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INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY 50X1

~~S-E-C-R-E-T~~

50X1-HUM

COUNTRY USSR

REPORT 50X1

SUBJECT Pilot's Instructions Manual on the MIG-21F-13 /FISHBED/ Aircraft

DATE DISTR. 4 February 1963

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2. The major headings of the Table of Contents are as follows:

a. Aircraft Maintenance

b. Engine Running on Ground

c. Checking Aircraft Systems after Engine Starting

d. Engine

e. Flight

f. Flight Limits

g. Service Instructions on KKO-3 Oxygen Equipment and Pressurized Cockpit 50X1

h. Flying Aircraft under Difficult Meteorological Conditions, Landing Approach and Landing with Employment of Instrument Landing Systems

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GROUP 1
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i. Night Flights

j. Firing in Flight

k. Rocket Equipment Carried Aboard Aircraft MIG-21F-13

l. Emergency Situations in Flight

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m. Maximum Flight Values of Indicated Air Speed, Mach Number, and Load Factor

n. Time and Range of Flight

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SECRET

МиГ-21ф-13 AIRCRAFT

PILOT'S INSTRUCTIONS

CONTENTS

I. AIRCRAFT MAINTENANCE

1. Pre-Flight Inspection

1. Before the take-off have the aircraft technician report on the aircraft readiness for flight, the quantity of fuel, oil, oxygen, air, alcohol, gun loading, rocket pod and bomb suspension, as well as on the maintenance or repair operations performed on the aircraft since the last flight day.

2. Aircraft Inspection

2. Prior to taking seat in the cockpit:
- check condition of tyres of L.G. wheels;
- make sure the ПВД airspeed tube and ТП-156 Pitot tube are free of protective caps and covers;
- make sure safety locks are inserted into the hole in the canopy remover gun rod;
- make sure the armament circuit breakers are cut off except those which should be cut in on the ground prior to take-off;
- make sure the seat ejection gun is charged;
- make sure the harness release mechanism hose is fastened to the right-hand belt strap and the pull-out cord is attached to the harness lock;
- see that no foreign objects are left in the cockpit or on the seat;
- check whether ground locks are inserted into the seat firing mechanism safety pin and into the canopy remover levers;
- check whether the face curtain, triggers on seat arresters, canopy autonomous jettison lever and harness lock emergency release handle are locked with wire;
- make sure the АД-3 safety harness lock and foot clasp opening automatic mechanism is cocked and adjusted for 1.5 sec.;
- check whether the flexible pin of the АД-3 automatic mechanism is locked and the pull-out cord is fastened to the aircraft side by means of the spring hook.

3. Inspection of Cockpit

In the cockpit safety measures being preserved:
- make sure the storage battery is charged and is switched on, all circuit breakers are also on;
- check whether the circuit breakers on the right-hand rear electric panel (to be switched on prior to take-off) are ON;

- make sure the actuating mechanism of the КП-27 oxygen apparatus is joined to the ОРК-2 common connector upper block and the hose of the КП-27 apparatus is connected to the РСД-3 pressure regulator;

- make sure the disconnection cord is attached to the lever of the ОРК-2 common connector lower block;

- check whether the emergency brake handle is sunk in position and locked properly;

- check whether the L.G. switch is in the neutral position and locked;

- make sure pressure in the main and emergency air lines is within 110 - 130 kg/sq.cm.;

- make sure pressure in the oxygen system equals 150 kg/sq.cm. (at an ambient air temperature of +15°C);

- check whether the oxygen feed valve is open (the pressure being from 9 to 10.5 kg/sq.cm.);

- make sure the fuel flowmeter pointer shows 2400 lit., the aircraft being filled to capacity (without the drop tank) or 2900 lit. (with the drop tank suspended).

Check whether the ОРК-2 common connector is properly coupled by pulling it upwards. If no clearance appears between the blocks, the connector is considered properly attached.

Check the upper block of the ОРК-2 common connector for proper attachment to the parachute straps.

Check the rip cord of the КАП-3 parachute automatic mechanism for attachment to the seat.

4. Inspection after Taking Seat in Cockpit

Take the seat in the cockpit and check the seat for proper adjustment according to your height and the pedals for proper adjustment according to the length of your legs.

Put the parachute harness on the shoulders.

Pass the leg yokes of the harness through the loops of the parachute side straps.

Fasten the straps together with the harness by the main lock.

Fasten the waist belt by rocking the handle on the right armrest.

Check the fastening of the shoulder belt (never using the handle) in the following order:

- bend forward so as to completely draw the belt out of the shoulder belt lock; in this event, the shoulder belt mechanism must get unlocked;

- lean backward and press your back to the ejection seat back rest. Upon that, the shoulder belt mechanism operates to fix the pilot in the backward position.

When in the cabin, the pilot should avoid sharply bending all the way forward so as to obviate his spontaneous locking.

The pilot's shoulder belt is unlocked by the handle on the left armrest of the ejection seat.

CAUTION: (a) The harness must be adjusted on the pilot as tight as possible, the shoulder strap closely adhering to the neck and shoulders without going loose.

(b) When the pilots put on winter garments for flight, the shoulder strap may be adjusted either under or over the collar closely adhering to the neck and shoulders of the pilot.

If pilots of different height are expected to fly the aircraft, the aircraft technician should check the seat adjustment to fit the pilots' height after the pilots have entered the cabin. In this event:

- the pilot should press his head to the headrest;

- the seat should be brought all the way up by means of the button switch (port side of the cabin); the technician must check the clearance between the top of pressurized helmet ГШ-4М and the canopy glass panel seeing that it is about 50 mm. In this position, the necessary degree of safety is ensured in case the pilot's bailing-out. In case the clearance is below 50 mm, pull the seat down to get the required clearance and adjust the actuated cylinder switch-off mechanism.

Connect the hoses of the flying helmet (or oxygen mask) and of the pressure suit to the РСД-3 pressure regulator.

Couple the electric plug connector and switch on the heater of the pressurized helmet transparent face piece.

Check the oxygen equipment set for proper operation with and without excessive pressure applied.

Command: "Remove seat and canopy ground locks" (ground locks from the seat triggers to be removed before the pilot takes his seat in the cabin).

Check whether the locks are removed from the canopy remover gun operating rods.

Check the brake system for operation with the front wheel brake applied and released. The pressure in the brake system must equal 10 - 11 kg/sq.cm. (by the pressure gauge in the cabin). When the pedals are actuated with the brake lever pressed, the pressure in the wheel released of the brake pressure must drop down to 0.

Check the engine control lever for easy movement and proper fixing in positions CUT OFF (СТОП), LOW SPEED (МАЛЫЙ ГАЗ), NORMAL (НОМИНАЛ), MAXIMUM (МАКСИМАЛ), AUGMENTATION (ФОРСАЖ).

CAUTION: To avoid overfuelling, perform checking with the circuit breaker of tank No.3 (service tank) cut off.

Check the control stick for smooth travel when controlling the ailerons (with the aileron boosters off).

Command: "Remove plugs, cut in ground power sources!".

CAUTION: Not to discharge the aircraft storage battery, employ only ground power sources for checking the aircraft instruments and units.

Cut in the storage battery. By reading off the aircraft voltmeter, make sure the ground source of power is connected (the voltmeter must show 26 or 29 V).

With the ground power source cut in, check the lamps on the L.G. signal panel and on the Т-4 and Т-6 light panels by pressing in turn their CHECK buttons. Check the operation of the fuel feed and fuel transfer pumps by their signal lamps.

Press the FLAPS RETRACTED push-button to make sure the corresponding lamp flashes on.

Set the altimeter pointer to the scale zero and check whether the barometric pressure scale reads the pressure of the day.

Check whether the clock indications are correct and prepare the clock for flight.

Cut in the aileron boosters.

Make sure the air duct inlet cone control and anti-surge shutters switches are in proper positions:

- inlet duct manual control switch must be in the position RETRACTED (УБРАНО);

- inlet duct control selector switch must be set in the AUTO (АВТОМАТ) position and locked;
- anti-surge shutter switch must be set to the AUTO (АВТОМАТ) position and locked.

Check operation of the trimmer effect mechanism:

- press the push-button on the control stick FORWARD and BACKWARD, the released control stick must accordingly deflect either forward or backward. The illuminated inscription TRIMMER EFFECT NEUTRAL on the T-4 light panel must go out immediately on pressing the trimmer effect button (provided the trimmer effect mechanism has been neutral prior to pressing the push-button);
- after checking, set the trimmer effect mechanism to the neutral position according to the signal lamp on the T-4 light panel. The neutral position of the trimmer effect mechanism is adjusted with the push-button pressed in the backward direction (from the position FORWARD);
- after setting the trimmer effect mechanism in the neutral position, deflect the control stick to extreme positions to make sure the signal lamp remains burning.

Check whether the AFU-3B stabilizer control system is ready for operation:

- check whether the selector switch is set in the AUTO position and locked;
- make sure the pressure switch LOW SPEED -HIGH SPEED (МАЛАЯ СКОРОСТЬ-БОЛЬШАЯ СКОРОСТЬ) is in the neutral position;
- the signal lamp STABILIZER IN LANDING POSITION (СТАБИЛИЗАТОР НА ПОСАДКУ) must burn on the T-4 light panel;
- make sure the pointer of the arm position indicator is in the extreme left position.

Check whether the air duct inlet cone control system is ready for operation:

- the cone control selector switch must be set in the AUTO position, closed with a cap in the BACKWARD position and locked;
- the manual control switch must be in the RETRACTED position (full BACKWARD position).
- cut in and check the AGK-1 artificial horizon, KCH gyro induction compass, RUD-53 turn indicator, PSRU-5T radio set, APK-10 automatic radio compass, SRO-1 aircraft transponder.

5. Checking PSRU-5T Radio Set

To check operation of the PSRU-5T radio set:

- couple the plug connector of the head-piece cord;
- switch on the radio set and warm it up during 3 or 4 min.;
- switch on the chosen channel. Check the radio set operation, when changed over to RECEPTION (ПРИЕМ) by listening to the receiver noises in the head-pieces;
- switch on the NOISE SUPPRESSOR (ПОДАВИТЕЛЬ ПОМЕХ) and check its operation with radio set operating for RECEPTION; the noises must be suppressed;
- change over the radio set for transmission, check it for self-monitoring and establish a two-way communication with the airfield radio station.

Switch on the chosen channel after checking the radio set for proper operation on other channels.

When flying with the PV-4M helmet or set the YK-2M amplifier switches located on the left side of the cabin into the HELMET (ГШ) and MICROPHONE (М) positions; when using the head-phone with the oxygen mask set these switches into the OXYGEN MASK (КМ) and THROAT MICROPHONE (Г) positions (this will switch off the YK-2M amplifier).

Note: To ensure a maximum communication range at all altitudes:
(a) switch on the FULL POWER (ПОЛНАЯ МОЩНОСТЬ) switch;
(b) switch out the NOISE SUPPRESSOR switch.

6. Gyro Induction Compass, Type KCH

The gyro induction compass, type KCH, installed aboard the aircraft is intended for determining:

- the aircraft course;
- the landing course angles;
- the bearing of radio stations.

It has the following advantages as compared to compasses AMK-3 and GMK-1 mounted on the aircraft of earlier makes:

- it ensures adequate precision of the course determination ($\pm 2^{\circ}$ being the maximum error) on the straight level flight;
- it affords high degree of accuracy while determining the course during non-steady flight.

7. Preparation of Gyro Induction Compass for Flight

Set the selector of control panel PU-3 to NORTH (СЕВЕР) when the flights are carried out in the northern hemisphere.

Set the latitude scale of control panel PU-3 to the latitude of the starting point; there is no necessity to change the scale setting when the radius of flight does not exceed 450 - 550 km.

When the flight distance is greater (latitude changing by more than $4 - 5^{\circ}$), set the latitude scale on the control panel to fit the mean latitude of flight.

8. Switching On and Checking Gyro Induction Compass before Taxiing

Start the engine and then cut in the circuit breaker of remote-indicating gyro horizon AGK. Cut in the KCH circuit breaker after the lamp on the AGK indicator has gone out.

Press the fast-slaving button 1 - 1.5 minutes after cutting-in the supply and keep it pressed until the course indicator scale has come to a stop. This done, read the magnetic course and make sure the indicator shows approximately correct course.

If necessary, manipulate the rack to adjust the specific course in the course indicator.

9. Checking Gyro Induction Compass before Take-Off

Prior to the take-off while the aircraft is on the runway, press the fast-slaving button and keep it pressed until the scale of the course indicator has come to a stop.

The readings of the magnetic compass must correspond to the magnetic compass of the aircraft on the runway.

Note: While checking the gyro induction compass, type KMC, for proper functioning, it is recommended that the change of indicator readings should be verified against the magnetic compass before and after pressing the button. The change should not exceed $3 - 4^{\circ}$ if after matching the magnetic compass has yielded correct readings before taxiing to the runway.

10. Operating Gyro Induction Compass in Flight

To set press the fast-slaving button of the gyro induction compass and the cage-uncage switch of the AIK in flight.

Note: It is ABSOLUTELY PROHIBITED to press the cage-uncage switch of the gyro vertical of the AΓΠ-1 during normal operation in flight.

When the button is pressed while performing aerobatics evolutions, pitching or diving with angles of bank exceeding 85°, at great angles of bank and pitch (more than 15 - 20°), gyroscope ΓA-2 is liable to fail thereby rendering unserviceable the gyro induction compass used as the directional gyro.

Should it become necessary to precisely determine the magnetic course under the conditions of normal operation of gyro induction compass KCM , or when the reference gyro of the AIK or gyroscope ΓA-2 fails to function, proceed as follows: keep on straight level flight at constant speed some 20 - 30 seconds before pressing the gyro induction compass fast-slaving button and at the moment of pressing the button. Then read the magnetic course off the indicator with the fast-slaving button pressed the moment the scale comes to a stop. If it uniformly swings in both directions, the readings should be taken relative to the middle position of the scale.

Note: 1. When the reference gyro of the AΓΠ-1 (or gyroscope ΓA-2) fails, the correct readings of the magnetic course can be obtained only with the fast-slaving button pressed.

2. Failure of gyroscope ΓA-2 , and therefore of the gyro induction compass used as a directional gyro indicator due to malfunctioning of the KCM units or the gyro vertical of the AΓΠ-1 as well as flights with 85° bank angles, can be detected judging by the following factors:

(a) during the straight flight, the indicator scale irregularly tosses (rotates, swings about the same marking of the scale through 5° angle at great speed), or yields erroneous readings of the course data;

(b) when turning or changing the course, the indicator scale does not change its position or shows the course data with great errors (fails to follow the turn), distorting the actual angle of turn and the course.

CAUTION: Be sure to turn off the circuit breaker marked КСМ prior to cutting out the circuit breaker of the AIK and the STORAGE BATTERY - GROUND SUPPLY (АККУМУЛЯТОР. НАЗЕМН. ПИТАНИЕ) switch.

11. AΓΠ-1 Gyro Horizon

The gyro horizon of the AΓΠ-1 has the following advantages as compared to the gyro horizons of earlier makes:

- the pilot need not re-orient the aircraft when changing from contact to instrument flight;
- the instrument affords correct indications of the aircraft attitude at diving angles up to 360° except for the 270°0.5 and 90°0.5° angles.

The gyro horizon is ready for employment 1 - 2 minutes after engaging the AIK circuit breaker. Before the take-off set the bank index at zero with the aid of the bank levelling rod.

12. Level Flight

Set the rate-of-climb indicator pointer at zero for the level flight. When the bank centering pointer is at zero the aircraft silhouette shows the angle of bank, i.e. the angle between the aircraft fore-and-aft axis and the horizon plane

If the levelled aircraft flies at steady speed with the air density being constant, the compass card has constant shifting value relative to the zero bank index through the magnitude corresponding to the angle of attack. The variation of the attack angle due to the change of the flight speed, air density and the aircraft levelling, causes the change of the bank scale on the compass card relative to the position of the silhouette plane.

The positive or negative angle of the aircraft bank is determined by the position of the central point of the silhouette plane.

After obtaining the steady speed of the aircraft having constant angle of attack, the level flight should be carried out by reference to the silhouette plane to be maintained at the positive angle by the bank scale.

13. Climb and Descent

During the bankless climb, the stationary silhouette plane must stand against the blue background above the artificial horizon line which goes down. The bank angle should in this instance be maintained by reference to the position of the silhouette plane on the bank scale.

During the bankless descent, the fixed silhouette plane must be kept against the brown background below the artificial horizon line which goes up. The angle of bank should be maintained by reference to the centre point of the silhouette plane on the bank scale.

14. Performance of Aerobatic Evolutions

While performing the aerobatic evolutions, the position of the aircraft in space (i.e. its bank) should be governed by the position of the silhouette plane relative to the line of the artificial horizon. The pitch of the aircraft should be determined by the position of the centre point of the silhouette plane on the pitch scale.

The climbing manoeuvres must be performed within the zones of angles from 0° to 180° with the silhouette plane standing against the blue background.

While performing the descending manoeuvres within the angle zone of 180° to 360°, the silhouette plane must be seen against the brown background.

The silhouette plane turns upside down when the aircraft performs the ascending and descending manoeuvres passing through the pitching zones of 90°5°; 270°5°.

CAUTION: 1. When the instrument yields erroneous indications which might be caused by accidental discontinuation of the power supply, then the aircraft should be brought to the level flight with simultaneous pressing of the switch marked ТО ВЕ USED IN LEVEL FLIGHT ONLY (ДЛЯ ГОРИЗОНТАЛЬНОГО ПОЛЕТА). After that, the cage-uncage lamp on the indicator must light up (caging time being 15 seconds). The indicating lamp goes out upon the termination of the caging cycle. The cage-uncage switch must be used only when the bank angles keep within ±4°.

2. It is PROHIBITED to use the cage-uncage switch if the AΓΠ-1 functions properly upon switching on the ground and in flight.

15. Automatic Radio Compass APK-10

The control panel mounts additional rheostat for varying the illumination intensity of the Km/s scale (marked KTU) for night flights.

The aircraft is provided with a special equipment for automatic changing from the outer homing beacon (to be done the moment the aircraft flies over the latter) to the inner homing beacon if the aircraft landing gear is retracted.

As the aircraft is flying over the inner homing beacon, the APK-10 automatic radio compass automatically switches over to the outer home radio beacon again as soon as the compass needle has travelled through 40 - 50° in either direction.

Under the adverse weather conditions, the INNER HOMING BEACON - OUTER HOMING [illegible] selector should be set to the OUTER (ДАЛЬНЯЯ) position, and in this instance the change-over will be done automatically.

The special equipment gets disconnected upon setting the INNER - OUTER (БЛИЖНЯЯ - ДАЛЬНЯЯ) selector to the INNER (БЛИЖНЯЯ) position.

16. Aircraft Towing

When towing the aircraft over the airfield, remember that towing with the open [illegible] is forbidden. The rod of the ПВД airspeed tube must be raised. The speed of towing is within 10 to 15 km/hr over a concrete pavement or within 5 to 6 km/hr over another [illegible].

II. ENGINE RUNNING ON GROUND

17. Preparation for Starting

The engine is tested for operation at maximum and augmented ratings in the beginning of each flight day on a special site intended for this purpose.

The engine is started from a ground source of power. Chocks must be placed under the aircraft wheels, the aircraft must be equipped with all fire-fighting means. Prior to starting remove all foreign objects found in front of, and behind the aircraft.

Prior to starting:

- set to the storage battery, generator and circuit breaker RADIO SET;
- set to the upper and lower rows of circuit breakers located on the left control panel by engaging the bar-handle to effect their simultaneous connection.

Notes: 1. To facilitate starting, do not energize the consumers not pertaining to the starting system.

2. When the circuit breaker SIGNAL SYSTEM OF GENERATOR, OIL PRESSURE, TURN INDICATOR COCKPIT LIGHTING (СИГНАЛ. ГЕНЕР., ПАВЛ. МАСЛА, ИНДИК.) is set in, the lamp GENERATOR ON (ГЕНЕРАТОР ВКЛЮЧЕН) on the T-6 light panel will flash on. The lamp will go out when the r.p.m. of the high-pressure turbine are not over 35% with the ground source cut off.

CAUTION: Never test the in-flight starting system before the engines are started on the ground. Then the in-flight starting system is tested with the engine temperature and coverage absent, parts of combustion chambers and starting units may burn out due to the oxygen supply.

18. Engine Ground Starting

Command: "Clear the engine!" and start the engine on hearing: "Engine cleared!"

Start the engine as follows:

- shift the engine control lever to the LOW SPEED position;
- depress the starting button for 1 or 2 sec. and then release it.

After the push-button is pressed the engine r.p.m. must automatically settle at low speed during a time period of not over 60 sec.

When the starting cycle is over the STARTING light on the T-6 light panel goes out.

The exhaust gas temperature at the turbine outlet must not exceed 550°C during the process of starting.

The low pressure turbine r.p.m. must not exceed 29.5+2% at the low speed rating.

Notes: 1. The high pressure turbine r.p.m. in the end of the starting cycle must be not less than 16% and not over 33%, at the low speed rating the r.p.m. must equal 46.5+2%.

2. As soon as the high pressure turbine r.p.m. reach 8 or 16%, the pressure gauge pointer must indicate oil pressure in the engine system.

3. To avoid pressure surges never shift the engine control levers beyond the low speed position during the starting process.

After the engine is started, cut in all the circuit breakers located on the right electric panel (generator, pump unit, remote-control artificial horizon, radio set, trimmer effect, etc.).

CAUTION: If the engine fails to start or if the permissible values are exceeded during the starting, discontinue starting immediately by bringing the engine control levers to the CUT OFF position.

If the engine is stopped before the ENGINE STARTING lamp goes out, cut in the starting units and keep them switched on not less than 40 sec. to complete the interrupted cycle of automatic starting units. A repeated starting can be performed only after the cause of the failure has been found and eliminated.

19. Engine Starting with Fuel Feed Manual Control

The starting with the fuel feed manual control is permissible in case the automatic starting cannot be performed due to some cause or other.

The starting is performed as follows:

- place the engine control lever in the CUT OFF position;
- depress the push-button STARTING and keep it pressed for 1 or 2 sec. After this begin feeding fuel to the engine by slowly sliding the engine control lever towards the LOW SPEED position.

The exhaust gas temperature at the turbine outlet must not exceed 550°C.

The end of the starting cycle is indicated by the moment the STARTING lamp on the T-6 light panel goes out.

20. Autonomous Starting

For autonomous starting:

- cut in the appropriate circuit breakers (as in the case of starting from the ground source);

- set the engine control lever to the LOW SPEED (МАЛЫЙ ГАЗ) position;
- press the START (ЗАПУСК) button and release it 2 - 3 seconds later.

Notes: 1. In the case of autonomous starting, it is possible that the engine r.p.m. should reach the low speed in 60 seconds after starting.

2. The autonomous starting may be repeated three times at maximum with the storage batteries completely charged and two times at maximum if the storage battery integrating meter shows 40 A/hr capacitance.

With introduction of autonomous starting of the engine, to ensure the engine starting on the ground air by-pass valves are installed on the engine and the flaps open position is brought in.

In the process of starting, the flaps should be opened to keep the position corresponding to the full augmented condition until the engine speed has reached 65% of the high pressure turbine r.p.m., after which they automatically assume the position corresponding to the maximum duty.

When the engine control lever is pulled backward, the flaps automatically leave the MAXIMUM DUTY (МАКСИМАЛ) position to come to the FULL AUGMENTED CONDITION (ПОЛНЫЙ ФОРСАЖ) corresponding to 60% of the high pressure turbine r.p.m. The difference in the r.p.m. of 60% and 65% is provided to prevent spontaneous repeated opening and closing of the flaps when the flight speed of the engine approximates 65%.

CAUTION: Should the engine fail to obtain the speeds corresponding to 40% of the high pressure turbine r.p.m. (no starting took place), cut out the circuit breaker marked STARTING UNITS (АГРЕГАТЫ ЗАПУСКА) after bringing the engine control lever to the STOP (СТОП) position.

Engine Limitations

The maximum permissible r.p.m. of the high pressure turbine on the ground and in flight should be within n = 103.5%.

The maximum permissible variation of the low pressure turbine r.p.m. under the maximum duty and augmented condition should not go beyond

$$n = 100^{+10}_{-0.5}\ \%.$$

21. Engine Warming Up and Testing

After the engine is started and the LOW SPEED rating is established, allow the engine to run at the same rating for 0.5 or 1 min. and check the readings which must be:

n = РНД (low pressure turbine r.p.m.) - 29.5±2%;
$t_{exhaust\ gas}$ - not over 420°C;
P_{oil} - at least 1 kg/sq.cm.

CAUTION: At low speed the engine continuous operation is permissible for not over 10 min.

Check the engine for operation at 60% and 90% ratings.

Check the engine for operation at normal rating:

РНД (low pressure turbine r.p.m.) = 93±0.7%;
P_{oil} - from 3.5 to 4.0 kg/sq.cm.
Time of continuous operation is unlimited.

CAUTION: 1. At ratings above normal the engine is tested on a site specially intended for the purpose and furnished with special wheel chocks and wire ropes.

2. During the engine testing the cone of the air inlet duct must be completely retracted. Never test the engine if the CONE EXTENDED lamp is burning.

3. At temperatures below zero the engine operation at a speed of less than 50% is permissible for not over 2 min., after this the engine speed must be raised to the r.p.m. above 50% for at least 30 sec.

Check the engine operation at maximum rating.

At maximum rating the gauges must indicate:

n = РНД (low pressure turbine r.p.m.) = 100±0.5%;
$t_{exhaust\ gas}$ - not over 710°C;
P_{oil} - from 3.5 to 4 kg/sq.cm.
Time of continuous operation is 10 or 15 sec.

Check the engine operation at augmented rating:

- shift the engine control lever to the AUGMENTED position until it rests against the stop;
- the moment the augmented rating is switched on is indicated by the lamp AUGMENTATION flashing on the T-6 light panel and by a jerk;
- when the augmented rating is switched on, the exhaust gas temperature must drop by 40 to 90°C as compared with the temperature of the maximum rating with its subsequent rise. A short-time increase in the low pressure turbine r.p.m. up to 106.5% during 5 sec. is permissible when the augmented rating is established, then the r.p.m. must settle at the actually adjusted maximum speed value (low pressure turbine) during a period of not over 2 min.

CAUTION: 1. In case the augmented rating change-over is accompanied by a pressure surge or exhaust gas temperature rise above the limit (700°C), shift the engine control lever to the MAXIMUM position or even lower. If pressure surges and temperature rise persist, stop the engine by placing the engine control lever in the CUT OFF position. The engine may be started again only after the cause of trouble has been eliminated.

2. If the engine control lever shifting fails to stop the augmentation, cut it off by means of the switch AUGMENTED - MAXIMUM.

3. If with the engine changed over to the augmented rating the fuel fails to burn in the afterburner (the exhaust gas temperature drops below 450°C), shift the engine control lever to the MAXIMUM position.

Instrument indications at the augmented rating must be as follows:

°(low pressure turbine) = 100±0.5%;
$t_{exhaust\ gas}$ - not over 700°C;
P_{oil} - from 3.5 to 4 kg/sq.cm.
Time of continuous operation if not over 15 sec.

22. Engine Acceleration Test

Check the engine acceleration by shifting the engine control lever from low speed to maximum during 1.5 or 2 sec.

The acceleration up to РНД (low pressure turbine r.p.m.) = 99% must take

from 9 to 12 sec. at ambient air temperature not below +15°C.

At lower temperatures the acceleration time increases accordingly (but not over 16 sec. when the ambient air temperature reaches −40°C).

An increase in the temperature of exhaust gases as measured at the turbine outlet must not exceed 720°C.

An increase in the low pressure regulator r.p.m. must be not over 106.5% during 3 sec. with a successive restoration of actually adjusted r.p.m. during a period of not over 2 min.

Engine low speed - augmented rating acceleration is checked in cases this is found necessary. The acceleration time (from low speed to augmented rating) must not be over 20 sec. All limit values for exhaust gas temperatures and turbine r.p.m. are similar to those given for the low speed - maximum rating acceleration test.

After testing the engine, check operation of the ignition plugs.

III. CHECKING AIRCRAFT SYSTEMS AFTER ENGINE STARTING

23. Cockpit Pressurization System Check

To check the cockpit systems, proceed as follows:

- close the canopy;
- pressurize the cockpit.

The cockpit air feed system must be checked with the engine operating at normal rating and the cockpit air feed cock open.

Make sure the cockpit is free of smoke.

To check the operation of the electrical air distributor, set the switch to the COLD and HOT positions. After the check set the switch to the AUTO position.

24. Generator Check

If the generator operates normally, its signal lamp with the inscription ГЕНЕРАТОР ОТКЛ on the T-6 light panel does not burn at all ratings of the engine. The voltmeter must indicate 27 or 29 V.

25. Hydraulic System Check

After the low speed rating settles, the pressure in the main and booster lines must equal 210 kg/sq.cm.

(a) With the control stick shifted energetically along the diagonal (and the aileron boosters on), the pressure in the main and booster lines must not drop below 180 kg/sq.cm.

(b) Check aircraft controls operation from the main hydraulic line. For this purpose press the BOOSTER LINE OFF button on the right-hand control panel. With the control stick shifted along the diagonal, the pressure in the booster line must not deviate from 210 kg/sq.cm., while in the main line the pressure must not drop below 180 kg/sq.cm.

26. Check of Aileron and Stabilizer Control

With the aileron boosters on, smoothly deflect the control stick to extreme positions 3 or 4 times. No jerks or creeping must be felt. Make sure the effort is created by the artificial feel mechanism.

Deflect the control stick forward and backward to check the operation of

of the stabilizer control booster. The stick must be free of jamming or jerks and must fully deflect to extreme positions. When released, the stick must return to the neutral position.

27. Check of Landing Flap Control

Actuate the flaps by pressing the button EXTENSION - RETRACTION. The flaps position is checked by the light of the FLAP EXTENDED lamp on the L.G. light panel and according to the signs given by the technician.

28. Preparation for Taxiing and Taxiing

The engine, instrument and system operation having been found normal, ask permission to taxi the aircraft to the runway.

Make sure the emergency brake lever is sunk in place and locked and the nose leg brake line is disconnected.

Close the canopy and pressurize it. Make sure the locks are properly closed.

Connect the ejection gun interlock release cable to the canopy.

Brake the wheels and issue the command to remove the chocks.

Note: When taxiing, to save the compressed air and to effectively perform braking, it is necessary to change over from the automatic to manual brake.

The taxiing speed must not exceed 30 km/hr or 15 km/hr with the drop tank and rocket launcher suspended. All turns during taxiing must be smooth.

Taxi to the runway and ask for taxiing to the take-off position (if the runway is free).

Place the aircraft upon the runway, taxi the aircraft 20 or 30 m. along the take-off line to set the nose wheel into the aircraft centre line plane and extend the flaps.

Unlock the L.G. control handle.

Apply the nose wheel brakes by turning the brake handle clockwise and fix the straps.

IV. ENGINE

29. General

The РД10-300 engine having a thrust of 3750 kg (bench tests) regulated at augmented rating allows smooth thrust regulation by means of the engine control levers from the position MINIMUM AUGMENTATION (МИНИМАЛЬНЫЙ ФОРСАЖ) to the position of MAXIMUM AUGMENTATION (МАКСИМАЛЬНЫЙ ФОРСАЖ) thus allowing manoeuvres of combat formations at high altitudes. When the engine operates at LOW THROTTLE, NORMAL RATING and MAXIMUM RATING, the exhaust nozzle shutters are slightly closed and do not change the nozzle diameter of 326^{+10} mm.

At MINIMUM AUGMENTATION the nozzle diameter is 610^{+10} mm.

At FULL AUGMENTATION (ПОЛНЫЙ ФОРСАЖ) the nozzle diameter is 679_{-10} mm.

The low pressure regulator r.p.m. remains stable within the range of MINIMUM AUGMENTATION - MAXIMUM AUGMENTATION, the exhaust gas temperature at augmentation throttling increases by 15 - 25°C.

The high pressure regulator r.p.m. increases by 1 or 1.5%.

30. Engine Ratings

Nos	Ratings	Low pressure regulator r.p.m., %	Exhaust gas temperature (behind turbine), °C	Oil pressure, kg/sq.cm.	Continuous operation
1	Maximum augmentation	100±0.5 during change-over, short-time r.p.m. increases not over 106.5 (not exceeding 5 sec.)	Not over 700°C, not over 720°C when running time exceeds 90 sec.	From 3.5 to 4.0	Not over 15 sec. on the ground, not over 10 min. at altitudes below 10,000 m. and not over 20 min. at altitudes over 10,000 m.
2	Minimum augmentation	100± 0.5	Not over 700°C, not over 720°C when running time exceeds 30 sec.	From 3.5 to 4.0	Not over 15 sec. on the ground, not over 10 min. at altitudes up to 10,000 m. and not over 20 min. at altitudes over 10,000 m.
3	Maximum rating	100±0.5 during change-over, short-time r.p.m. increases not over 106.5	Same	Same	Not over 1 min. on the ground, not over 10 min. at altitudes up to 10,000 m. and not over 20 min. at altitudes over 10,000 m.
4	Normal rating	93±0.7	Without limits	Same	Without limits
5	0.8 of normal rating	86±0.7	Same	Same	Same
6	Low speed		Not over 420°C	At least 1	Not over 10 min. on the ground, without limits in flight
	Low speed r.p.m. are adjusted on the ground relative to ambient air temperature				
7	Starting		Not over 960°C		Not over 60 sec. from the moment starting push-button is depressed till low speed is attained, not over 60 sec. during autonomous starting

31. Engine Acceleration Time

The engine control lever shifting time during acceleration is 1.5 to 2.0 sec.

(a) acceleration time from low speed r.p.m.:
to 99% . . . . . 9 - 12 sec.
to augmented rating (maximum, minimum and intermediate). . not over 20 sec.

(b) acceleration time from 85% rating to 99 % . . . . . from 7 to 10 sec.

(c) engine acceleration from maximum rating to augmented rating (maximum, minimum and intermediate). . . . . not over 9 sec.

Notes: 1. Time of engine continuous operation within the range of 95 - 100% is limited similarly to operation at maximum rating.
2. Repeated acceleration up to ratings over 95% (by the L.P. regulator) is permissible only after engine cooling at normal or lower ratings (at least for 1 min.).
3. Decrease in oil pressure down to 3 kg/sq.cm. at altitudes over 10,000 m. is permissible.
4. Maximum r.p.m. of the H.P. regulator equals 103.5%.
5. Short-time (not over 5 sec.) rapid increase of the L.P. regulator r.p.m. during augmented rating change-over and during acceleration is not over 106.5%.
6. When the engine is started, check operation of spark plugs during 30 sec. at low speed rating.

32. Maximum Rating

In climb with the engine operating at a maximum rating exhaust gas temperature behind the turbine usually somewhat decreases.

At the altitude of 10,000 m. gas temperature at the turbine outlet must not be lower than 550°C.

Simultaneously with the gas temperature reduction, the H.P. regulator r.p.m. decreases up to 3% due to a decrease in the ambient air temperature.

33. Augmented Rating

The maximum augmented rating can be set reliably at altitudes below H = 16,000 m. when the indicated speed is not less than 430 km/hr; at higher altitudes the minimum air speed at which the maximum augmented rating can be set reliably increases. At altitude of 19,000 km. it reaches 600 km/hr. change-over time being up to 4 sec.

When changing over for the augmented rating, watch the AUGMENTED RATING lamp, both rotor r.p.m. and exhaust gas temperature at the turbine outlet.

A decrease in the exhaust gas temperature as measured at the turbine outlet may reach 90°C.

A short-time (not over 5 sec.) increase in the L.P. regulator r.p.m. must not exceed 106.5%.

A decrease in the H.P. regulator r.p.m. can be registered during the augmented rating setting, but no limits are specified for the decrease.

The augmented rating must be introduced smoothly, without sharp increases and above-limit temperatures of exhaust gases.

In case the change-over for the augmented rating is accompanied with speed rise and exhaust gas temperature jumps shift the engine control lever back to the MAXIMUM RATING.

If the lever shift fails to return the engine to the maximum rating, stop the augmented operation of the engine by switching off the AUGMENTED RATING (FORSAZH) switch.

When the engine operates at the augmented rating or picks up speed, watch both rotors r.p.m., and exhaust gas temperature. When the engine picks up speed, the H.P. regulator r.p.m. increases.

Maximum speed of the H.P. regulator is 103.5%, maximum temperature of exhaust gases as measured at the turbine outlet is 700°C, at altitudes up to 15,000 m. and 720°C at altitudes up to 15,000 m.

In case the H.P. regulator speed is above 103.5% or the exhaust gas temperature exceeds 700°C, stop engine acceleration and find out the cause of the trouble as soon as the aircraft lands.

When the H.P. regulator r.p.m. reaches 102.5 or 103.5% with the engine still picking up speed, a reduction in the L.P. regulator r.p.m. may be registered.

The H.P. regulator r.p.m. reaches the maximum value when the M number in the flight is close to the maximum value.

The engine may be changed over for ratings below the maximum rating when the exhaust gas temperature sets at 500°C (after the decrease).

When the engine operates at the MINIMUM AUGMENTATION, the fuel pressure becomes less as compared to the pressure registered during the maximum augmentation, the fuel burning becomes less stable. All this may result in thrust pulsation (at high altitudes and small indicated air speeds).

Indicated speeds at which the engine operation becomes unstable (at minimum augmentation) are:

- 400 km/hr at altitude of 13,000 m.;
- 480 km/hr at altitude of 15,000 m.;
- 560 km/hr at altitude of 17,000 m.

In case axial buffeting is registered at the throttled augmented rating which is an evidence of the fuel unstable burning, place the engine control levers strictly in the FULL AUGMENTATION position; in case the aircraft is flown with the engine operating at MINIMUM AUGMENTATION increase the indicated speed or decrease the altitude.

V. FLIGHT

34. Take-Off

Perform the take-off with the L.G. automatic brake operating.

On obtaining permission to take-off, gradually increase the engine r.p.m. up to maximum, make sure the engine operates normally, release the brake handle and begin the take-off run.

Perform the take-off with the engine operating at a maximum rating or at the MINIMUM AUGMENTATION rating and the flaps extended.

If a reduction of the take-off distance is necessitated, the full augmented rating can be employed during the take-off.

At the beginning of the take-off run the control stick must be kept in the neutral position.

As soon as the speed of 200 km/hr is gained, raise the nose wheel from the ground by a smooth backward pull at the control stick.

During a normal raising of the nose wheel the aircraft nose must also rise to the horizon and preserve this position till the take-off.

CAUTION: Never raise the aircraft nose above the horizon otherwise the aircraft false keel may bump against the runway.

The aircraft clears off the ground at a speed within 310 to 315 km/hr.

Note: The take-off distance with the engine operating at the maximum rating, without the drop tank suspended and the flaps extended is from 900 to 1100 m.; with the take-off performed at the augmented rating the distance constitutes 650 m.

The length of take-off run at maximum rating with two K-13 rockets is from 1200 to 1300 m.

The length of take-off run at augmented rating with drop tanks and two K-13 rockets is 900 or 1000 m., that without drop tanks is 600 m.

Take-off with one rocket pad has no peculiarities.

The presence of the drop tank influences the take-off conditions but inconsiderably.

After the take-off the aircraft must display a proper stability without a tendency for pitching or banking.

Note: As the aircraft is equipped with highly effective ailerons, the wing-to-wing roll during the take-off is damped with the aileron small-angle movements to avoid a large-amplitude rolling near the ground at small speeds.

Retract the landing gear on reaching 10 or 15 m. above the ground.

At speeds up to 380 km/hr the landing gear retraction time is 7 or 8 sec.; at higher speeds the retraction time increases, besides an incomplete retraction of the landing gear may be the result of higher speeds.

Check whether the landing gear retraction is indicated by the signal light and by a pressure rise in the hydraulic system (up to 210 kg/sq.cm.).

Make sure the landing gear is retracted and set the L.G. control valve to the central position.

CAUTION: In case one of the signal lamps does not burn with the landing gear retracted at high speeds, keep the L.G. control valve in the RETRACTED position and decrease the speed down to 350 km/hr. This must effect a complete retraction of the landing gear.

Retract flaps at altitudes within 100 - 150 m. The moment the flaps are retracted the aircraft slightly lowers.

35. Side Wind Take-Off

During the take-off with a side wind of 10 or 15 m/sec. blowing the aircraft tends to bank to the side opposite to the wind. Banking is usually accompanied with a slight turn.

The aircraft tendency to banking and turning is easily removed by deflecting the ailerons against the bank. To maintain the direction at the beginning of the take-off run, wheel brakes may be made use of. A gradual growth of speed and an

increase in the effectiveness of the controlled surfaces lessen considerably the aircraft tendency to banking and turning.

36. Rectangular Pattern Flight

Climbing to a flight altitude during the traffic flight above the airfield is usually conducted with the engine operating at a normal rating.

During the traffic flight above the airfield with the landing gear retracted maintain speed of 500 km/hr. The low pressure turbine r.p.m. will be 80%.

37. Fuel Consumption Control

Fuel consumption in flight is checked by the indications of the flow meter and by the light of the signal lamps.

CAUTION: 1. Cut out the respective circuit breakers on the left control panel in accordance with the fuel consumption progress and pump signal lights.

2. The pumps of the 4th and 5th tanks must be cut out 8 or 10 min. after the respective lamps flash on.

3. When the FUEL RESERVE (АВАРИЙНЫЙ ОСТАТОК) light panel flashes on (for consuming the fuel reserve in the tanks), engage all fuel pumps that have been previously disengaged, and then disconnect them after 1-minute steady burning of the lamps of every pump.

38. Preparation for Landing

Prior to landing:

- check whether the gun circuit breaker is cut off and the fire button (in case guns have been used in flight) is safetied;
- make sure the pressure in the hydraulic system equals 210 kg/sq.cm.;
- check whether air pressure equals 130 kg/sq.cm. in the emergency system and 80 or 100 kg/sq.cm. in the main air system.

Reduce speed to 500 km/hr and extend the landing gear.

Check the landing gear extension by the light of the green lamps.

Keep the L.G. control valve in the EXTENDED position till taxiing the aircraft to the parking place.

When flying with the landing gear extended maintain speed at 450 km/hr (the low pressure turbine r.p.m. will be 80%).

Check whether the automatic brake system and the nose wheel brake are switched on.

Set the trimmer effect mechanism to the neutral position.

39. Landing Approach

Perform the horizontal flight and the 3rd turn after extending the landing gear as well as gliding before extending the flaps at a speed of 450 km/hr.

Before the 3rd turn make sure the inscription STABILIZER IN LANDING POSITION (СТАБИЛИЗАТОР НА ПОСАДКЕ) on the T-4 light panel is illuminated.

Before the 4th turn extend the flaps and check their movement by the light of the signal lamps.

The extension of the flaps originates a slight tendency for pitching which is easily removed by a deflection of the control stick.

Note: If the lamp EXTEND L.G. flashes on after the flaps are extended showing that the landing gear extension has not been effected (or has been incomplete), go around, extend the landing gear completely and then perform landing.

Perform gliding after extending the flaps at a speed of 400 km/hr.

The final turn must be performed at a speed of at least 400 km/hr to be finished at an altitude of 300 m.

When gliding after the final turn with the flaps extended maintain speed at 350 km/hr gradually reducing it to 320 km/hr at the beginning of levelling off. When landing with rockets, the glide speed should be increased by 10 - 15 km/hr.

Glide to the touch-down point calculating to apply power to reach it. All corrections must be performed either by changing the engine r.p.m. (in case of undershooting) or by applying air brakes (in case of overshooting).

Note: When landing with the landing gear and flaps extended the engine speed (low pressure turbine) must be maintained at 60 or 70%.

40. Landing

At an altitude of 10 or 12 m. reduce the angle of gliding by pulling the control stick backward so as to bring the aircraft to 1 m. above the ground.

Having levelled off the aircraft, smoothly pull the engine control lever to the LOW SPEED position to perform floating.

Float with a gradual descent, for which purpose increase the angle of incidence by smoothly pulling the control stick backward to land the aircraft upon two main wheels (without pancaking) with the stick pulled almost to the extreme position.

During a normal landing (fuel reserve of 300 - 500 lit., flaps extended) the landing speed is 260 or 280 km/hr.

During landings with the control stick insufficiently pulled back, the landing speed and landing run increase respectively.

When floating, keep looking at 30° to the left and 30 or 40° m. forward upon the ground.

After the touch-down (upon two wheels) continue to look forward and to the left as when floating. Only after the nose is down, look straight forward and begin braking.

Note: To reduce the landing run, do not hold the aircraft running with the nose leg up for a long time. As soon as the aircraft is stable on the two main wheels, help the aircraft to lower the nose wheel by pushing slightly the control stick forward and begin braking.

The aircraft wheels are braked by pressing upon the brake lever to actuate the automatic brake system.

Note: The automatic brake system allows to shift the engine control lever fully backward after the nose wheel is down(without giving rise to skidding) and to considerably reduce the landing run.

The landing run is reduced, as a rule, by employing the drag parachute. The drag parachute is released at speeds not over 280 km/hr.

If the aircraft balloons due to some mistake in the landing technique, the aircraft position is corrected as follows:

- when landing at higher speeds (the nose wheel is slightly above the ground), restrict further ballooning as soon as the aircraft clears the ground and then, as

the speed and altitude reduce, land the aircraft upon the two main wheels;

– when landing at normal or even lower speeds, arrest the control stick in the position it has occupied at the moment of ballooning. As the aircraft approaches the ground, land the aircraft upon the main wheels by a smooth but energetic pull at the control stick.

In case of a high floating (above 1 m), stop pulling the control stick backward and then land the aircraft upon the two wheels after the aircraft loses speed and altitude.

When the main brake system fails, slow down the aircraft speed with the help of the drag parachute; besides apply wheel brakes repeatedly by pulses using for this purpose the emergency brake control valve.

After the landing run is over, retract the flaps, switch in the nose wheel steering mechanism, cut off the nose wheel brake and taxi the aircraft off the runway.

CAUTION. Never taxi the aircraft with the canopy open.

41. Actions to Be Carried Out by Pilot during Landing Run Near Landing Marks (Correct Reckoning)

The parachute should not be released for correctly reckoned landing run.

(a) After the main legs have touched the ground, the pilot must bring the aircraft to nose-down position at once.

(b) He must press the brake lever all the way down.

(c) After the aircraft has come to a stop, the landing flaps must be retracted.

(d) The nose wheel brake must be disengaged.

(e) The autopatic brake toggle switch must be changed over to the MANUAL (РУЧНОЕ) position, and perform the taxiing.

42. Actions to Be Carried Out When Flying Over Landing Marks for Landing on Limited Runway

For ensuring the least long run:

(a) after the main legs have touched the ground, the pilot must at once bring the aircraft nose down by gently pushing the control stick forward during 1 – 2 seconds.

(b) The brake parachute must be released immediately after bringing the nose down.

(c) At the same moment the brake lever must be pressed all the way down.

(d) The landing flaps must be retracted.

(e) If necessary, stop the engine.

(f) After the aircraft has come to a stop, the nose wheel brake should be cut out.

(g) The automatic brake toggle switch should be set at the MANUAL (РУЧНОЕ) position after which the taxiing may be done.

43. Recommendations to Pilot When Automatic Brake System Fails

If the automatic brake system fails, the pilot must:

(a) Release the brake parachute and retract the landing flaps.

(b) Let go of the brake lever completely (to avoid skidding while changing over to the manual control).

(c) Set the automatic brake lever to the MANUAL (РУЧНОЕ) position.

(d) Brake the aircraft by smoothly pressing the brake lever.

(e) Disengage the engine.

44. Recommendations to Pilot When Both Automatic and Manual Brake Systems Fail

Should the automatic and manual brake systems fail (want of air, break of rope, etc.), the pilot must:

(a) Release the parachute.

(b) Change over to emergency braking by pulling forward the emergency brake valve control in short pulls (to avoid tear of tyres).

(c) Retract the landing flaps.

(d) Stop the engine.

45. Landing with Side Wind

The landing with a side wind of up to 15 m/sec. blowing at 90° in relation to the aircraft affords no great difficulty.

Compensate the aircraft drift by slipping in the opposite direction with a bank of 10 or 15°.

In case of a stronger wind the drift must be compensated by slipping alongside with changing the aircraft heading.

By the end of floating, gradually reduce slipping so as to eliminate banking completely (the pedals must be in the neutral position) by the moment of the touch-down. Land the aircraft upon two main wheels.

After landing gradually lower the nose wheel until it reaches the ground with the purpose of increasing the aircraft directional stability.

Maintain the direction of the run by deflecting the pedals towards the side opposite to the turn (during the first half of the run) and by applying the brakes (during the second half of the run).

46. Landing without Extending Flaps

When landing with flaps intently inactive, keep the gliding speed at 360 – 370 km/hr gradually reducing it by the beginning of the rounding-out to 330 or 340 km/hr.

The aircraft speed at gliding must be maintained at 60 or 70% (low pressure turbine).

47. Go-Around

The go-around is possible from any altitude (even rounding-off altitude). After taking the decision to go around, increase the engine r.p.m. up to MAXIMUM.

On reaching the speed of 350 – 370 km/hr, begin climbing and retract the landing gear.

Retract flaps at an altitude of 150 – 200 m.

48. Stopping Engine at Parking

After placing the aircraft for parking, de-energize all electric consumers (except pump No.2) and stop the engine by placing the engine control lever in the CUT OFF position.

In case the engine operates at 85%, first keep it operating at 85% during 10 sec. and then shift the lever to the STOP position.

After setting the lever to STOP, cut off circuit breakers STORAGE BATTERY, PUMP No.2, STARTING UNITS, SIGNALLING OF OIL PRESSURE, GENERATOR AFTERBURNER ON.

CAUTION: Never close the main fuel line shut-off cock (except cases of fire) before the high pressure turbine stops.

49. Climbing to Ceiling Altitudes

Climbing at the engine MAXIMUM rating must be performed at speeds within 900 to 950 km/hr (smaller pointer).

To reduce the climbing time, employ the engine augmented rating. In this case the climbing speed must be within 950 - 1000 km/hr (smaller pointer). Climbing to the service ceiling altitudes is performed as follows:

- climb to the altitude of up to 8000 m. with the engine operating at the maximum rating and speed maintained within 900 to 950 km/hr (smaller pointer);
- at the altitude of 8000 m. change over for the augmented rating and climb further with the M number gradually increasing from 0.85 to 0.9 at the altitude of 8000 m. and to 1.6 at altitudes of 13,000 or 13,500 m.

The further climbing up to the ceiling will be performed with a constant value (1.6) of the M number.

When climbing with the engine operating at the augmented rating from the altitude of 12,500 m. a sensible reduction of vertical speed component from 15 to 20 m/sec. to 5 or 7 m/sec. is observed at altitudes above 19,000 m.

At service ceiling altitudes the engine performance is stable at the augmented rating and allows small turns. With the control stick in the extreme back position the aircraft can perform a turn accompanied with g growing to 1.5 or 2.0 and a rapid loss of speed.

When the service ceiling altitude is attained on the augmented rating and with the drop tank not suspended, the total fuel reserve amounts to 600 or 700 lit. permitting to fly at the ceiling altitude during 3 min.

On taking decision to finish the flight, shift the lever to stop the augmented rating and descend with M number gradually reducing.

The moment the augmented rating is switched off the aircraft shows a considerable loss of speed.

VI. FLIGHT LIMITS

50. Maximum M Number (without Suspensions)

2.05 is established as the maximum value of M number in flights without suspension loads such as drop tank or bombs at an altitude above 12,500 m.

Gain speed in a horizontal flight or with a slight loss of altitude with the augmented rating of the engine.

The shifting of the air intake cone into the second(intermediate) and extreme front positions is accompanied with a change in the sound created in the intake duct.

The aircraft is stable during acceleration. The change of efforts exerted upon the control stick is practically insignificant. With the M number growing above 1.1 or 1.2 the efforts on the pedals (to perform slipping) grow considerably. Ailerons are effective throughout the whole range of changes in the M number up to the limit values.

The following instruments must be under constant control of the pilot:

- exhaust gas temperature indicator;
- r.p.m. indicator;
- oil pressure indicator;
- T-4 and T-6 warning light panels.

51. Maximum Indicated Speed without Rocket Pods

The limit value for the indicated speed (larger pointer) during flights without suspended loads is 1200 km/hr from the ground to 12,500 m.

During the aircraft acceleration with the trimmer effect mechanism neutral, certain efforts appear on the control stick at the indicated speed of 750±100 km/hr; at the speed of 850 or 950 km/hr the efforts decrease until they are almost zero and remain practically constant at a further increase of the indicated speed up to 1200 km/hr.

With the aircraft flying at limit values of indicated speed and M number, the efforts arising on the control stick are easily removed by the trimmer effect mechanism.

52. Flight with Drop Tank

Prior to flight make sure the circuit breakers EMERGENCY RELEASE OF BOMBS, DROP TANK, ROCKET POD are cut-in on the right-hand instrument panel (under a transparent shield).

When taking-off with the primed drop tank suspended never forget to extend flaps.

The technique of taking-off with the tank suspended has no peculiarities safe for the increased length of the take-off run.

The limits given below are established for the flight with the drop tank suspended: V_{ind} = 1000 km/hr (larger pointer) at altitudes from 0 to 12,000 m. and M = 1.6 at altitudes above 12,000 m.

The growth of M number above 1.6 results in intensive slipping which cannot be compensated because of great efforts applied to the control pedals.

The flight with limit values of speed and M number has no peculiarities. The aircraft is stable throughout the whole range of speeds and M number values.

The drop tank can be jettisoned in a level flight at speeds of 500 - 1000 km/hr (larger pointer) and at M number of up to 1.9. The tank jettison is effected by actuating the push-button.

To effect the drop tank jettison:

- swing back the safety cap on the left panel and press the button TANK DROPPING;
- as soon as the tank is dropped, the lamp DROP TANK SUSPENDED (on the instrument panel lower part) goes out.

In case the tank is dropped in emergency with the fuel contained, the readings of the fuel flow meter remain false for the amount of fuel dropped in the tank.

53. Flight with Two K-13 Self-Homing Rockets without Drop Tank

Maximum indicated speed at altitudes from 0 to 5000 m. . . . . 1100 km/hr
Maximum indicated speed at altitudes from 5000 to 12,500 m. . .1200 km/hr

M number at altitudes above 12,300 m. 2.0
Maximum overload (θ_y) 7.0

54. Flight with Two K-13 Rockets and Drop Tank

Maximum indicated speed at altitudes from 0 to 12,000 m. . . . . 1000 km/hr
M number at altitudes above 12,000 m. 1.6
Maximum overload with drop tank full or empty (θ_y) 6

55. Manoeuvring

The aircraft MiG-21F-13 is well controllable during simple, complicated and advanced manoeuvres.

Negative and zero overloads created during manoeuvres must last not over 15 sec. at engine ratings without augmentation and not over 5 sec. at the augmented rating.

CAUTION: The manoeuvres with negative and zero overloads are possible when the fuel reserve is not below 500 lit. (the LOW LEVEL lamp does not burn).

A manoeuvre with a negative overload may be repeated only after 30 sec. of a level flight.

During manoeuvres with negative and zero overloads the oil pressure at the engine inlet may drop down to zero.

The oil pressure at the engine inlet must restore immediately on finishing the manoeuvre.

CAUTION: Engine operation with the zero oil inlet pressure is permissible for not over 15 sec.

When performing aerobatics in the vertical plane with M numbers exceeding 1, the aircraft yields only to exagerated movements of the control stick.

The radii of vertical aerobatics are increased due to high entrance speeds.

During vertical aerobatics with the engine at the maximum rating, the aircraft suffers a rapid loss of speed when approaching the upper point of the manoeuvre. This requires exact and coordinated movements of the control stick.

To check the accuracy of aerobatic manoeuvres, resort to the indications of the AGK-1 artificial horizon which allows:

- to exactly set the values of the given banks, angles of diving, pitching and to check them during manoeuvring;
- to check whether the movements of the control stick and pedals are coordinated when entering the aerobatic manoeuvre, when in the process of the manoeuvre or when rounding off;
- to determine the aircraft attitude in relation to the horizon and to correct the aircraft attitude;
- to detect mistakes (banks, slipping, non-coordinated movements of the control stick and pedals), especially during vertical aerobatics.

During aerobatics at mean altitudes with high overloads and at high altitudes with comparatively small overloads the aircraft displays phenomena characteristic of the stalling angle conditions (pre-stall buffeting, wing-to-wing roll). On observing these phenomena, arrest the control stick in its movement backward. Do not resume the backward movement until the buffeting and roll disappear.

When performing aerobatic manoeuvres including a descent component, increase the engine r.p.m. at a dive angle of 30°; enter the vertical component from a level

flight with the engine operating at a given duty.

During aerobatic flights trim the aircraft at the altitude of 6000 m. and indicated speed of 800 km/hr.

Use the anti-g suit to perform aerobatic manoeuvres at low and mean altitudes or when performing a steep diving from high altitudes.

When mastering the MiG-21F-13 aircraft, perform aerobatics at altitudes not below 4000 m.

56. Banked Turn

Banked turns can be performed at any altitude and speed rated for the MiG-21F-13 aircraft.

The right and left banked turns do not differ from each other.

The banking element of a turn performed at the engine maximum rating at an altitude above 5000 m. may reach an angle of 60°. A bank of over 60° may result in a speed reduction.

During banked turns the aircraft displays buffeting at small overload values. A further increase in overload values does not result in the aircraft stalling into the spin as $Cy_{max.}$ (lift coefficient) is considerably higher than Cy in the beginning of the buffeting. Never pull the control stick excessively backward as this will make the aircraft roll from wing to wing which may end in a spin.

During banked turns or spins performed at speeds corresponding to M = 1.1 or over and altitudes above 10,000 m., the control stick may be pulled all the way backward (in certain cases) without establishing the Cy_{max} conditions.

Bear in mind, however, that with the M number below 1.1 the aircraft develops a considerable angular movement and increases the angle of attack due to an increase in the stabilizer effectiveness. In this case reduce the control stick deflection to compensate the movement angles.

Characteristics of banked turns most advantageous in time are given in the Table below.

Table

Characteristics	Engine rating		
	Maximum		Augmented
	H = 5000 m.	H = 10,000 m.	H = 12,000 m.
Indicated air speed (V_{ind}), km/hr	900	900	1000
Time (t), sec.	50	100	85
Radius of turn (R), m.	2000	4000	4000
Load factor (n)	3.2	1.6	2.3

Banked turns with the rocket pods suspended practically do not differ from turns without the rocket pods.

57. Chandelle

The chandelle can be performed at normal, maximum and augmented ratings of the engine and speeds not exceeding rated maximum values.

During a chandelle performed at the maximum rating and entry speed (indicated) of 900 or 950 km/hr the aircraft achieves an altitude of 3000 or 4000 m. (at an entrance speed of 4300 m.). The speed of recovering from the chandelle must be not less than 400 km/hr (indicated).

The technique of performing a chandelle has no peculiarities as compared to other type aircraft.

58. Half-Turn

Half-turn can be performed at any altitude between 3000 m. and the ceiling.

The half-turn entry speed (indicated) depends on the altitude and usually equals the following values:

not over 400 km/hr at altitudes of 3000 m.;
from 400 to 600 km/hr at altitudes within 6000 -10,000 m.;
from 400 to 500 km/hr at altitudes within 12,000 - 14,000 m.;
from 350 to 400 km/hr at altitudes above 15,000 m.

The half-turns at the above speeds can be performed either with retracted or extended (at the entry) air brakes.

When learning to perform the half-turn above the airfield begin the half-turn at altitudes within 6000 - 10,000 m. The loss of altitude will constitute from 3000 to 5000 m.

Prior to entering the half-turn establish the required speed (depending on the altitude); then slowly pull the control stick backwards to set the pitch angle within 10 to 15°, deflect the control stick and the pedals to the side of the half-turn so as to turn the aircraft with wheels upwards during 2 or 3 sec. and reduce the engine r.p.m. down to the low speed value.

In the wheels-up position, stop turning the aircraft and, without trying to preserve the position, smoothly pull the control stick backward to roll the aircraft out of the dive into a level flight at an indicated speed within 600 to 700 km/hr. When the aircraft is being recovered from the dive, efforts of a pulling character will be felt on the control stick.

When recovering from the dive be careful to coordinate the control stick movement with the recovering procedure.

In case the control stick movement is too slow, the aircraft speed increases considerably thus causing a considerable loss of altitude. Recover the aircraft from the dive in this case with a more energetic pull at the control stick (without allowing the aircraft to roll from wing to wing).

59. Roll

The aircraft design permits to perform snap and slow controlled rolls.

For training purposes a snap controlled roll is performed as follows. Bring the aircraft into a level flight at an indicated speed of 600 or 700 km/hr. Introduce a pitching with an angle of 10 or 15° and fly trying to preserve the position attained, then with a smooth movement of the control stick towards the side of rolling turn the aircraft around its longitudinal axis. The time needed for the snap roll is 4 or 5 sec.

To perform a snap roll at high speeds, the pitch angle is set within the limits of 20 - 30° (depending on the speed). In all other aspects the high-speed snap roll does not differ from the roll performed at 600 or 700 km/hr.

A slow controlled roll takes 10 or 12 sec. It is performed with a variable angle of attack (one part of the manoeuvre requires positive angles of attack, the other part of the manoeuvre - negative angles of attack), the pilot suffering overloads varying in sign.

To perform the slow roll, bring the aircraft from a level flight at an indicated speed of 600 or 700 km/hr to a pitch of 15 or 20°, keep it in the position and roll the aircraft around its longitudinal axis by a smooth deflection of control stick towards the side of rolling.

During the roll, coordinate the movement of the control stick and pedals to keep the aircraft nose from lowering.

The barrel rolls can be performed both in the horizontal and vertical planes at speeds of not below 400 km/hr (indicated speed).

Double (multi) rolls are two or more rolls performed one after another without intervals. The two (or multi) rolls may be either snap or slow horizontal ones. The entry speed in this case is not below 600 or even 700 km/hr.

The technique of performing a double (multi) roll is similar to single snap and slow controlled rolls.

60. Nesterov's Loop

Enter Nesterov's loop at altitudes not over 4000 - 5000 m. with the engine at the maximum rating or at altitudes of not over 6000 - 7000 m. with the engine at the augmented rating.

The entry indicated speed at the maximum rating must not be less than 900 km/hr.

The loop is performed as follows.

Gain the required speed and deflect the control stick backwards so as to ensure an overload value of 4.5 or 5.5 when the aircraft attains 30 or 40° of pitch. Without reducing the pull, keep the aircraft on the trajectory curve in the vertical plane.

The control stick backward movement is performed so as to keep the aircraft roll (angular speed) approximately constant and to ensure an indicated speed of not less than 350 km/hr (with an overload number of 1.5) by the moment the aircraft occupies a wheels-up position.

When in the loop, keep the aircraft from banking as this will lead the aircraft away from the vertical plane.

In the upper point of the loop, when the aircraft nose reaches the horizon, slowly reduce the engine r.p.m. up to the low speed rating, enter the dive and then level off as when performing similar actions in a banked turn.

The peculiarity of Nesterov's loop at the maximum rating is a great loss of speed in the upper point which requires an accurate coordinated movement of the aircraft controlled surfaces.

When the aircraft stick is excessively deflected, the aircraft displays buffeting and a wing-to-wing roll. A too slow movement of the control stick usually results in a loss of speed and aircraft "hovering". The overload is checked during the loop by the load factor indicator.

61. Oblique Loop

When the pilot creates a bank of 10 to 45° relative to the horizon prior to Nesterov's loop and then follows the loop preserving the preset bank, the aircraft will describe a closed curve in a plane oblique to the horizon.

The oblique loop is performed similarly to Nesterov's loop.

The main difficulty in performing the oblique loop is to preserve the preset banking when approaching or passing the upper point of the loop.

When in the wheels-up position, the pilot, whose conventional actions of the horizon-to-earth position become reversed, must determine and preserve the

aircraft banking relative to the constant horizontal. This means that with the aircraft in the upper point of the oblique loop and with the left-wing banking (provided left-wing banking has been chosen), the pilot must keep the left wing lowered and the right wing raised relative to the horizontal. Then, as soon as the aircraft enters a dive, the pilot must tread upon the pedal opposite to the bank to preserve the direction when levelling off.

As soon as the aircraft is levelled off, the pilot must eliminate the bank and set the pedals into the neutral position by gradually reducing the deflection angle.

During the second half of the oblique loop the aircraft must not roll around its longitudinal axis, especially towards the bank as this may result in a tight spin.

When performing oblique loops for the first time, never set a bank exceeding 20°.

Altitude and speed limits for the oblique loop do not differ from those established for Nesterov's loop.

62. Nesterov's Half-Loop

The first half of the manoeuvre is similar in its character and technique to the first half of Nesterov's loop.

The half-loop entry speed must not be less than 900 or 950 km/hr at an altitude not above 7000 m. with the engine maximum or augmented rating. When entering the half-loop at an altitude of 5000 m. (at the maximum rating) the aircraft climbs through a distance of 4000 m.

The speed of the aircraft in the wheels-up position in the upper point must be at least 370 km/hr. When passing the upper point, smoothly deflect the control stick towards the chosen side of the roll and perform a half-barrel by turning the aircraft through 180° around its longitudinal axis.

The movement of the controlled surfaces must ensure a complete half-barrel during a period of 3 or 4 sec.

Simultaneously with the control stick deflection towards the roll side, slightly release the control stick to move it a little bit forward when the aircraft completes a roll through 90° in order to increase the aircraft directional stability and to reduce the angle of attack (so as not to loose speed).

In case the aircraft speed in the upper point of the half-loop is less than 370 km/hr, convert the manoeuvre into Nesterov's full loop as small speed and large deflection angles of the controlled surfaces may lead to a spin.

63. Zoom

The zoom can be performed with the engine operating at the normal, maximum, or augmented rating at an entry speed not exceeding the maximum speed value at the given altitude and angles of ascent up to 80°.

The zoom ends in a turn following which the aircraft begins a level flight.

The speed in the beginning of levelling off must be not less than 450 - 500 km/hr at ascent angles within 60 - 80° or 400 - 450 km/hr at ascent angles less than 60°.

The climb during the zoom depends on the engine rating, entry speed, angle of ascent, and entry altitude.

64. Zooming Half-Turn

The half-turn in zooming is possible at any altitude within 4000 to 12,000 m. The speed of entry ranges from 800 km/hr to the maximum speed value of a level flight.

When performing a zooming half-turn for training purposes, start at altitudes within 5000 to 10,000 m. at a speed of 800 or 850 km/hr.

Only those pilots who have mastered the technique of flying this type aircraft can perform zooming half-turns at altitudes below 5000 m. or above 10,000 m. and entry speeds above 850 km/hr.

Prior to entering aerobatic manoeuvre with the engine control lever in the NORMAL position, accelerate the aircraft to gain the required speed and smoothly pull the control stick backward to introduce the angle of ascent the value of which fully depends on the excess of the aircraft speed. Thus, the angle of ascent introduced at a speed of 800 or 850 km/hr must be within 40 to 45°.

When the aircraft speed becomes equal to 500 or 450 km/hr in the upper point of the zoom (provided the entry speed is 850 km/hr), effect a smooth deflection of the controlled surfaces to roll the aircraft around its longitudinal axis through 180° (a half-barrel) and pull the control stick backwards until the aircraft is in the wheels-up position (at a speed of 400 km/hr).

Depending on the altitude the zooming half-turn may be ended either by a second half of the loop or by levelling off.

In case the zooming entry speed approximates the maximum value and the angle of ascent is within 60 - 80°, begin the 180°-roll at a speed of 600 or 560 km/hr and try to attain the wheels-up position in the upper point of the zooming half-turn (when the aircraft nose reaches the horizon) at a speed not less than 370 km/hr.

65. Spiral

The spiral with a bank of 45° can be performed at a speed of 300 - 350 km/hr with the engine operating at a low speed rating.

Prior to entering the spiral, begin a glide at a speed of 300 - 350 km/hr, and then bring the aircraft into the spiral by actuating the control stick and the pedals.

The speed in the spiral is changed by lowering or raising the aircraft nose, i.e. by changing the angle between the aircraft longitudinal axis and the horizon.

The technique of flying the aircraft in the spiral does not differ in its main features from the technique required to perform a banked turn. The loss in altitude constitutes 1500 or 1600 m. per one turn of the spiral provided the spiral has begun at the altitude of 5000 m.

The rounding-out is effected by actuating the control stick and the pedals accompanied by an increase in the engine r.p.m. at the beginning of a level flight.

The engine r.p.m. may be also increased during a glide after recovering from the spiral.

When accomplishing a steep spiral with the angle of more than 30° between the horizon and the aircraft longitudinal axis, first eliminate the bank and then level off the aircraft from the dive.

Perform the spiral with the L.G. and flaps extended at the increased r.p.m. of the engine, at the indicated speed of 450 km/hr and at the vertical descending speed component of not over 26 or 30 m/sec.

66. Spin

The aircraft stalls into a spin only in case the pilot makes serious mistakes in the flying technique or aims at spinning for some reason or other.

The lowest indicated speed at which the aircraft loses its stability with the engine at the low speed rating and with the L.G. and flaps retracted is 215 km/hr. A slight buffeting appears when the speed is still further reduced from a value of 280 km/hr (with the pedals in the neutral position). The buffeting increases but slightly as the speed is gradually reduced to the minimum value.

The effectiveness of the ailerons decreases considerably at the speed of 260 km/hr (indicated) and then becomes reduced to nought at speeds of 250 or 240 km/hr. The stabilizer and the rudder are effective enough to keep the aircraft in a level flight without a bank and to bring the aircraft to a glide with the purpose of increasing the speed. The balanced position of the control stick with the aircraft flying at the lowest speed is at the point which marks 2/3 of the control stick backward travel.

At the speed of 215 km/hr the aircraft drops to a wing which is accompanied by a nose-heavy condition. To restore the aircraft controllability and to reduce the angles of attack at this moment, release the control stick to shift it forward.

No difference is observed in the technique of the right and left spirals safe for the fact that the right spiral is characterized with a greater uneveness of rotation.

The aircraft is rather stable when running the first 1.5 turns of the spiral but the speed of rotation slows down in the end of the turn and the aircraft nose reaches 20 or 30° above the horizon.

Then the speed of rotation becomes still greater uneven. 1/4 or 2/4 of a turn later the aircraft stalls, rolls from wing to wing, but continues spinning towards the given leg.

The angle between the aircraft longitudinal axis and the horizon changes from 80° of dive to 20 or 30° of pitch. These changes are characteristic of the aircraft only as compared to the performance of other type aircraft in the spin.

The efforts applied to the pedals vary in the process of the spin. A considerable buffeting accompanies the aircraft rotation and, especially, stalling.

In case the pilot fails to keep the aircraft from entering the spin, the pilot must shift the engine control lever to the low speed position, deflect the pedal along the spin, and pull the control stick all the way backward (with the ailerons in the neutral position). Then he must run the aircraft through a turn and then energetically push the pedals against the spin; 0.5 or 1 sec. later the pilot must push the control stick forward beyond the equilibrium position.

When the pedals are deflected, the aircraft slows down its rotation and recovers from the spin as soon as the control stick is pushed forward (the recovering period must last not more than one turn).

To round off from the spin when the aircraft stalls in its rotation, it is sufficient to set the pedals neutral and to push the control stick forward. The aircraft will recover from the spin immediately.

VII. SERVICE INSTRUCTIONS ON KKO-3 OXYGEN EQUIPMENT AND PRESSURIZED COCKPIT

67. Pressurized Cockpit

Irrespective of the altitude all flights must be performed with the cockpit pressurized and the air feed system operating. The cockpit is pressurized by setting the pressurization cock on the left side of the cockpit to the front neutral position.

The cockpit air supply line is set into operation by shifting the handle of the cockpit air feed cock on the right control panel in the front extreme position. In flights the switch COCKPIT HEATING (ОБОГРЕВ КАБИНЫ) must be in the position AUTOMATIC (АВТОМАТ).

If the cockpit glazing dims during the flight, set the COCKPIT HEATING switch to the HOT (ГОРЯЧИЙ) position. In case the dimming persists, increase the flight speed for a short time.

The cockpit is depressurized on the ground when the aircraft reaches its parking place. This is performed automatically by opening the canopy as the canopy opening handle is interlocked with the cockpit air feed cock. Besides, the cockpit can be depressurized by moving the air feed cock handle to the extreme rear position (with the canopy closed).

The aircraft oxygen equipment must be necessarily operative and the KD-27 parachute breathing apparatus present and connected during the flight.

It is permissible for the pilot to fly the aircraft at altitudes up to 7000 m. and at speeds not over 750 km/hr (indicated speed) in the KM-3ОМ mask and the ШИК-1М anti-g suit, the usage of the ВКК-3М high-altitude pressure suit and ГШ-4М pressurized helmet being unnecessary in this case. The hose of the РСД pressure regulator feeding oxygen to the pressure suit must be plugged.

Flights up to the altitude of 15,000 m. at speeds of up to 750 km/hr can be performed with the employment of the КМ-3ОМ mask together with the ВКК-3М pressure suit.

Flights at altitudes above 15,000 m. or at speeds exceeding 750 km/hr (irrespective of the altitude in the last case), and also when fulfilling combat tasks, are permissible only with the high-altitude pressure suit and pressurized helmet on.

CAUTION: Prior to a flight in the ВКК-3М pressure suit lock the head of the АД-5А automatic unit overload regulator in the MINIMUM (МИНИМУМ) position.

68. Checking High-Altitude Pressure Suit and Oxygen Equipment When Preparing for Flight

Prior to putting on the pressure suit (previously adjusted to the pilot's size), check the suit fabric, seams, covers and tapes of the tightening device for intactness and the suit zippers for proper condition. Besides, make sure the suit shows no frayed places, torn or untied laces.

Examine the pressurized helmet and the oxygen mask paying attention to the following:

- intactness and proper condition of hoses, inhaling and exhaling valves, body, rubber gaskets of the hose bayonet joints;
- intactness of the helmet transparent face-piece;
- intactness of heater conductors, communication wires and plug connectors;
- tightness of the mask inhaling valve;
- tightness of the mask exhaling valve. For this purpose, through a bayonet joint connect the mask exhaling valve to the hose running to the mask-to-face tightening device. Then press the mask tightly to the face and make a deep exhale. If the exhale is obstructed, the exhaling valve is airtight.

Check the tightness of the mask-to-face tightening device. For this purpose blow into the tightening device hose through the mouth, clamp the hose with fingers and check whether the device is intact and allows no leakage.

Check whether the KII-27 parachute oxygen breathing apparatus is properly arranged in the parachute bag pocket and properly charged, and whether the connection mechanism safety pin locking is in a proper condition. The pressure in the breathing apparatus is checked by the pressure gauge through a glass-protected port. The pressure of oxygen at temperatures from -5°C to +20°C must be 150 kg/sq.cm. The breathing apparatus is inserted into the bag pocket with the switch forward and with the connection mechanism (hose connected to the OPT-2 connector) on the left side.

After putting on the suit make sure it is properly fitted. With no pressure in the tightening devices, the suit tightly fits the body without causing unpleasant sensations or hindering the pilot's movements. If the suit is excessively loose, ask the doctor on duty to tighten the respective laces.

Check the suit tightening device for leakage by connecting the suit to the KV-6 oxygen installation or KIIT apparatus and creating a pressure gradually rising to 1 kg/sq.cm. (the checking is conducted by the doctor on duty or by a technician in charge). During the check go over all seams, laces, zippers to see they are in a proper condition, see also that the pressure exerted by the suit upon the body is uniform.

Before flights in the pressurized helmet, check whether the helmet is airtight (with the help of the KIIT device) and is properly fitted.

Note: The selection and fitting of the pressure suit, headset, pressurized helmet and the oxygen mask with the mask-to-face tightening device are carried out by the doctor in accordance with Instructions on employment of oxygen breathing equipment.

69. Checking KKO-3 Oxygen Equipment before Flight

On taking seat in the cockpit, open smoothly the oxygen apparatus valve to check its opening. Check the oxygen pressure in the system by reading off the pressure gauge of the MK-18 indicator. The system pressure must be equal to 150 kg/sq.cm. (at the ambient air temperature of +15°C).

Check heating of the pressurized helmet transparent face-piece (by the sensation of heating). In case the transparent face-piece dims, it is allowable to eliminate dimming by pressing the button HELMET ACCELERATED HEATING (БЫСТРЫЙ ОБОГРЕВ ТЕРМОШЛЕМА) for 1 or 2 min.

Check position of the oxygen apparatus knob and handles on the KV-2 control panel. The excessive pressure knob must be turned all the way clockwise, the air feed handle must rest in the position MIXTURE (СМЕСЬ), while the handle controlling the oxygen feed to the pressure suit must be in NEUTRAL (N) position.

Check the oxygen equipment as follows:

(a) at excessive pressure:

- fix the helmet transparent face-piece or the oxygen mask in the operating position;
- open the suit oxygen supply line by setting the handle on the KV-2 control panel in the SUIT ON (ВКЛЮЧЕНИЕ КОСТЮМА) position;
- by fingers close the openings in the PKA-5 pressure regulator body;
- by slowly turning the excessive pressure knob counter-clockwise create a pressure corresponding to 2000 mm or 1000 mm of water in the helmet or in the mask. Watch the pressure rise on the scale of the M-2000 pressure gauge.

The oxygen equipment operation is considered normal if the suit increases its pressure upon the body with a pressure rise in the mask and helmet and the M-2000 pressure gauge displays a pressure drop during an inhale and a pressure rise during an exhale.

After the check:

- set the suit oxygen feed handle in the neutral (N) position;
- turn the excessive pressure knob all the way clockwise.

CAUTIONS: 1. The flight must be postponed if the oxygen equipment is found faulty, i.e. a fully open knob does not create pressure of 2000 mm (for the helmet and of 1000 mm of water for the mask), due to some leakage in the system or other defects.

2. Never build up pressure in the helmet or mask if the pressure suit is not put on or shows no pressure as this may injure the lungs (under normal conditions the pressure in the suit builds up 1 or 2 sec. earlier than in the helmet or mask).

(b) without excessive pressure:

- inhale and exhale several times with the air feed control handle on the KV-2 control panel set in turn to positions MIXTURE and 100% O_2. The equipment operation is considered normal if the flags of the MK-18 indicator follow every inhale and exhale.

Note: The indicating flags may remain motionless when using oxygen at altitudes from 0 to 2000 m. with the air feed control handle in the position MIXTURE.

70. Operation of Oxygen Equipment in Flight

Put on the mask or fit the transparent face-piece of the pressurized helmet when on the ground, prior to taxiing to the take-off line.

In flight check the oxygen consumption by the MK-18 indicator pressure gauge and operation of the KII-34 oxygen regulator by the indications of the MK-18 indicator. The indicating flags must rise apart at each inhale and fall down together at each exhale.

If the oxygen pressure in the system drops to 30 kg/sq.cm. and below, lower to a safe altitude (4000 m.).

When flying in the pressurized helmet, see that the transparent face-piece of the helmet is properly heated. As soon as the transparent face-piece displays dimming, turn clockwise the handle of the PKO-45 heater rheostat on the cabin left side. As soon as dimming is eliminated, turn the handle back until the index of the handle is in a position corresponding to the scale indications.

In case the helmet transparent face-piece heater rheostat fails (the transparent face-piece remains dimmed), periodically use the HELMET RAPID HEATING button on the cockpit left side by pressing it for 1 or 2 min. and lower to a safe altitude (4000 m.)

If it is difficult to breathe due to a great resistance to breathing or due to the pilot's poor state, a continuous (emergency) oxygen supply line must be connected by setting the suit oxygen supply handle on the KV-2 control panel (left-hand control panel) from the neutral (H) position to the SUIT ON position. This will inflate the suit bladders and will send oxygen into the pressurized helmet and the mask in a continuous stream.

As soon as the cockpit becomes depressurized (cockpit altitude being 11,000 and 13,000 m. or even more as shown by the cockpit altitude and differential pressure indicator), the aircraft system builds up pressure in the pressure suit 1 or 2 sec. later and, one more second later, in the mask or in the pressurized helmet. From this moment on the pilot is supplied with oxygen under a pressure depending on the cabin "altitude":the higher is the altitude, the more is the pressure in the mask (pressurized helmet) and BKK pressure suit. The pressure under the mask is checked in this case by the scale of the M-2000 pressure gauge.

A longer flight in a depressurized cockpit may be performed only at altitudes not exceeding 12,000 m., the time of the flight depending fully on the amount of oxygen contained in the aircraft system.

To save oxygen during a long-time flight in a depressurized cabin at an altitude of 12,000 m. or below, disconnect manually the continuous oxygen supply line by setting the suit oxygen supply handle on the KV-2 control panel from the neutral position to the AUTO-OFF (ВЫКЛ.АВТОМАТ) as this line can be automatically disconnected only at altitudes from 8000 to 10,000 m.

If a rise in the flight altitude (and cockpit "altitude") above 12,000 m. is still necessitated, set the suit oxygen supply handle to the neutral position before effecting the rise.

When flying in the zone of atomic radiation, use only pure oxygen, for which purpose set the handle on the KV-2 control panel to the 100% O_2 position before entering the zone.

When having the oxygen mask on, make it fit more tightly to the face to exclude the radioactive dust from the breathing organs.

As soon as the cockpit altitude in the end of the flight drops to 4000 m. remove the oxygen mask or the transparent face-piece of the pressurized helmet.

VIII. FLYING AIRCRAFT UNDER DIFFICULT METEOROLOGICAL CONDITIONS, LANDING APPROACH AND LANDING WITH EMPLOYMENT OF INSTRUMENT LANDING SYSTEMS

Landing approach and landing by using instruments and instrument landing systems may be performed as a straight-in landing with two 180°-turns or a rectangular pattern landing.

71. Prior to Flight

Prior to beginning a flight under difficult meteorological conditions, make sure the AGB-1 artificial horizon, GYD-55 turn indicator, gyro induction compass, APK-10 direction finder, PRV low range radio altimeter, and flight control instruments operate normally.

Never forget to cut in the circuit breaker ARTIFICIAL HORIZON (АГД) on the right electric panel 3 or 4 min. before the take-off, to preclude flights with the artificial horizon inoperative.

Cut in the circuit breakers AIR SPEED TUBE-CLOCK (ПВД-ЧАСЫ) and EMERG.AIR SPEED TUBE (АВАР.ПВД) and give the command for the technician specialized in instruments to check operation of the heaters (by touch). The check over, cut out the circuit breakers.

Prior to starting the engines set the course setting pointer of the ZKA-2 course indicator to the landing heading position and cut in the KCH compass circuit breaker on the right-hand electric panel.

When still at parking, prior to taxiing, or when on the runway, prior to the take-off, depress the synchronizing button until the ZKA-2 course indicator and magnetic course indications become synchronized, i.e. until the magnetic course scale stops rotating.

After starting the engine check operation of the flight control instruments, radio communication, radio technical and radar equipment.

Prior to the take-off, cut in the heaters of the air speed tube and emergency air speed tube, check the APK-10 direction finder indications (its radio station relative bearing must be equal to 180°), indications of the course setting unit (its pointer must rest against 0° - landing heading), and press the time counter button on the clock.

72. Climbing through Overcast and Level Flight towards Distant Homing Radio Station

After the take-off, retract the landing gear, check whether artificial horizon indications correspond to the true position of the aircraft in relation to the natural horizon, and then begin the climb.

A training climb must be performed with the engine operating at the normal or maximum ratings and the TAS smaller pointer at 900 or 950 km/hr all the time while climbing through clouds. A trained pilot may employ the augmented rating (if found necessary) during the climb.

When gaining altitude pay particular attention to preserving the aircraft lateral stability (by the indications of the artificial horizon), longitudinal stability (by the TAS values) and directional stability (by the indications of the gyro induction compass, type KCH).

Regularly check correctness of the artificial horizon indications by comparing them with those of the turn-and-slip indicator, rate-of-climb indicator and compass to detect possible errors in the indications in due time.

In case the KCH gyro induction compass fails, the flight may be performed by the indications of the artificial horizon constantly checked against indications of the turn-and-slip indicator. If the AGB-1 artificial horizon fails, check the flight by the indications of the turn-and-slip indicator in combination with those of other flight control instruments.

The flight conducted against the turn-and-slip indicator readings (without the artificial horizon) requires higher attention and skill on the part of the pilot.

On finding the radio set, direction finder, flow meter, and transponder

simultaneously inoperative (which is due to the failure of the inverter feeding all these consumers), switch in the emergency supply circuit by cutting in the circuit breaker EMERGENCY INVERTER (АВАРИЙНЫЙ ПРЕОБРАЗОВАТЕЛЬ) on the right electric panel.

Notes: 1. Bear in mind this action will cut off the sight and the radar ranging unit.

2. The radio set will become serviceable again after its valves get warmed during 1 or 1.5 min.

As soon as the radar ranging unit is found no longer needed, set the sight switch bearing the inscription RADAR – OPTICS (РАДИО-ОПТИКА) in the position OPTICS to exclude its influence upon the APK-10 direction finder when flying towards the distant homing radio station during the instrumental landing, and to avoid the enemy detection.

To exclude errors in indications of the КСИ gyro induction compass after flight unstable conditions, synchronize the КСИ gyro induction compass indications prior to approaching for the instrumental landing by pressing the synchronizing push-button after 40 sec. of a straight level flight at a constant speed.

After the required altitude (in the clouds or above the clouds) is gained, set the aircraft in a level flight (by using ILS indications), keep the indicated speed at 300 km/hr, turn towards the distant homing radio station checking the aircraft position after the turn and the direction of the further flight by indications of the КСИ gyro induction compass and by sending transponder requests.

After the distant homing radio station is left behind, perform manoeuvres to enter the landing heading.

IX. NIGHT FLIGHTS

73. Prior to Flight

Check the lighting equipment of the aircraft:

- set in the circuit breaker aircraft LIGHTS, L.G. SIGNAL LIGHT (ФАРЫ, СИГНАЛИЗАЦИЯ ВЫПУСКА ШАССИ) located on the front right-hand electric panel;
- switch in the circuit breaker SIGNAL LAMPS OF GENERATOR, TURN INDICATOR, COCKPIT LIGHTING, OIL PRESSURE (СИГНАЛИЗАЦИЯ ГЕНЕРАТОРА, ВУП, КЛС, ДАВЛЕНИЕ МАСЛА) on the left electric panel;
- adjust cockpit lighting by employing the КЛСРВ-45 rheostat;
- by using the РЗФО-45 rheostat light up the ЗФО ultra-violet lamps, adjust their light filters and set the lamp fittings in the working position;
- switch on navigational lights, set the switch to one of the required positions;
- set the aircraft lights switch to the TAXIING LIGHT (РУЛЕНИЯ) position to make sure the taxiing light functions properly and is correctly adjusted. Then set the switch to the LANDING LIGHT (ПОСАДКА) position to see that the landing light is in a proper condition and sends a light beam in the required direction. After this set the switch in the RETRACT (УБОРКА) position;
- cut in the circuit breakers SIGHT HEATER (ОБОГРЕВ ПРИЦЕЛА) and SIGHT (ПРИЦЕЛ) arranged on the front right-hand electric panel and adjust the required brightness of the sight reticle, after which cut out the circuit breakers;
- fix the shutters of the T-4 and T-6 warning light panels and of the flight control signalling unit in the position convenient for the night flight;
- close the shutters of the pilot lamps;
- check position of the instrument panel shutter intended to remove light patches and instrument reflections from the canopy glass panels;
- adjust the lighting of the direction finder control panel scale with the help of the SCALE LIGHT (ПОДСВЕТ) knob.

Note: Prior to taking seat in the cabin, make sure all the circuit breakers arranged on the rear right-hand electric panel are cut in.

No peculiarities are observed in starting the engine and in taxiing the aircraft at night.

The take-off at night and in the day time is performed following the same technique. The take-off direction is checked against the lights of the runway. After the take-off level off the aircraft gradually increasing the speed and altitude, retract the landing gear and then begin climbing.

In a moon-lit night the flying technique does not differ from that of flying the aircraft in the day time. In case the natural horizon is invisible, fly the aircraft according to the indications of the flight control instruments.

The 3rd turn in the landing approach must be performed somewhat farther than in day time. The final turn must be finished at an altitude of 250 or 300 m.

The landing on a light-flooded runway presents no special difficulties, its technique is similar to that of landing in the day time.

The aircraft is equipped with a landing light which allows to land without ground light facilities. When landing without ground lights:

- do not reduce the engine r.p.m. to values below 60 or 70% until the levelling-off altitude is reached. When the altitude of levelling off is reached, gradually pull the engine control lever all the way backward.

The landing with the landing light (without ground lights) is more difficult and requires higher attention and skill on the part of the pilot. After the landing run is over, set the switch into the TAXIING LIGHT position and taxi the aircraft to the parking place.

74. Landing Lamp Employment during Night Flights

During the landing approach:

Set the LANDING LAMP, LANDING, TAXIING, RETRACTION (ФАРЫ, ПОСАДКА, РУЛЕНИЯ, УБОРКА) switch to the LANDING (ПОСАДКА) position over the inner homing radar at altitudes of 110 to 120 metres. In this event, the beam axis of the starboard landing light will face forward covering 50 – 60 m. area at an altitude of 30 metres. It will be directed some 11° off the fore-and-aft axis leftwards, i.e. following the direction of the pilot's eyes. The left landing lamp is in this instance directed to infinity. After landing and upon extension of the nose wheel, the beam of the starboard landing lamp will slant under the aircraft, while the beam of the port side one will illuminate the forward hemisphere some 50 – 60 metres ahead of the aircraft instead of the starboard landing light.

At the end of the run:

- set the landing lamp switch to TAXIING (РУЛЕНИЯ) position so that the left landing lamp should illuminate the taxiway.

After taxiing to the parking place:

- cut out the taxiing lamp by setting the switch to the RETRACTION (УБОРКА) position.

X. FIRING IN FLIGHT

75. Armament Control on Ground and in Air

Prior to the flight cut in the circuit breakers arranged under the glass cover on the aircraft starboard: EMERGENCY RELEASE, ROCKET FIRE, DROP TANK

(АВАРИЙНЫЙ СБРОС, РС, СБРОС БАКА), GUN, ROCKET PODS, CAMERA GUN (ПУШКА, РС,ФКП), DROP TANK, ROCKET PODS (БАК,РС), ARMED - SAFE (ВЗРЫВ - НЕВЗРЫВ).

Note: On the ground the gun is loaded so that it requires only one charging (which is performed by the pilot in the air)to load the guns finally for firing.

10 or 15 min. before the actual firing prepare the sight and radar ranging unit for firing by cutting in the circuit breakers SIGHT (ПРИЦЕЛ), SIGHT HEATER (ОБОГРЕВ ПРИЦЕЛА), RADAR RANGING UNIT (РАДИОДАЛЬНОМЕР). If a possibility exists to employ the sight and the radar ranging unit immediately on taking-off, cut in the above circuit breakers on the ground, after starting the engine.

76. Prior to Employing Sight

- change over the sight to the GYRO (ГИРО)position;
- set the switch on the sight control panel to the RADIO (РАДИО) position and check whether the HIGH VOLTAGE (ВЫСОКОЕ НАПРЯЖЕНИЕ) lamp lights up;
- check the sight for proper functioning by performing small turns; the moving reticle must deflect to the side opposite to the turn;
- adjust the brightness of the reticle.

The gun fire is effected by actuating the fire control push-button on the control stick.

To fire the gun:

- cut in the circuit breaker GUN (ПУШКА);
- reload the gun by depressing the reloading push-button for 2 sec.;
- check whether the gun is ready for firing by the light of the red lamp in the lower part of the instrument panel;
- check whether the sight selector switch is in the НР-30 position;
- swing off the trigger guard;
- aim at the target;
- press upon the trigger guard (the fire will be automatically controlled by the camera in case the CAMERA GUN circuit breaker is cut in).

77. To fire Rockets Suspended in Rocket Pods

- set the sight selector switch to the ROCKET POD (РС) position;
- cut in the ROCKET POD (РС) circuit breaker and check the ROCKET POD ZERO (НУЛЕВОЕ ПОЛОЖЕНИЕ РС) by the light of the starboard signal lamps.

Depending on the task set the required rate of firing by actuating the switch AUTOMATIC SALVO (АВТОМАТ-ЗАЛП):

- set the required angle of elevation (depending on the altitude);
- swing the trigger guard forward;
- catch the target;
- press upon the trigger guard (the fire will be controlled by the camera in case the CAMERA CONTROLLER circuit breaker is cut in).

To preclude engine stalls, fire the gun at TAS of not less than 680 km/hr.

When 2 rocket pods of УБ-16-57 type are suspended, never exceed the speed of 1000 km/hr (indicated speed) and the value of the M number equal to 1.8. Permissible load factor must not exceed Пе6.

To use the camera gun without firing:

- make sure the circuit breakers GUNS and ROCKET PODS are off, while the ФКП.

CAMERA GUN circuit breaker is on:

- set the sight selector switch to the НР-30 or ROCKET POD (РС) position;
- swing the trigger guard forward;
- aim at the target;
- press upon the trigger guard.

Note: It is forbidden to use the camera gun after the gun or rocket pod fire.

The fire over. reload the guns, swing back the trigger guard, set the sight to the FIXED (НЕПОД) position, cut out the circuit breakers GUN (ПУШКА), RADAR RANGING UNIT (РАДИОДАЛЬНОМЕР), SIGHT (ПРИЦЕЛ), SIGHT HEATER (ОБОГРЕВ ПРИЦЕЛА), ROCKET POD (РС) and CAMERA GUN (ФКП).

During sighting and firing bear in mind the following:

- use the damping push-button to reduce the time required to set the angle of lead when aiming with the aircraft running up the target;
- prior to manoeuvring the aircraft to assume the attack position, set the outer base ranging unit to a range of 2000 m.;
- to ensure a proper follow-up of the angle of lead, keep the sight reticle centre upon the target centre for 3 or 5 sec. prior to firing.

Note: Slight deflections of the sight reticle relative to the target centre with an amplitude of 2 or 3 diameters of the central point are permissible and require no further correction in aiming. Attempts at correcting the accuracy of aiming any lead to a negative result: increased error in aiming due to the aircraft wing-to-wing roll.

- the plane-to-target distance during aiming is afforded by the range indicator (the accuracy is ±100 or 150 m.);
- aiming with the radar ranging unit employed and the СРД altitude unit switched on (search distance limited) must be conducted at altitudes not lower than 1000 - 1300 m;
- in case the radar ranging unit fails (the TARGET LOCKED ON (ЗАХВАТ) lamp remains dead and the pointer of the range indicator on the sight head is motionless), set the target base and manually introduce the range value as indicated by the outer base range finder;
- the radar ranging unit cannot be employed for aiming at ground targets, therefore the range values in this case must be introduced manually with the help of the outer base range finder;
- when the automatic system of the sight fails (at turns the reticle remains immovable), set the sight switch to the FIXED position and use the fixed reticle for aiming.

78. To effect the dropping of the rocket pods together with the rocket pod carrier, swing off the EMERGENCY BOMB RELEASE, ROCKET PODS safety cap and press the push-button (two green lamps must go out).

To drop signal flares, turn on the signal flare switch and press upon the push-button of the needed colour.

XI. ROCKET EQUIPMENT CARRIED ABOARD AIRCRAFT МиГ-21Ф-13

79. General Information

The rocket equipment system carried aboard the aircraft and designated К-13 is intended to hit air targets under the contact flight conditions.

The equipment is used:

- at speeds of 0.8 Mach to the maximum value;
- at altitudes of 500 m. to the upper limit;
- at ranges of aimed fire of 1 to 3.5 km.;
- target aspect angle of 0 to 3/4.

The employment of the equipment carried aboard the aircraft МиГ-21Ф-13 is limited at altitudes exceeding 15,000 m. due to hampered visual detection of the target and sighting.

The rocket equipment of the aircraft МиГ-21Ф-13 includes:

(a) optical sight АСП-5НД;

(b) aircraft distance-measuring equipment СРД ensuring the target lock-on at distances up to 9 km.;

(c) rocket permissible launching range computer ВРД-2А;

(d) aircraft overload transmitter МП-28А operating, in conjunction with altitude warning unit ВС-14500;

(e) two starting units АПУ-13у;

(f) two self-homing rockets К-13.

Note: The К-13 type rockets are used with the equipment only temporarily. Later, rockets К-13А having increased period of powered flight (up to 21 seconds) and, hence, increased firing range will be used.

80. Description of Rocket К-13

The К-13 rocket is divided into four compartments:

- control compartment with heat homer (ТГС) and rudder compartment accommodating two pairs of rudders and solid-reactant gas generator (ПАД);
- warhead intended to produce blast effect;
- proximity optical fuse;
- solid-propellant engine.

The housing of the rocket is 2837-mm long cylinder having 127-mm diameter. Attached to the housing are four control surfaces - wings with rollerons (deflecting surfaces which stabilize the rocket in flight obviating the roll effect and employ the principle of gyro) attached to the wing edges. The rocket has a streamlined shape and weighs 76 kg.

The control compartment serves to home the rocket on the target after the launch with the necessary degree of precision affording the functioning of the fuse.

While sighting, the optical axis of the heat homer keeps aligned with the sight axis (accurate within 0.9°). When no target is seen within the field of vision of the heat homer, the pilot hears weak noises caused by the heat homer as an indication of its normal operation.

As the target located at a distance of 8 - 10 km. (depending on the type of the target and the rating of its engines) comes within the field of vision of the heat homer, the latter sends an aural signal (characteristic rumble) to the pilot's headset. The aural signal indicates that the heat homer has locked on the target.

Solid-reactant gas generator is intended for generating power necessary for driving the rudders and charging the supply unit of the control compartment. The powered flight of the rocket lasts as long as 11 seconds, the time the solid-reactant gas generator is functioning.

Proximity optical fuse ensures explosion of the warhead as the rocket flies by the target not more than 11 metres off it, and the destruction of the rocket some 17 - 20 seconds after launching if it fails to hit the target. The fuse is armed (ready for functioning) 0.1 - 0.8 seconds after the solid-propellant engine of the rocket has stopped. In this instance, the rocket has already covered at least 0.5-km. range from the carrier aircraft.

Solid-propellant engine is used to accelerate the rocket to the necessary speed. The time of the engine operation is within 2 - 3.5 seconds. During this time the rocket succeeds to acquire some additional speed of 2000 km/hr relative to the carrier aircraft.

After the engine has stopped, the rocket flies on by the inertia decelerating and continuing to home on the target.

81. Employment of Rocket К-13

Homing rocket К-13 is effective against the targets having caloric radiation when launched from the side of the rear hemisphere at aspect angles up to 3/4.

The maximum permissible launching range depends upon the altitude and speed of the aircraft and upon the closing rate. The greater are the altitude and closing rate the greater is the maximum launching range. Thus, when firing at TAS of 1000 km/hr without exceeding the target speed (firing done at equalized speeds), the maximum permissible launching range is 1.5 km. at altitudes of 2000 - 3000 metres, and 3.5 km. at altitude of 12,000 metres. 320-km/hr closing rate increases the maximum computed range of launching by another 1 km.

Note: When rockets К-13 having solid-reactant gas generator (ПАД) with 11- sec. operating time are launched from aircraft equipped with computers ВРД-2А, the maximum launching range must not exceed 3.9 km., as computers ВРД-2А solve the problems of computing the launching range for rockets К-13А having solid-reactant gas generators with 21-sec. operation time and hence greater range of the launching. In this event, the maximum range of launching must be controlled by means of the range indicator of radar ranging unit УД-1.

Minimum launching range covering 1 km. is ensured by reliably arming the fuse.

The rocket is provided with heat-seeking guidance system, therefore the carrier aircraft is free to perform any manoeuvre upon launching of the rocket.

When sighting, it should be borne in mind that the heat homer sends an aural (buzzing) signal to the pilot's headset if it is directed toward the sun, sunlit clouds, contrails, and the like.

The rockets may be launched at targets flying above and below the aircraft at aspect angles up to 2/4 in the vertical plane from the permissible ranges if the pilot has a visual control of the target seen against the background of the clouds or earth.

The target contrail in no way hampers the homing of the rocket.

The launching becomes impossible if a cloud stands between the fighter and the target and if the sun is seen at bearing angles of 20 - 30°. When attacking the target toward the sun under angles of 40 - 90°, the aural signal is difficult to hear as the heat homer loudly "buzzes" in the sun.

It is prohibited to launch the rockets if the load factor of the carrier aircraft exceeds 2 at altitudes within 0 to 14,500 metres, or 1.6 at altitudes exceeding 14,500 metres as the rocket is liable to correct the initial error thus failing to hit the target.

The rocket is normally homed on the target if the initial rules of launching are observed, i.e. if:

- the pilot has superimposed the central point of the sight reticle upon the target and separate the maximum level of the aural signal sent out by the heat homer;
- the red overload warning lamp is out thus allowing the pilot to launch the rockets;
- the green permissible range lamp is on and the distance to the target does not exceed 3.5 km.

Note: When the rockets are launched from the aircraft in level flight at altitudes below 1000 metres, it is PROHIBITED to make use of the indications of the distance measuring equipment and the computed permissible range lamp due to the effects of the ground. In such cases, the rocket may be launched for 1 - 1.3 km. range to be determined usually.

The surface of the ground affects the indications of the distance measuring equipment when the rockets are launched at altitudes below 2500 metres from aircraft diving through 30° angles.

82. Air and Ground Control of Rockets K-13

Rocket Control Equipment Installed in Cabin of MiG-21Q-13 Aircraft

(a) The left console of the aircraft cabin mounts:

LOCK-ON SIGNAL (СИГН.ЗАХВ.) rheostat serving as a volume control of the aural signal sent out by the heat homer to the pilot's headset;

- ROCKET POD - CANNON - HOMING ROCKETS (РС, ПУШКА-СС) mode-of-operation selector for distance measuring equipment and firing circuits;
- HOMING ROCKET LAUNCHING - LEFT - RIGHT (ПУСК СС-ЛЕВ.-ПРАВЫЙ) selector for individual launching of the rockets and individual monitoring of the aural signals sent out by their homers;
- HOMING ROCKET LAUNCHING - SALVO - SINGLE (ПУСК СС-ЗАЛП-ОДИНОЧНО) selector. When the selector is set at SALVO (ЗАЛП), two rockets are launched upon pressing the firing button (in this instance, the position of the ROCKET LAUNCHING - LEFT - RIGHT selector is immaterial; it is used for monitoring the aural signals only);
- ONE SALVO - TWO SALVOES - AUTOMATIC (РС I ЗАЛП-2ЗАЛП-АВТОМАТ) rocket group selector.

(b) The upper left portion of the instrument panel carries:

- EMERGENCY RELEASE OF ROCKETS, ROCKET PODS (АВАР.СБРОС РС,АПУ) button serves for emergency release of both rocket pods АПУ-13У together with the rockets or without the rockets if they have already been launched;
- TANK JETTISON (АВАР.СБРОС БАКА) switch;
- STARBOARD CANNON RELOADING (ПЕРЕЗАРЯДКА ПРАВАЯ) button.

(c) Mounted on the left portion of the bracket of sight АСП-5НД are:

- range indicator of distance measuring equipment ДД-1 with 0 to 8 km. scale showing the present range-to-target data determined by the distance measuring equipment at the moment of launching;
- CONTACT BROKEN (ВЫХОД ИЗ АТАКИ) red warning lamp showing that the aircraft stands at a break-away starting distance from the target (1 km.);
- OVERLOAD (СИГНАЛ ПЕРЕГР.) red warning lamp goes on under overload conditions when the rocket cannot be launched;

- PERMISSIBLE RANGE (РАЗРЕШЕННАЯ ДАЛЬНОСТЬ) green warning lamp showing that the aircraft is the permissible range off the target (the signal being sent out by computer ВРД-2А);
- sight range indicator with 0 - 2000 m. scale showing the present range data to the target as determined by the optical range finder or distance measuring equipment when firing shells or launching rockets;
- selector marked Б-С intended for switching over the sight and firing circuits to the rockets;
- selector marked РС-НР-30 (ROCKETS - CANNON НР-30) and intended for switching over the sight and firing circuits to the rockets or cannon;
- selector marked Н-ДУАС and intended to connect the altitude transmitter or attack and slip angle transmitters to the sight.

(d) Mounted in the right portion of the bracket of sight АСП-5НД are:

- OPTICAL - RADIO (ОПТИКА-РАДИО) selector used for supplying the data to the sight either from the optical range finder or from the distance measuring equipment;
- HIGH VOLTAGE (ВЫСОКОЕ) green warning lamp indicating the readiness of the distance measuring equipment for operation.

(e) Arranged in the right upward portion of the instrument panel are:

- two green warning lamps labelled HOMING ROCKETS SUSPENDED (ПОДВЕШЕНЫ СС) and LEFT-RIGHT (ЛЕВ.-ПРАВ) serves to show that the rockets are available in launchers АПУ-13У . As soon as the rockets clear the launchers the lamps go out;
- EMERGENCY LAUNCHING OF HOMING ROCKETS (АВАР. ПУСК СС) button for supplying voltage to the glow plugs of the solid-propellant rocket engines of both rockets in case of emergency launching.

(f) The middle board under the instrument panel carries:

- ROCKET POD SUSPENDED (ПОДВЕСКА АПУ) green warning lamps (two lamps) showing that rocket pods are suspended from the underwing beam carriers. The lamps go out upon the emergency launching;
- CANNON (ПУШКА) red indicating lamp lighting up to show that the cannon is ready for firing;
- FUEL TANK SUSPENDED (ПОДВЕСКА БАКА) green indicating lamp showing that the fuel tank is suspended.

(g) The right console in the cabin is provided with:

- two green warning lamps marked ZERO POSITION - ROCKETS - LEFT - RIGHT (НУЛЕВ. ПОЛОЖ. РС,ЛЕВ. ПРАВ.) and showing that the rocket launcher controls are brought to the original position.

(h) Arranged in the upper row of the front board of the right console in the cabin is:

- COMPUTER CONVERTER circuit breaker supplying voltage to converter ПТ-125Ц that supplies power to computer ВРД-2А.

The second row of controls (left to right) includes:

- SIGHT (ПРИЦЕЛ) circuit breaker;
- SIGHT HEATER (ОБОГРЕВ ПРИЦЕЛА) circuit breaker;
- DISTANCE MEASURING EQUIPMENT (РАДИОДАЛЬНОМЕР) circuit breaker. It applies the voltage to inverter НО-750А supplying power to the ДИД and to the control panel;
- INFRA-RED SIGHT (ОКБ-52) circuit breaker;
- ROCKETS (РС) circuit breaker;

- CANNON (ПУШКА) circuit breaker;
- CAMERA GUN (ФКП) circuit breaker;
- HOMING ROCKET HEATER (ОБОГРЕВ СС) circuit breaker. It supplies the voltage to the heaters of the solid-reactant gas generator;
- HOMING ROCKET FILAMENT (НАКАЛ СС) circuit breaker. When switched on, it supplies voltage to the heat homer and the homer gyro rotor starts spinning. 2 - 3 minutes later, the heat homer is ready for operation;
- HOMING ROCKET LAUNCHING (ПУСК СС) circuit breaker. It feeds the current to the rocket launching circuits.

(i) The rear board of the right console in the cabin counts:

- EMERGENCY RELEASE OF ROCKETS, FUEL TANK, ROCKET POD, HOMING ROCKETS (АВАР. СБРОС РС, БАКА,АПУ, АВАР. ПУСК СС) circuit breaker. It applies voltage to the circuits of rocket pod emergency release and homing rocket emergency launching (upon pressing the respective buttons);
- CANNON - HOMING ROCKET, ROCKET, CAMERA GUN (ПУШКА, СС, РС, ФКП) circuit breaker. It supplies power to the firing circuits of the equipment to be used by pressing the firing button on the aircraft control stick.

83. Rocket Launcher K-13 Controlled while Firing Rockets

(a) The pilot must check prior to the take-off:

- that the rockets are properly and reliably suspended;
- whether the protective shrouds are taken off the heat homers, optical fuses and launch-latches.

(b After the pilot has climbed into the cabin but prior to starting the engine, he must proceed as follows:

- make sure that EMERGENCY RELEASE OF ROCKETS, FUEL TANKS, ROCKET PODS, HOMING ROCKETS (АВАР.СБРОС РС, БАКИ, АПУ,АВАР.ПУСК СС) and CANNON - ROCKETS - CAMERA GUN (ПУШКА, РС-ФКП) circuit breakers are cut in;
- set the Б-С selector to С ОС-НР-30 selector to НР-30, OPTICAL -RADIO (ОПТИКА-РАДИО) to RADIO (РАДИО);
- set the CAGE - UNCAGE switch on the sight head to FIXED (НЕПОД);
- set the ROCKET -CANNON - HOMING ROCKET (РС-ПУШКА-СС) mode-of-operation selector of the distance measuring equipment to the HOMING ROCKET CC position;
- set the HOMING ROCKET LAUNCH (ПУСК СС) variation selector to SALVO (ЗАЛП) or SINGLE (ОДИНОЧНО) depending upon the flight mission. If it is SINGLE, additional adjustment to RIGHT (ПРАВ.) or LEFT (ЛЕВ) is required.

(c) After starting the engine, the pilot should:

- cut in the circuit breakers labelled COMPUTER INVERTER (ПРЕОБР.ВРД), SIGHT HEATER (ОБОГРЕВ ПРИЦЕЛА), SIGHT (ПРИЦЕЛ), D.M.E. (РАДИОДАЛЬНОСТЬ), CAMERA GUN (ФКП), HOMING ROCKET HEATER (ОБОГРЕВ СС), HOMING ROCKET FILAMENT (НАКАЛ СС);
- make sure that after suspension of the rockets, two warning lamps marked HOMING ROCKET SUSPENDED - LEFT - RIGHT and two warning lamps marked ROCKETS SUSPENDED - ROCKET POD (ПОДВЕСКА РС, АПУ) go ON;
- make sure the D.M.E. ready-for-operation lamp marked HIGH VOLTAGE (ВЫСОКОЕ) is ON.

CAUTION. To avoid breaking of the heat homer gyro, the take-off and landing are prohibited when the aircraft carries the rocket load with the HOMING ROCKET FILAMENT (НАКАЛ СС) circuit breaker with OFF.

(d) After the take-off, the pilot should:

- listen to the noise produced by the starboard and port heat homer(by switching over the HOMING ROCKET LAUNCH - LEFT - RIGHT selector) to make sure they function normally. If necessary, the sound volume should be adjusted by LOCK-ON SIGNAL rheostat;
- for safety, the HOMING ROCKET LAUNCH (ПУСК СС) circuit breaker should be cut in 3 - 5 minutes before firing.

(e) For launching the rocket, the pilot must:

- impose the target with the centre point of the sight reticle; in this event the aircraft assumes attitude necessary for the heat homer to lock-on the target; the heat homer produces characteristic sound. Gently moving the aircraft control stick, he should find the maximum volume point which might stand somewhat off the reticle centre point;
- watch the shortening of the range referring to the range indicator of the distance measuring equipment ИД-1 ;
- press the firing button and keep it pressed until the rocket has cleared the launcher all the while sighting by the maximum volume point when the PERMISSIBLE RANGE (РАЗРЕШЕННАЯ ДАЛЬНОСТЬ) lamp goes ON (but not more than 3.5 km. by the indicator of D.M.E.) and there is no forbidding signal due to overloads.

The rocket usually leaves the launcher 0.5 - 1.0 seconds after pressing the firing button.

For launching the second rocket, the selector should be brought to position LEFT (ЛЕВ.) or RIGHT (ПРАВ.) as required.

If the aircraft continues to approach the target, BREAK-AWAY (ВЫХОД ИЗ АТАКИ) red warning lamp goes ON when the distance to the target becomes 1 km.

When the rockets are launched in salvo (the launching variation selector being set opposite SALVO (ЗАЛП), the rocket may clear the launcher with a small interval (up to 0.5 second).

For emergency launching of the rockets, HOMING ROCKET EMERGENCY LAUNCHING (АВАРИЙНЫЙ ПУСК СС) should be pressed. In this instance, both rockets leave the launcher and fly with the control compartments (no target homing being obtained) inactive and the fuses active.

The АПУ-13у rocket pod is released in emergency by pressing the EMERGENCY RELEASE OF ROCKETS - ROCKET PODS (АВАР.СБРОС РС АПУ) button.

XII. EMERGENCY SITUATIONS IN FLIGHT

Readiness of the pilot to meet all accidents in flight is vital for taking measures ensuring safe flight.

Whenever the aircraft meets with an accident calling for aid or rescue measures, IFF equipment should be used for sending out distress signals.

All failures of the aircraft equipment that may happen in flight must be reported by the pilot to the flight control officer so that further actions might be carried out depending on the circumstances and taking into account the orders of the flight control officer.

84. Pilot's Actions when Engine Fails Spontaneously in Flight

When the engine stops spontaneously in flight:

- immediately set the engine control lever to the CUT-OFF (СТОП) position;
- report the engine failure to the control station over the radio;

- descend down to 12,000 metres (toward your own or neighbouring airfield) and start the engine.

The engine with the oxygen supply for igniting the main combustion chambers can be reliably started at an altitude of 12,000 m. at 20 - 30% autorotation revolutions of the low-pressure rotor. 450 - 690 km/hr I.A.S. corresponds to the specified revolutions of the autorotation.

The system of the oxygen supply is rated for 3 starting procedures, the continuity of one starting not exceeding 30 sec.

Note: When the oxygen supply system has run out of oxygen or when the system is defective (the pressure indicated by the pressure gauge is zero) start the engine at altitudes not exceeding 8000 m. with 15 - 30% autorotation revolutions of the low-pressure rotor, which corresponds to 400 - 690 km/hr I.A.S.

85. In-Flight Starting of Engine

Bring the engine control lever to the LOW SPEED position at altitudes not exceeding 12,000 m., provided the engine autorotation revolutions keep within permissible limits; immediately after that cut in the IN-FLIGHT STARTING (ЗАПУСК В ВОЗДУХЕ) circuit breaker and at the same time engage the pump, fuel starting solenoid valve, ignition and oxygen supply of the main combustion chamber igniters. In this instance, light panel T-6 with inscription ENGINE STARTING (ЗАПУСК ДВИГАТЕЛЯ) must go on and the engine r.p.m. must increase.

Note: The engine starting is controlled by the increase of the r.p.m. and the appearance of a sound. The temperature of the exhaust gases behind the turbine goes up slowly and cannot serve as a reliable indication of the initial stage of starting.

CAUTION: It is prohibited to keep the IN-FLIGHT STARTING (ЗАПУСК В ВОЗДУХЕ) selector engaged more than 30 sec to obviate brek out of the booster coils.

Should the engine fail to be started in 30 sec., cut out the IN-FLIGHT STARTING (ЗАПУСК В ВОЗДУХЕ) circuit breaker, set the engine control lever to the CUT-OFF (СТОП) position and repeat the starting procedure after blowing the engine in the course of 15 - 30 sec.

With the generator cut out (GENERATOR OFF - ГЕНЕРАТОР ВЫКЛЮЧЕН) lamp has lighted up), disengage the following consumers of the power supply: pump No.3, camera gun, heater of the Pitot tube ТП -156, automatic radio compass АРК-10 and aircraft transponder СПО-1 to be cut in whenever necessary.

Note: In case the generator cuts out, the sight with a heater, distance measuring equipment, infrared sight СИВ-52 , radio altimeter РВ-2 , marker receiver МРП-56 and pumps No.1, 4 and 5 get disengaged automatically.

Having obtained the flight speed required for starting the engine, cut out the aileron boosters with a view to saving the hydraulic mixture to be used for engine-off landing.

Try to start the engine down to the altitude of 2000 m. If the engine has failed to be started down to that altitude, the decision should be taken to bail out, or to land the aircraft with the engine off.

The engine-off landing can be carried out safely only when the booster hydraulic system functions faultlessly and the aileron boosters are disconnected.

86. Engine-Off Landing Procedure

Land the aircraft with the engine off only on an airfield.

The engine-off landing can be carried out safely only when the booster hydraulic system functions faultlessly (with the aileron boosters disconnected).

Prior to landing:

- set the engine control lever to the CUT-OFF (СТОП) position;
- shut off pump No.2 and close the fuel cut-off valve;
- cut out the power consumers unless further supply is absolutely necessary;
- check if the aileron hydraulic boosters are cut out;
- check if PUMP UNIT (НАСОСНАЯ СТАНЦИЯ) circuit breaker is ON;
- check the pressure in the hydraulic systems.

After the aircraft has reached the altitude of 2000 m., make sure the booster hydraulic system operates faultlessly by watching the pressure drop warning lamp and left pointer of the pressure gauge in the booster hydraulic system.

Note: The booster hydraulic system is considered to be functioning properly in the following cases:

- in the case of normal autorotation of the engine, the pressure in the booster hydraulic system is maintained within 180 - 210 kg/sq.cm. as indicated by the pressure gauge, and the yellow warning lamp is off. In this instance, the consumption of hydraulic mixture necessary to control the stabilizer (aileron boosters off) are compensated by the НП-34 main pump of the booster hydraulic system;
- if pump НП-34 of the booster hydraulic system fails to ensure the specified pressures (due to faults of the system or decrease of the autorotation revolutions) and the pressure in the hydraulic system comes down to 165 kg/sq.cm., emergency pump unit НР-27 is engaged in operation and the yellow warning lamp lights up. After that, the pressure in the hydraulic system will be safely maintained within 165 - 180 kg/sq.cm. The yellow warning lamp will keep on up to the landing.

Down to the altitude of 200 m. the aircraft should glide at a speed of 420 - 450 km/hr by the wide needle to the point of the first levelling-off (the first marker beacon) standing 700 metres off the runway.

The vertical speed of descent approximates 35-40 metres per second.

Extend the landing gear as prescribed for the emergency cases having made sure the landing judgement has been done correctly.

Do not extend the flaps and the brake flaps.

The aircraft having come down to the altitude of 200 metres, carry out the first levelling of the plane, and decrease the glide angle to the value typical of the landing procedures done with the engine operating.

The vertical speed of descent must come down to 4 - 6 metres per second by the altitude of 30 - 40 metres. By the initial stage of the landing, the aircraft assumes the attitude the pilot is used to as far as the trajectory slope angle and the vertical speed of descent are concerned provided the speed along the trajectory is adequate

$$V = 350 - 360 \text{ km/hr.}$$

Perform the second levelling-off at an altitude of 15 - 20 m. exactly as it is done during the normal landing with the engine operating, bring the aircraft to the ground at an altitude not exceeding 1 m. and land it.

87. Pilot's Actions Necessitated by Failure of Hydraulic Systems

In case both hydraulic systems fail in flight (which is evidenced by flashing of the pressure drop warning lamps and steady drop of pressure in the two hydraulic systems below 165 kg/sq.cm., the latter being checked with the aid of the pressure gauge), the crew must leave the aircraft by catapulting irrespective of whether the engine is operating or not.

If one (main or booster) hydraulic system fails which is evidenced by flashing of the pressure dro, warning lamp and by the pressure gauge indications, the flight should be stopped. It is forbidden to use the brake flaps during the landing approach, the landing gears should be extended as prescribed for the emergency procedure, the flaps being kept in.

If pump НН-34 of the booster hydraulic system fails and pump unit НН-27 is engaged when the aircraft is fifteen minutes off the airfield, it is necessary:

- make sure the pump unit is operative and put it out of operation (to avoid overheating);
- when approaching the airfield, set pump unit НН-27 into operation to build up pressure in the booster hydraulic system.

The engine-off landing of the aircraft with the main hydraulic system failed can be carried out safely only when the booster hydraulic system functions normally.

Do not land the aircraft with the engine inoperative and the booster hydraulic system failed (pressure dropping below 165 kg/sq.cm.) but leave the aircraft by ejecting at safe altitudes.

88. Pilot's Actions in Case of Fuel Pressure Drop

The pressure drop of fuel behind the fuel supply pump is indicated by lighting up of the SUPPLY TANK (РАСХОДНЫЙ БАК) inscription of light panel T-6. In this instance set the engine r.p.m. to the normal rating or lighter duty, bring the aircraft down to the altitude of 7000 m. and discontinue the mission.

Avoid negative overloads to obviate stoppage of the engine.

89. Pilot's Actions in Case of Oil Pressure Drop in Engine

When the pressure of oil has come down to zero, discontinue the mission, decrease the engine r.p.m. and immediately land the aircraft.

90. Pilot's Actions in Case of Engine Fire

The fire is indicated by:

- lighting up of the FIRE (ПОЖАР) label on light panel T-6;
- smoke trail behind the aircraft tail (seen during the turns).

To extinguish the fire:

- set the engine control lever to the STOP (СТОП) position;
- press the SHUT-OFF VALVE (ПЕРЕКРЫВНОЙ КРАН) button;
- decrease the speed of flight to 450 - 500 km/hr; bring the aircraft ascending;
- press the FIRE-EXTINGUISHER (ОГНЕТУШИТЕЛЬ) button of the fire system;

- decide on landing the aircraft or ejecting depending on the circumstances;
- do not start the engine again after using the fire system.

91. Pilot's Actions in Case of Failure of Pitot-Static Tube ПВД-5 and Pitot Tube ТП-156

The failure of the static pressure and of the static and impact pressures of the Pitot-static tube is indicated by erroneous readings of the speed indicator, rate of climb indicator and machmeter, variable-ratio boost control unit АУУ-5Б, nose cone automatic control indicator. The failure of the impact pressure system only supplied by Pitot-static tube ПВД-5 is evidenced by readings of the speed indicator, machmeter, variable ratio boost control unit and nose cone automatic control indicators.

In case of simultaneous failure of speed indicator, machmeter, variable ratio boost control unit and nose cone automatic control indicators, switch the supply system of the above instruments from the main Pitot-static tube ПВД-5 over to emergency Pitot tube ТП-156, discontinue the mission and land the aircraft.

In case all instruments fail at a time and remain inoperative after switching over to emergency Pitot tube ТП-156 , discontinue the mission and fly the aircraft until it can be landed consulting the indications of the gyro horizon, turn indicator, engine r.p.m. indicator; having descended down to the altitude below 600 m. shown by the radio altimeter, navigate the aircraft referring to the data supplied by the ground radio aids.

Notes: 1. Static Pitot tube ПВД-5 and Pitot tube ТП-156 must be heated when required, for otherwise they are liable to get iced which brings about failure of the instruments connected to the above tubes. In this instance, the indications of the instruments must read actual values measured some 2 - 3 minutes after switching the electric heaters on.

2. If the instruments fail when the aircraft flies with afterburner ON, disengage the latter and manually set retractible cone to the original position after braking the aircraft.

3. If all or part of instruments fail in flight, change the variable ratio boost control unit from HIGH SPEED (ВЫСОК. СКОРОСТЬ) to LOW SPEED (НИЗК. СКОРОСТЬ) prior landing approach. While doing this, bear in mind that the rod of the servo mechanism takes 18 - 20 sec. to shift.

92. Pilot's Actions under Icing Conditions

When the aircraft is flying through the overcast under icing conditions, break through the clouds and after having stabilized the aircraft in the level flight cut in the de-icer system. Engage the system by pulses (duration of one pulse being 2 - 3 sec.) with the interval of 10 - 15 sec.

If ice is formed on the aircraft when the latter descends through the clouds, there is no need to change the flight procedure, the de-icer system being used from altitudes of 1000 m. and upward.

The ice is best removed from the aircraft when it flies at high speeds (if it is practicable under the flight conditions) of up to 700 km/hr I.A.S. at middle altitudes and up to 800 - 900 km/hr I.A.S. at high altitudes.

93. Pilot's Actions after Breakdown of Aircraft Oxygen System

The breakdown of the aircraft oxygen system is indicated by:

- sharp decrease of the oxygen pressure in the system (as shown by the pressure gauge);
- discontinuation of the oxygen supply to the pressurized helmet or mask (blinker segments of indicator MK-18 remain still in the closed position);
- failure of parachute oxygen breathing apparatus KI-27 to build up excessive pressure in the chambers of anti-g suit tensioner, pressurized helmet or mask (pressure gauge M-2000 showing no pressure) after engaging the oxygen supply system in the de-pressurized cabin (cabin altitude and differential pressure gauge showing altitudes exceeding 12 km.).

Observing one of the above indications of the oxygen system breakdown, immediately cut in the parachute oxygen breathing apparatus KI-27 operating the emergency control switch and descend to an altitude of 4000 m. and lower.

While descending, make sure the air-dilution switch on remote control station AV-2 is set at MIXTURE (СМЕСЬ).

Note: When engaging parachute oxygen breathing apparatus KI-27 manually without disconnecting common connector OPK-2, make sure the air-dilution switch is brought to the MIXTURE (СМЕСЬ) position to ensure supply of the air from the atmosphere (at altitudes below 10,000 m.) through apparatus KI-34 when apparatus KI-27 supplies inadequate portions of the oxygen needed for the crew.

94. Pilot's Actions in Case of Dimming of Canopy Glass Panels

In the case of dimming of the canopy glass panels, make sure the valve supplying the air to the cockpit is opened and the canopy is pressurized, increase the engine r.p.m., set the regulator of the air temperature supplied to the cockpit to the HOT (ГОРЯЧИЙ) position, and decrease the speed of descent.

95. Pilot's Actions in De-Pressurized Cockpit at High Altitudes

With the cockpit de-pressurized for reasons other than deterioration of the canopy glass panels or wash out of the canopy sliding portion, descend until the cockpit altitude becomes 12,000 m. and lower ensuring the endurance flight and further performance of the flight mission, provided no other defects have been located.

If the canopy glass panels are damaged or the canopy sliding portion is washed out, decrease the altitude and speed of flight as soon as practicable. The aircraft with the damaged glass panels of the canopy or with the canopy jettisoned can fly at speeds up to 900 km/hr if the pilot has the headset on, and up to 700 km/hr if he has the pressurized helmet on.

96. Pilot's Actions upon Detecting Smoke in Cockpit

Upon detecting smoke in the cockpit, the pilot must:

- change over to the pure oxygen supply by setting the air-dilution switch on the control station AV-2 to the "100% O_2" position;
- disconnect the air supply from engine by bringing the supply valve control on the right console to the extreme rearward position, and descend below 12,000 m.;
- if the smoke persists, decrease the speed and altitude of the flight and proceed depending upon the circumstances. If necessary jettison the canopy.

97. Pilot's Actions in Case of Dimming of Pressurized Helmet Transparent Face-Piece

In the case of dimming of the transparent face-piece of the pressurized helmet due to the breakdown of the heating system, the pilot must discontinue the flight mission and proceed in the following way:

1. While flying in pressurized or de-pressurized cockpit when the cockpit pressure does not exceed 12,000 m. (according to the indications of the cabin altitude and pressure differential gauge), he must set the emergency oxygen supply switch on control station AV-2 to the SUIT CONNECTED (ВКЛ.КОСТ.) position, shifting it off the "N" position and turn the excess pressure knob all the way leftward. Then the pilot must bring the aircraft down to a safe altitude of 4000 m., remove the face-piece and disconnect the oxygen emergency supply by setting the switch and the knob to their original positions.

If after cutting-in of the oxygen emergency supply system the dimming of the pressurized helmet persists, the pilot must remove the transparent face-piece and press it to the face so that the upper edge of the piece stands below the level of his eyes but covers the nose and does not interfere with the pilot's observations of the instrument indications. It is forbidden to remove the transparent face-piece at altitudes exceeding 12,000 m.

Keeping the transparent face-piece pressed to the face, the pilot should bring the aircraft down to an altitude of 4000 m., cut out the emergency supply of oxygen and take the face-piece off the face.

2. During the flight in de-pressurized cockpit when the cockpit altitude exceeds 12,000 m. (according to the indications of the cockpit altitude and pressure differential gauge), the pilot must switch over to the maximum descend speed in order to reach an altitude of 12,000 m., in the shortest time possible. While descending, he must set the oxygen emergency supply switch on control station AV-2 to the SUIT CONNECTED (ВКЛ.КОСТ.) position from the "N" position and turn the excess pressure switch all the way leftward. The pilot must keep the face-piece pressed to his face at altitudes exceeding 12,000 m. At altitudes below 12,000 m. if the dimming of the transparent face-piece persists, he must take off the face-piece and apply it to his face so that the upper edge of the glass stands below the level of his eyes and protects his nose without interfering with observations of the instrument indications.

Keeping the transparent face-piece pressed to the face, the pilot must descend down to an altitude of 4000 m., cut out the emergency supply of oxygen and take the face-piece off the face.

Note: 1. In emergency cases when there is no other way out but to continue the flight at high altitudes the pilot might perform level flight for a short time at altitudes ranging from 12,000 - 8000 m. (while the pressure of oxygen in the system is 30 kg/sq.cm.) with the oxygen emergency supply system engaged. In this instance, the transparent face-piece of the pressurized helmet may be both removed or pressed to the

face. The pilot must concentrate his attention on the consumption of oxygen bearing in mind that it sharply increases reaching the value of 40 - 50 lit/min. When the pressure in the oxygen system reaches 30 kg/sq.cm., he must descend the aircraft down to an altitude of 4000 m.

2. Upon engagement of the oxygen emergency supply system, the anti-g suit first clings to the pilot's body but then the pressure is relieved.

98. Pilot's Actions during Emergency Extension of Landing Gear

If the landing gear will not come out by the usual method (no pressure in the main hydraulic system), the pilot must resort to the emergency measures prescribed for the purpose. To this end:

- set the landing gear emergency control valve switch to the NEUTRAL (НЕЙТРАЛЬНО) position;
- open the landing gear emergency control valve;
- make sure the landing gear has come out watching the green warning lamps which must light up; after that proceed to landing the aircraft.

99. Pilot's Actions in Case of Generator Failure

The failure of the generator in flight may be detected by flashing of the GENERATOR OFF (ГЕНЕРАТОР ВЫКЛЮЧЕН) inscription on light panel T-6 and by the indications of the voltmeter (the voltage coming from 28 - 29 V down to 22 - 23 V of the storage battery).

When the generator fails:

- discontinue the flight mission;
- report the accident to the flight control officer using the radio set;
- cut out the following consumers: pump No.2 (at altitudes below 7000 m.), pump No.3, camera gun, radio altimeter, marker receiver МРП-56П, automatic radio compass АРК-10 and transponder СРО-1. The radio compass, transponder and transmitter of radio station РСИУ-5Т should be cut in for a short time and in turns, if necessary.

The time of safe flight of the aircraft with the generator failed and the power consumers being supplied from the aircraft storage batteries in the procedure outlined above both in the day time and at night reaches 15 - 20 minutes.

Note: 1. Breakdown of the generator in flight automatically disconnects the sight with the heater, distance measuring equipment, infrared sight СКВ-52, radio altimeter, marker receiver МРП-56П, and pump Nos 1, 4 and 5.

2. To increase the time of safe flight, it is permissible to cut out other consumers of power the pilot can do without under the flight conditions.

3. When the voltage in the aircraft mains goes below 20 V retract the landing gears following the emergency procedure. In this instance, the pilot should bear in mind that the brake parachute cannot be used.

100. Failure of Inverter ПО-750

Breakdown of inverter ПО-750А supplying the voltage to radio station РСИУ-5 Г, radio compass АРК-10, IFF transponder, remote-reading induction pressure gauge ДИМ-6Т, fuel flowmeter РРС-16Б-4, and ionization fire warning unit ИС-2 is evidenced in flight by discontinuation of the radio communication (in all channels), failure of the radio compass to respond to the departure of the aircraft from the rated relative bearing of the radio station, failure of the fuel flow gauge indicator (scale standing still).

Having observed the above indications of the inverter breakdown, the pilot must cut in the INVERTER EMERGENCY CHANGE OVER (АВАР.ПЕРЕКЛ.ПРЕОБРАЗОВ.) circuit breaker mounted on the front right electric panel in the cabin.

All the above consumers should be switched over to other inverter ПО-750А, and the pilot will determine whether they are set into operation after heating of the radio valves (in 1 - 1.5 min.).

101. Pilot's Actions after Breakdown of Variable-Ratio Automatic Boost Control Unit АУ7-3Б

In case of failure of variable-ratio automatic boost control unit АУ7-3Б, change over to the manual control of servo mechanism of the АУ7-3Б after having decreased the speed of flight.

For changing over to the manual control, set the selector on the left console from the AUTOMATIC (АВТОМАТ) to the MANUAL (РУЧН.) position, and make use of the manual push button marked VARIABLE-RATIO BOOST CONTROL UNIT GOVERNOR (УПРАВ.АУ7) setting it to the LOW SPEED (МАЛАЯ СКОРОСТЬ) position. Bear in mind that HIGH SPEED (БОЛЬШАЯ СКОРОСТЬ) corresponds to the smaller arc of the variable-ratio boost control unit rod, and the LOW SPEED (МАЛАЯ СКОРОСТЬ) to the bigger one.

While manipulating the variable-ratio boost control unit by hand, pay more than ordinary attention to the indications of the variable-ratio boost control unit gauge and compare the latter with the readings yielded by the speed indicator and the altimeter. The I.a.s. must not exceed the speed to which the position of the variable-ratio boost control unit corresponds by more than 100 - 130 km/hr, otherwise the aircraft is liable to some oscillating as the position of the unit rod does not correspond to the speed of flight.

While a servo mechanism is being controlled manually, the level flight slow evolutions and landing procedure only can be performed.

Should the unit rod fail in the smaller arc position (electric motor failure) so that its servo mechanism cannot be changed over to the take-off and landing position (to bigger arc), decrease I.a.s. and land the aircraft with the unit rod arranged at the smaller arc.

Landing with the unit rod set at smaller arc requires more than ordinary attention and accurate actions on the part of the pilot. He should bear in mind, that in this instance the travel of the stabilizer is almost twice decreased, the efforts applied to the control stick increase 2 - 2.5 times (about 20 - 25 kg), and the speed of landing goes up. Therefore, the gliding speed must be increased by 20 - 30 km/hr, the gliding being done at a smaller angle of the flight trajectory slope.

When making use of the trim mechanism, remember that the time of the mechanism travel from one extreme position to the other takes 9 - 12 sec. irrespective of the flight procedure.

102. Pilot's Actions after Breakdown of Anti-Surge Shutters Automatic System

The failure of anti-surge shutters is indicated by the appearance of flutter when the flight is carried out with M = 1.5 and over after pulling the control stick forward through the length exceeding half of its travel.

In this instance, the pilot must open the shutters manually. For this purpose he must bring the shutters control from the AUTOMATIC (АВТОМАТ) to the OPENED (ОТКРЫТО) position. After that the fluttering must disappear.

Decrease the speed, cut out the afterburner and after decreasing M below 1.5 close the shutters by bringing the control to the CLOSED (ЗАКРЫТО) position. Further flight should be done with M not exceeding 1.5.

103. Pilot's Actions after Breakdown of Retractible Cone Control System

The failure of the cone automatic control system is indicated by:

- non-extension of the cone when the aircraft flies at speeds involving M = 1.5 or 1.9 (lamp on light panel Т-4 is off and sound in the intake channel does not change);
- non-retraction of the cone when the aircraft speed involves M = 1.9 or 1.5 and lower.

In this instance:

- the pilot must not fly the aircraft at speeds involving M exceeding 1.5 if the cone fails to be extended. In case the flight must be continued, the cone should be extended manually;
- retract the cone manually if it fails to be retracted with M = 1.9 or 1.5;
- set the mode-of-operation selector to MANUAL (РУЧНОЕ);
- set the manual control switch to the position corresponding to M of the flight speed.

If the cone failed to be retracted manually, discontinue the flight mission. While flying, keep the r.p.m. within 85%.

104. Failure of Jet Nozzle Shutter Control Follow-Up System

In case the jet nozzle shutter control follow-up system fails (engine thrust does not change with the engine control levers shifted from MINIMUM AUGMENTATION to FULL AUGMENTATION, a rapid increase or decrease of engine thrust during flight under the AUGMENTED RATING), switch on the NOZZLE EMERGENCY CONTROL switch allowing to effect a two-position control of the shutters (the maximum augmentation position being ensured).

105. Rapid Decrease in Engine R.P.M. (Below 80%) Due to Pressure Surges in Engine

In case of a spontaneous decrease (below 80%) in the r.p.m. due to pressure surges in the engine, immediately shift the engine control levers to the STOP position. If the pressure surging persists, throw over the tumbler switch ANTI-SURGE SHUTTERS on the left control panel to open the shutters. As soon as the engine stops, start it anew according to "Aircraft МиГ-21Ф. Pilot's Instructions".

106. Pilot's Actions during Surge of Air Intake

Surge of the air intake is evidenced by light knocks appearing in the air intake channel and felt by the pilot in the cockpit.

If the air intake surge is observed at the aircraft speeds involving M = 1.5 and more, proceed as follows:

- cut out the afterburner with the aid of AUGMENTED CONDITION (ФОРСАЖ) control;
- gradually send the aircraft climbing and decrease the speed of flight.

If the measures taken fail to eliminate the surge, manually open the anti-surge shutters by changing the shutter control from the AUTOMATIC (АВТОМАТ) to the OPENED (ОТКРЫТО) position.

After eliminating the surge and bringing the aircraft speed involving M below 1.5, return the shutter control to the original position marked AUTOMATIC (АВТОМАТ).

107. Pilot's Actions while Bailing Out

The pilot must be trained on the ground to acquire automatic habits required by the ejection procedure.

The canopy-protected ejection seat, as compared with the seat having a seat curtain to protect the pilot's face, has the following advantages:

(a) the seat fully protects the pilot against the air stream during bail out. This allows to increase the safe speed up to 1100 km/hr (indicated speed);

(b) considerably reduces time necessary for preparations prior to bail out (from the moment the decision is taken till the hand triggers are pressed). No special attitude is prescribed for the pilot, the pre-jettison time being necessary only for trigger pressing. The seat is equipped with an automatic harness-tightening device which operates during the seat ejection;

(c) the seat ensures a more energetic separation of the pilot from the seat, which reduces the minimum safe jettison altitude to 110 m.

The seat of the МиГ-21Ф-13 aircraft may be ejected either together with the canopy or with preliminary jettisoning of the canopy.

108. Seat Ejection with Canopy

Prior to ejection:

- reduce the aircraft speed (conditions permitting);
- grip the seat armrests and press the trigger on one of the armrests, or both triggers on both armrests.

The consecutive stages of ejection develop automatically, no actions on the part of the pilot are necessary. Minimum altitude for ejection in a level flight is 110 m. Ejection safe speed ($V_{ind.}$) is 1100 km/hr.

109. Seat Ejection with Preliminary Jettisoning of Canopy

Prior to ejection:

- swing back and pull the red handle on the right side of the instrument panel to effect the jettisoning of the canopy;
- grip the seat armrests and press upon the triggers (on both armrests, or on one of them).

110. Failure of Seat Ejection Gun at High Altitudes

In case both triggers are pressed but this does not effect ejection, do as follows:

- reduce flying speed (conditions permitting);
- pull the KM-27 oxygen apparatus opening handle to open oxygen emergency supply;
- disconnect the parts of the OPK common connector by pulling the lever of the upper block or the handle attached to the oxygen supply hose;
- pull at the handle attached to the seat bowl between the legs to actuate the mechanism releasing the seat straps (the handle will separate from the seat and remain in the pilot's hands);
- jettison the canopy by unlocking and pulling the emergency handle (painted red) on the starboard;
- leave the aircraft;
- on reaching a safe height, take off the transparent face-piece of the helmet.

111. Canopy Fails to Separate from Seat after Ejection

In case the canopy does not separate from the seat 1.5 sec. after the ejection, pull at the emergency handle of the seat bowl (between the legs) to effect the seat strap release and to separate the canopy.

112. Emergency Escape from Aircraft on Ground

When an emergency escape from the aircraft on the ground is necessitated, proceed as follows:

- open the canopy (if it has not been removed) by pulling back the canopy opening handle (on the portside). If the canopy still remains in its place (due to the absence of air in the system or to the jamming of locks), pull the emergency opening handle on the starboard.

CAUTION: When employing the canopy emergency opening system, the pilot must bend as low as possible in the cabin.

- take off the face shield of the flying helmet (if it has not been removed);
- disconnect the OPK common connector;
- energetically pull the harness emergency release handle on the seat bowl front.

XIII. MAXIMUM FLIGHT VALUES OF INDICATED AIR SPEED, MACH NUMBER, AND LOAD FACTOR

1. Without suspended loads:

(a) indicated air speed (larger pointer readings) at altitudes from 0 to 12,500 m. must not be over 1200 km/hr;

(b) M number at altitudes above 12,500 m. must not exceed 2.05;

(c) maximum load factor equals 8 with a fuel reserve of 1100 lit. or 7 when the aircraft fuel quantity exceeds 1100 lit.

2. With the drop tank suspended (but without other suspended load):

(a) indicated speed (larger pointer readings) at altitudes from 0 to 12,000 m. must not exceed 1000 km/hr;

(b) Mach number at altitudes above 12,000 m. must not be over 1.6;

(c) maximum load factor must be equal to 6 (with the drop tank either full or empty).

3. With the APC-57 rocket pods suspended (without the drop tank):

(a) indicated air speed (larger pointer readings) at altitudes from 0 to 13,500 m. must not exceed 1000 km/hr;

(b) Mach number at altitudes above 13,500 m. must not be above 1.8;

(c) maximum load factor is 6.

4. With APC-57 rocket pods and drop tank suspended:

(a) indicated air speed (larger pointer readings) at altitudes from 0 to 12,000 m. must not exceed 1000 km/hr;

(b) maximum value of Mach number at altitudes exceeding 12,000 m. must be not over 1.6;

(c) maximum load factor is 6 (with the drop tank either full or empty).

5. Flight with two S-13 rockets suspended:

(a) without the drop tank:

- at altitudes from 0 to 5000 m. the indicated speed is 1100 km/hr;
- at altitudes from 5000 m. to 12,300 m. the indicated speed is 1200 km/hr;
- at altitudes of 12,300 m. and higher with Mach number = 2.0 maximum permissible load factor equals 7;

(b) with the drop tank suspended:

- at altitudes from 0 to 12000 m the indicated speed is 1000 km/hr;
- at altitudes of 12000 m and higher with Mach number = 1.6 maximum permissible load factor (with the tank full or empty) is 6.

CAUTION. Augmented ratings of the engine allow to gain speeds exceeding the above given values.

6. Lowest indicated air speed (without suspended loads) is 215 km/hr.

7. Aircraft evolution speed at all altitudes equals 350 km/hr (larger pointer readings).

8. Maximum air speed with the landing gear extended must not exceed 700 km/hr (larger pointer readings).

9. Maximum air speed at which the drag parachute may be employed equals 280 km/hr.

10. The drop tank may be ejected at all altitudes and engine ratings at speeds from 500 to 1000 km/hr (larger pointer readings) with Mach number not exceeding 1.5.

11. The air brakes can be extended within the whole range of air speed and M number values.

12. The flight with the canopy jettisoned is possible under the following conditions:

(a) at speeds up to 500 km/hr (larger pointer readings) when the pilot has the headset and breathing mask on;

(b) at speeds up to 700 km/hr (larger pointer readings) when the pilot is in the pressurized helmet.

Landing Weight Limits

13. Normal landing weight is:

(a) aircraft weight without wing suspension loads with the total fuel reserve not exceeding 1100 lit.;

(b) aircraft weight with rocket pods with the total fuel reserve not exceeding 500 lit.

14. An overloaded aircraft may land:

(a) without the wing suspension loads with the total fuel reserve not exceeding 2500 lit. (an immediate landing after the take-off with the drop tank suspended);

(b) with rocket pods suspended and total fuel reserve not exceeding 1800 lit. (an immediate landing after the take-off with the rocket pods, the drop tank to be obligatory jettisoned prior to landing);

15. When taxiing with the drop tank and wing loads suspended, never exceed the speed of 15 km/hr.

XIV. TIME AND RANGE OF FLIGHT

To fly the aircraft over the maximum distance during the maximum period of time (in a level flight), maintain the indicated air speed within the limits given in the Tables 1 to 3.

The flight distance and time increase with an increase in the flight altitude. The maximum flight distance and time can be attained at altitudes within 11,000 - 12,000 m.

Table 1

Distance and Duration of Flight
MiG-21F-13 Aircraft
with R-11F-300 Engine and 7% Fuel Reserve
At Altitude of 11000 m.

Flight characteristics	Air speed, km/hr		Low pressure turbine r.p.m.	Fuel consumption, kg/km.	Fuel consumption, kg/hr.	Distance		Duration of flight, hr. min.	
	indicated air speed	true air speed				level flight distance	operational distance	level flight duration	operational duration of flight
1	2	3	4	5	6	7	8	9	10
Without suspension loads (with pylons and beams)									
Initial flight weight . . . . . 6965 kg; Total fuel reserve . . . . . 1905 kg; Fuel reserve for level flight . . . . . 1260 kg.									
Maximum distance flight	520	925	87	0.98	905	1290	1470	1-24	1-42
Maximum duration flight	440	795	85	1.07	850	1180	1360	1-29	1-47
With two K-13 rockets									
Initial flight weight . . . . . 7110 kg; Total fuel reserve . . . . . 1905 kg; Fuel reserve for level flight . . . . . 1190 kg.									
Maximum distance flight	520	925	91	1.09	1010	1090	1300	1-11	1-31
Maximum duration flight	440	795	89	1.17	930	1020	1230	1-17	1-37

1	2	3	4	5	6	7	8	9	10
With two K-13 rockets and 490-lit. drop tank jettisoned after it becomes empty									
Initial flight weight . . . . . 7560 kg; Total fuel reserve . . . . . 2315 kg; Fuel reserve for level flight . . . . . 1540 kg.									
Maximum distance flight	520	925	92	1.14	1060	1350	1580	1-27	1-49
Maximum duration flight	440	795	90	1.23	980	1250	1480	1-34	1-56

The following points are taken into account:

(a) fuel consumed by the engine on the ground (starting, engine testing, taxiing) during 7 min. constitutes 60 kg;

(b) fuel consumption, take-off distance and time for the take-off and climb correspond to the values given in Tables below;

(c) fuel consumed by the aircraft following the landing pattern above the airfield of landing during 4 min. is 80 kg;

(d) non-consumed fuel reserve equals 30 kg;

(e) 7% fuel reserve (relative to the total fuel reserve) is 120 kg at γ = 0.775 kg/cu. cm. or 125 kg at γ = 0.83 g/cu.cm.

Table 2

Fuel Consumption, Time and Distance with MiG-21ф-13 Taking-Off and Climbing at Maximum Rating with P-11ф-300 Engine

V_{true} = 930 km/hr

Flight altitude, m.	Without drop tank with pylons and beams			Flight altitude, m.	With two K-13 rockets			With two K-13 rockets and drop tank suspended		
	Fuel consumption, kg	Time, min.	Distance, km.		Fuel consumption, kg	Time, min.	Distance, km.	Fuel consumption, kg	Time, min.	Distance, km.
1000	70	1.3	5	1000	80	1.5	5	100	2	10
3000	160	3.0	30	3000	185	3.3	35	210	4.2	45
8000	215	4.0	50	8000	250	4.9	60	290	6.4	75
10,000	230	5.2	65	10,000	310	7.1	90	360	8.2	110
11,000	270	6.0	85	11,000	340	8.4	110	400	9.8	130

Table 3

Fuel Consumption, Time and Distance with MiG-21ф-13 Aircraft Gliding with Drop Tank Suspended or without Drop Tank

Flight altitude, m.	Fuel consumption, kg	Time, min.	Distance, km.
1000	-	0.5	5
3000	20	3.0	35
8000	40	5.0	60
10,000	60	7.0	85
11,000	75	8.0	100
17,500	120	13	165
19,000	135	14	180

Notes: 1. Glide is performed at a low speed.
2. The engine control lever must be at the low speed stop.
3. Air brakes must be retracted.