to 20 km.

Besides, additional vertical marks TOP (ВЕРХ) and BOTTOM (НИЗ) allow the pilot to determine position of the target in altitude relative to the intercepting fighter. If only TOP (ВЕРХ) marks are seen, it means that the target is higher than the aircraft longitudinal axis. If only BOTTOM (НИЗ) marks are seen, it means that the target is lower than the aircraft longitudinal axis. When both kinds of marks are seen, it means that the target is in the plane passing through the aircraft longitudinal and lateral axes (the accuracy in this case being within $\pm 3.5^{\circ}$).

When under aim
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orresponds to the
ngitudinal axis.
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When under aiming conditions, on the indicator screen there appears an artificial image of the target (a pip) whose centre corresponds to the target location with respect to the aircraft longitudinal axis. To make aiming procedure more convenient, scale marks are provided on the indicator screen: smaller circle - 1^0 (1 km), area - 5^0 (5 km) and 10^0 (10 km). Range marks (vertical dashes) are made over the horizontal dashes of the pip.

The computing unit of the radar sight computer automatically missile launching permitted range depending on the flying altitude and the rate at which the interceptor approaches the target. These data are fed to the indicator and observed as dark areas at the sides of the target pip.

To change over the radar sight from operation under scanning conditions to operation under aiming conditions, the pilot should bring the target pip into the look-on area ($\pm 5^0$ in azimuth, target TOP (ВЕРХ) and BOTTOM (НИЗ) marks observed, range - 5 - 10 km) and press the look-on button on the aircraft control stick.

The radar sight can operate under FIXED BEAM (ЗАКРЕПЛЕННЫЙ ЛУЧ) conditions. When this is the case, the antenna zone is set in the direction of the aircraft longitudinal axis.

Control and checking of the radar sight are accomplished through the use of the control and check panels.

Mounted on the control panel are:

(a) radar sight selector switch having the following positions: STATION OFF (СТ. ВЫКЛ.), SUPPLY ON (ВКЛ.) which means that preparatory switching-on operations have been performed, and HIGH VOLTAGE ON (ВЫС. ВКЛ.);

(b) indicating light that becomes on after switching-on of high voltage;

(c) mode of operation selector switch having the following positions: TRACKING (СОПРОВОЖДЕНИЕ) when operating successively under scanning and aiming conditions, FIXED BEAM (ЗАКР. ЛУЧ) when operating under fixed beam conditions and BARRAGE (ПОМЕХА).

Mounted on the check panel are:

(a) milliammeter used for checking the radar sight operating parameters;

(b) five-position selector switch with the following positions: TK-1 (current of crystal 1), TK-2 (current of crystal 2), TK-3 (current of crystal 3), TM (current of magnetron) and ИД (pressure check).

The instrument normal indication in positions TK-1, TK-2 and TK-3 will be 2 - 8 divisions; in position TM, 16 - 22 divisions, and in position ИД, 16 - 19 divisions.

Mounted on the front panel of the indicator is selector switch DAY - NIGHT (ДЕНЬ - НОЧЬ) for selecting the brightness of the image according to the time of the day, control LIGHTING (ПОДСВЕТ) for adjusting brightness of the screen scale, and button INSTANTANEOUS ERASURE (МГН. СТИР.) for instantaneous erasure of the image on the screen. Located on the indicator screen framing is a red warning light indicating a moment breaking off the target, the light becoming on as soon as the fighter has reached a distance of 1.65 km away from the target.

Mounted over the upper left-hand panel of the instrument board is button TARGET RESET (СБРОС ЦЕЛИ) used for changing over the radar sight from aiming conditions to scanning conditions.

The radar sight is energized through circuit breaker ИД-30, ШИ located on the rear right-hand switch panel in the cockpit.

Marker radio receiver МРП-56П is designed for receiving signals sent by the marker beacons of ILS system and for indicating a moment of flying over these beacons.

When the aircraft is flying just over a beacon, the red-light warning inscription becomes on and a sound signal is heard by the pilot in his head phones.

Included in the marker receiver set are: receiver, antenna and signalization unit.

The signalization system upper operating limits in altitude when flying over the marker beacon are from 2000 to 3000 m.

AIRCRAFT PERFORMANCE CHARACTERISTICS

Fuel capacity, lit:

without the drop tank	2755
with the drop tank	3205

Normal flying weight with two missiles R-3s or units UB-16-57y (specific weight of 1 m³ being 0.83 g/cub.cm), kg:

without the drop tank 7750

with the drop tank 8220

Unstick airspeed with missiles R-3s, km/hr:

without the drop tank ..... 320 - 320

with the drop tank ..... 320 - 320

Take-off run length with missiles R-3s at the minimum augmented rating, m:

without the drop tank ..... 800 - 950

with the drop tank ..... 900 - 2000

Best climbing airspeed (as read by plan pointer), km/hr:

without the drop tank ..... 850 - 870

with the drop tank at the maximum rating - 800 - 820

with and without the drop tank at the augmented rating ..... 820 - 2000

Maximum rate of climb with missiles R-3s (at an altitude of 8000 m the drop tank should be jettisoned and augmented rating should be switched on), m/sec:

at 5000 m 39

at 5000 m (with the drop tank) 39

at 10,000 m 66

at 15,000 m 59

Minimum time of climb with missiles R-3s (at an altitude of 8000 m the drop tank should be jettisoned and augmented rating should be switched on; for climbing use interception profile), min:

to 5000 m 2.9

5000 m (with the drop tank) 3.0

10,000 m 4.9

10,000 m (with the drop tank) 6.4

15,000 m 8.2

15,000 m (with the drop tank) 9.7

19,000 m 9.1
19,000 m (with the drop tank) 10.6
Service ceiling with missiles P-3o, m 19,000
Maximum permissible indicated airspeeds, km/hr:
(a) with missiles P-3o and without external stores (without the drop tank):
up to 5000 m 1100
from 5000 to 12,500 m 1200
over 12,500 m ..... M = 2.05
(b) with the drop tank, with missiles P-3o or with units YB-16-57y and the drop tank, with units YB-16-57y but without the drop tank:
up to 12,000 m 1000
over 12,000 m ..... M = 1.6
Breaking G-load 12
Maximum operating G-load (with fuel remainder less than 1800 lit) 7
Minimum maneuvering indicated airspeed (for all altitudes), km/hr 400
Indicated airspeed corresponding to maximum range of flight, km/hr:
at 5000 m 670
at 10,000 m 525
at 11,000 m 490
Indicated airspeed corresponding to maximum duration of flight (for all altitudes), km/hr 440
Maximum lift-drag ratio:
with the landing gear and flaps retracted 8
with the landing gear and flaps extended 5
Best indicated airspeed when gliding from aircraft ceiling (at altitudes below 15,000 m engine control lever should be at idle rating stop, air brakes retracted), km/hr ..... 500 - 550

Normal landing weight, kg 6200
Maximum (overload) landing weight (in exceptional cases), kg 7250
Landing airspeed, km/hr:
with 500-lit fuel remainder ..... 265 - 290
with 1200-lit fuel remainder ..... 275 - 300
Landing roll length (with fuel remainder being 500 - 1200 lit), m:
(a) on a concrete runway (three wheels are braked):
without the drag chute ..... 1000 - 1400
with the drag chute ..... 800 - 1100
(b) on a soil runway (two wheels are braked):
without the drag chute ..... 1000 - 1200
with the drag chute ..... 700 - 800
(c) on a snowy runway (two wheels are braked):
without the drag chute 1700
with the drag chute ..... 950 - 1050

FLIGHT RANGE AND DURATION

Range and duration of flight increase with the increase in altitude. Maximum range and duration of flight may be reached when flying at altitudes of 10,000 - 11,000 m.

When calculating flight range and duration, the following should be taken into consideration:

(a) the amount of fuel consumed when the engine is operated on the ground (including engine starting and testing, taxiing to the take-off position and back) for 7 min - 70 kg;

(b) the amount of consumed fuel, the flight path and time when taking off, climbing and gliding - according to the pertinent tables;

(c) the amount of fuel consumed when flying landing pattern for 8 min - 260 kg (this corresponds to flying twice the landing pattern, each landing pattern flight requiring 4 min of time and 140 kg of fuel);

(d) the amount of dropped fuel - 30 kg;

(c) on a snowy runway (two wheels are braked):

Normal landing weight, kg 6200
Maximum (overload) landing weight (in exceptional cases), kg 7250
Landing airspeed, km/hr:
with 500-lit fuel remainder ..... 265 - 290
with 1200-lit fuel remainder ..... 275 - 300
Landing roll length (with fuel remainder being 500 - 1200 lit), m:
(a) on a concrete runway (three wheels are braked):
without the drag chute ..... 1000 - 1400
with the drag chute ..... 800 - 1100
(b) on a soil runway (two wheels are braked):
without the drag chute ..... 1000 - 1200
with the drag chute ..... 700 - 900
(c) on a snowy runway (two wheels are braked):
without the drag chute 1700
with the drag chute ..... 950 - 1050

FLIGHT RANGE AND DURATION

Range and duration of flight increase with the increase in altitude. Maximum range and duration of flight may be reached when flying at altitudes of 10,000 - 11,000 m.

When calculating flight range and duration, the following should be taken into consideration:

(a) the amount of fuel consumed when the engine is operated on the ground (including engine starting and testing, taxiing to the take-off position and back) for 7 min - 70 kg;

(b) the amount of consumed fuel, the flight path and time when taking off, climbing and gliding - according to the pertinent tables;

(c) the amount of fuel consumed when flying landing pattern for 8 min - 280 kg (this corresponds to flying twice the landing pattern, each landing pattern flight requiring 4 min of time and 140 kg of fuel);

(d) the amount of trapped fuel - 40 kg;

(c) 7% fuel remainder of the main fuel reserve - 160 kg.

The data on fuel consumption, time and path during take-off and glide are presented in Tables 7 and 8; the data on flight range and duration are contained in Table 9.

Table 7

Fuel Consumption, Time and Path when Taking Off and Climbing

Altitude, m	With missiles P-3c			With drop tank					
				without missiles			with missiles P-3c		
	fuel cons., kg.	time, min	path, km	fuel cons., kg	time, min	path, km	fuel cons., kg	time, min	path, km
1000	150	1.1	10	150	1.2	10	160	1.3	10
5000	225	2.5	30	240	2.7	40	255	3.0	40
10,000	350	6.2	100	400	7.2	110	420	7.9	120
11,000	380	7.7	120	450	8.6	130	470	10.3	160

Notes: 1. Up to an altitude of 1000 m take-off and climb should be performed at the minimum augmented rating.
2. When at an altitude of 1000 m climb should be performed at the maximum rating and at a true airspeed (as read by the slim pointer of the airspeed indicator) of 850 - 870 km/hr.

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Fuel Consumption, Time and Path when Gliding

Altitude, m	Fuel consumed, kg	Time, min	Path, km
3000	10	0.5	10
5000	30	3.5	40
10,000	60	8.0	80
11,000	70	8.5	100
15,000	90	12.0	140
16,000	120	14.0	170
19,200	140	15.0	190

Notes: 1. When gliding, maintain an indicated airspeed (as read by the wide pointer) of 500 - 550 km/hr.
2. Starting from 15,000 m keep the engine control lever at the take rating stop.
3. Keep the air brakes retracted.

Flight Range and Duration

Airspeed, km/hr	Fuel consump.	Fuel consump.	Range, km		Duration, hr-min	
			level	oper-	level	oper-
					flight	ational

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Table 9

Flight Range and Duration

Flight condition	Airspeed, km/hr		Fuel consump. per km, kg/km	Fuel consump. per hour, kg/hr	Range, km		Duration, hr-min	
	IAS	CAS			level flight	operational	level flight	operational
1	2	3	4	5	6	7	8	9

with Missiles P-3c (without launching missiles) but without Drop Tank

Initial flying weight - $\frac{7750}{7580}$ kg. Total fuel capacity - $\frac{2280}{2130}$ kg (2755 lit)

A l t i t u d e - 5000 m

Amount of fuel required for level flight - $\frac{1520}{1370}$ kg

Maximum range	670	880	1.61	1420	$\frac{940}{850}$	$\frac{1010}{920}$	$\frac{1 - 04}{0 - 58}$	$\frac{1 - 18}{1 - 12}$
Maximum duration	440	590	1.81	1070	$\frac{840}{750}$	$\frac{910}{820}$	$\frac{1 - 25}{1 - 17}$	$\frac{1 - 39}{1 - 31}$

1	2	3	4	5	6	7	8	9

Altitude - 10,000 m

Amount of fuel required for level flight - $\frac{1390}{1240}$ kg

Maximum range	525	695	1.22	1090	$\frac{1140}{1020}$	$\frac{1310}{1190}$	$\frac{1 - 16}{1 - 08}$	$\frac{1 - 38}{1 - 30}$
Maximum duration	440	760	1.33	1010	$\frac{1040}{930}$	$\frac{1210}{1100}$	$\frac{1 - 22}{1 - 14}$	$\frac{1 - 45}{1 - 36}$

Altitude - 11,000 m

Amount of fuel required for level flight - $\frac{1350}{1200}$ kg

Maximum range	490	880	1.15	1010	$\frac{1170}{1040}$	$\frac{1370}{1240}$	$\frac{1 - 20}{1 - 11}$	$\frac{1 - 44}{1 - 34}$
Maximum duration	440	795	1.22	970	$\frac{1110}{980}$	$\frac{1310}{1190}$	$\frac{1 - 23}{1 - 14}$	$\frac{1 - 47}{1 - 38}$

with Missiles P-3c and Drop Tank Jettisoned when Emptied

Initial flying weight - $\frac{8190}{8020}$ kg. Total fuel capacity - $\frac{2700}{2520}$ kg (3255 lit)

1	2	3	4	5	6	7	8	9

Altitude - 11,000 m

Amount of fuel required for level flight - $\frac{1670}{1490}$ kg

				1010	1450	1680	1 - 39	2 - 05

1	2	3	4	5	6	7	8	9

Altitude - 11,000 m

Amount of fuel required for level flight - $\frac{1670}{1490}$ kg

Flight range	490	880	1.35	1210	$\frac{1480}{1300}$	$\frac{1680}{1530}$	$\frac{1 - 30}{1 - 29}$	$\frac{1 - 65}{1 - 55}$
Maximum duration	440	795	1.22	970	$\frac{1370}{1220}$	$\frac{1600}{1450}$	$\frac{1 - 43}{1 - 32}$	$\frac{1 - 69}{1 - 58}$

without Missiles but with Drop Tank (drop tank not to be jettisoned)

Initial flying weight - $\frac{8040}{7870}$ kg. Total fuel capacity - $\frac{2700}{2520}$ kg (3255 lit)

Altitude - 10,000 m

Amount of fuel required for level flight - $\frac{1770}{1590}$ kg

Maximum range	525	895	1.32	1180	$\frac{1340}{1210}$	$\frac{1530}{1400}$	$\frac{1 - 30}{1 - 21}$	$\frac{1 - 53}{1 - 44}$
Maximum duration	440	760	1.46	1110	$\frac{1210}{1090}$	$\frac{1400}{1280}$	$\frac{1 - 36}{1 - 26}$	$\frac{1 - 59}{1 - 49}$

Notes: 1. The figures in the numerator stand for the fuel with a specific weight of 0.83 gr/cub.cm, whereas those in the denominator stand for the fuel with a specific weight of 0.775 gr/cub.cm.
2. With the total fuel capacity amounting to 2820 lit, flight range and duration will be increased approximately by 2%.

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