AIRCRAFT Ty-16

DESCRIPTION OF DESIGN

BOOK I

AIRCRAFT PERFORMANCE CHARACTERISTICS

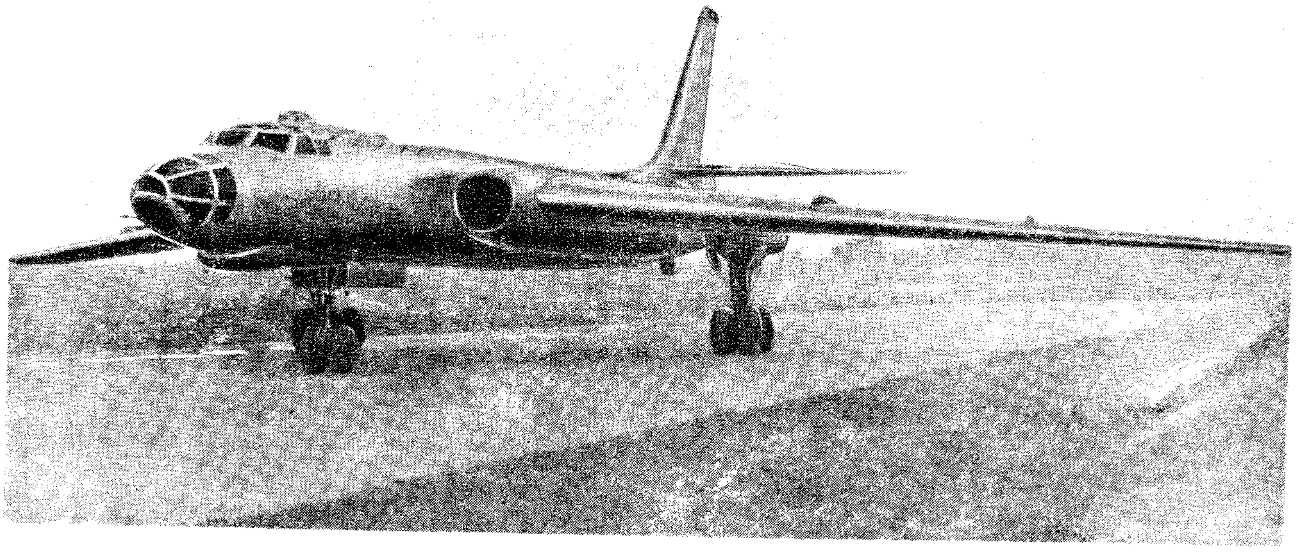

FIG. 1. Ty-16 Jet Aircraft

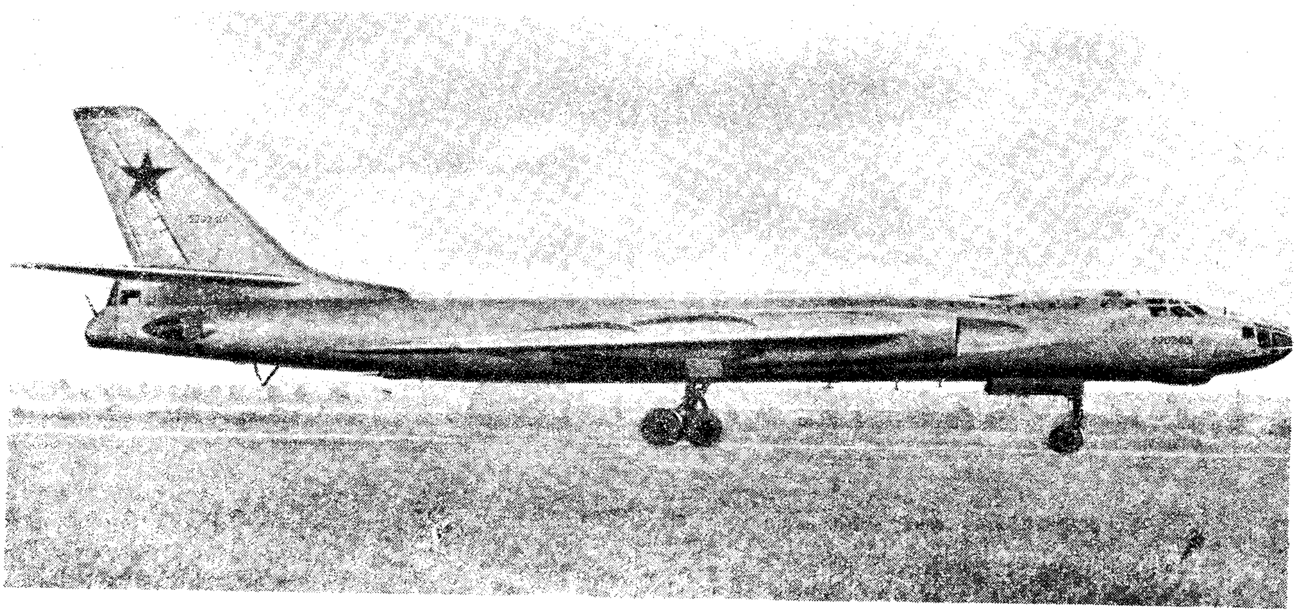

Fig. 2. Ty-16 Jet Aircraft. Side View

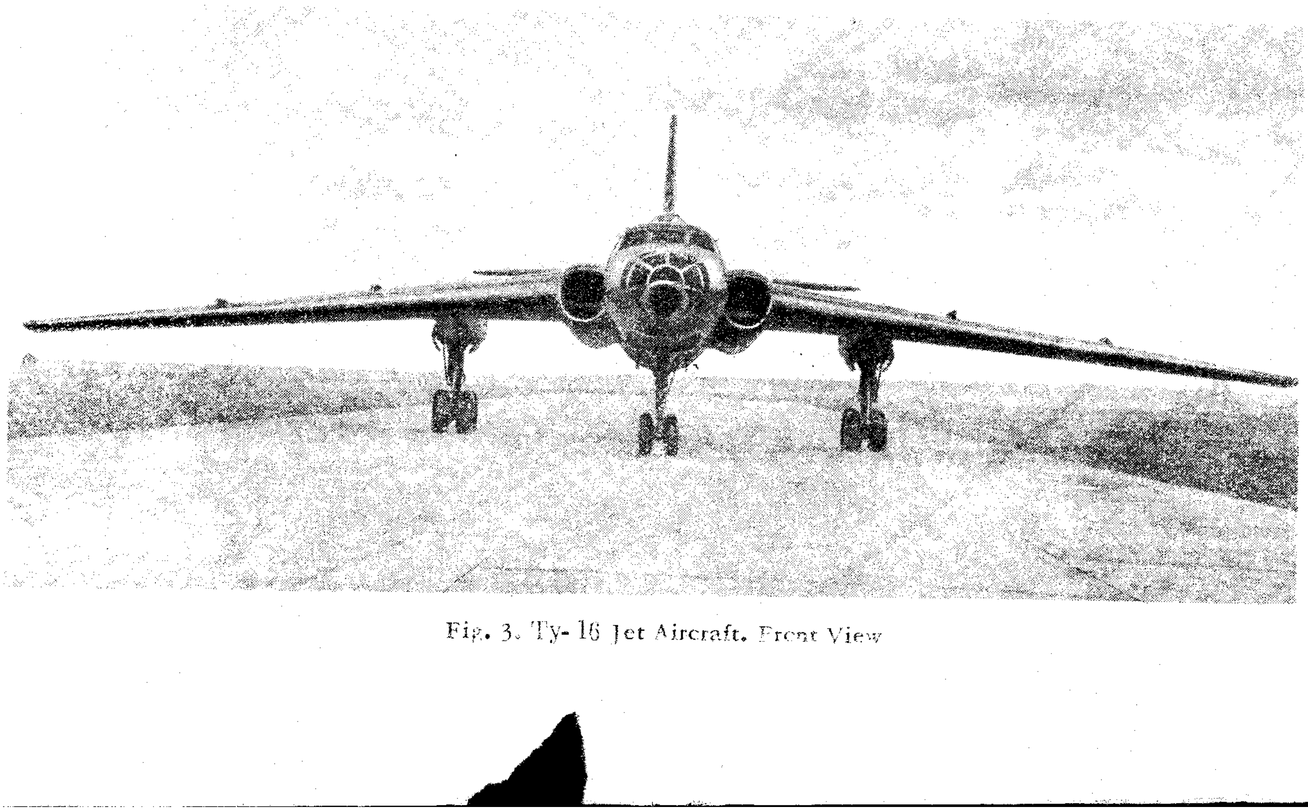

Fig. 3. Ty-16 Jet Aircraft. Front View

I. GENERAL

The Ty-16 aircraft is a high-speed jet long-range bomber (See Figs 1, 2 and 3) intended for heavy bombing of strategic targets.

The aircraft is provided with means to perform formation or single bombing of targets located deep in the enemy rear and having strong anti-aircraft defence in the day time and at night under any weather conditions from high altitudes (up to 13,000 m.).

The aircraft can be employed for reconnaissance purposes, for auxiliary group or single flights deep in the enemy rear and for bombing sea targets.

The aircraft is furnished with up-to-date navigational, radio and radar equipment and gun armament.

The Ty-16 aircraft is an all-metal midwing monoplane with swept-back wings. The aircraft is equipped with two engines of model AM-3 mounted on the fuselage side panels behind the inner wing. Engine air intakes are located along the fuselage sides before the wing. Rated thrust of one engine on the ground is 7000 kg.

The fuselage (See Fig.4) is divided into compartments along its whole length. The front and rear compartments are sealed cabins to accommodate six members of the crew.

Arranged in the front cabin are posts for:

(a) navigator, in charge of course plotting and bombing;

(b) left pilot who is aircraft commander;

(c) right pilot;

(d) navigator-operator controlling and servicing the РБП-4 radar bomb sight and firing the upper gun mount.

The rear cabin accommodates:

(a) radio operator, in charge of radio communication with the ground and lower gun mount fire;

(b) tail gunner firing the tail gun and controlling the ПРС-I radar gun sight.

The entrance to the front cabin is effected through the manhole under the navigator-operator's seat, while the rear cabin is entered through the manhole under the seat of the tail gunner. The compartment behind the front cabin is provided with a door in the compartment floor. The fuselage tail compartment located near the rear cabin has an entrance door in the bottom of the fuselage tail part.

For emergency escape the aircraft is provided with hatches having jettisonable covers: for the left and the right pilots - in the ceiling of the cabin, for all other members of the crew - in the bottom of the fuselage.

From the inside the sealed cabins are coated with sound- and heat-insulating material.

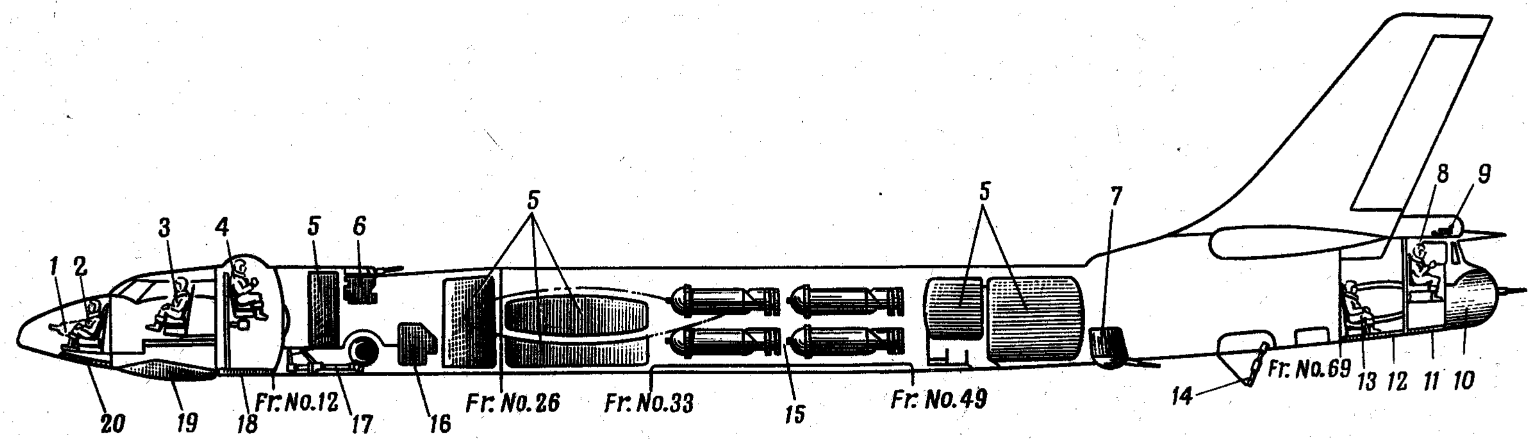

Fig. 4. Fuselage Longitudinal Section

1 – nose 23-mm gun, type AM–23; 2 – navigator; 3 – pilots; 4 – navigator-operator; 5 – fuel tanks; 6 – top gun mount with two 23-mm guns of AM–23 type; 7 – bottom gun mount with two 23-mm guns of AM–23 type; 8 – tail gunner; 9 – antenna of radar gun sight; 10 – tail gun mount with two 23-mm guns of AM–23 type; 11 – entrance door of rear cabin; 12 – radio operator's emergency escape door; 13 – radio operator; 14 – tail skid; 15 – bomb compartment; 16 – camera mount, type АФА-33М; 17 – nose leg; 18 – entrance door of front cabin; 19 – antenna of radar bomb sight, type РБП-4; 20 – navigator's emergency escape door.

The bomb compartment is located in the fuselage between frames Nos 33 and 49 and is closed with a two-leaf door.

Fuel tanks are arranged in the inner wing, in outer wings between wing spars and in the fuselage.

Gun armament of the aircraft comprises one fixed gun in the nose part of the fuselage (for firing in the flight direction) and three movable mountings (top, bottom and tail).

II. AIRCRAFT DESIGN

The aircraft has a straight-line sweep-back at 35° along the aerodynamic centre line, wing dihedral angle in the chord plane being -3°. The wing is a two-spar structure; the middle portion of the wing (case) made of thick-skinned panels is reinforced with stringers and carries fuel tanks arranged between the fuselage and rib No.12. The wing nose is made removable.

The wing has two joints (along the fuselage side and along rib No.7) and carries a symmetrical-section member having a thickness of 15.7% along the fuselage side, a member with a thickness of 15% along rib No.7 and a member of 12% in thickness at the tip of the wing.

The trailing edge of the wing (along its whole length) carries slot flaps and ailerons. The flaps are extended backwards and deflect to an angle of 35°.

The ailerons are aerodynamically balanced along their axes. All the flaps and the ailerons,as well as the wing trailing edge,are made of duralumin.

The fuselage consists of five independent compartments:

(a) nose canopy Ф-I;

(b) front sealed cabin Ф-2;

(c) front compartment Ф-3;

(d) tail compartment with bomb compartment Ф-4;

(e) rear sealed cabin Ф-6.

The fuselage is an all-metal semi-monocoque structure with smooth stressed skin.

The aircraft frame and fuselage skin are made of duralumin.

The nose canopy frame, entrance doors and emergency escape hatch covers, entrance door and emergency escape hatch framings, and the frame of the tail canopy are cast of magnesium alloy. Some unloaded members of the fuselage are made of magnesium alloy sheets.

The aircraft empennage is a one-fin symmetrical cantilever structure having a straight-line sweep-back at 42° along the aerodynamic centre line. The empennage frame and skin are made of duralumin, the fin tip fairing being made of wood. Both fin and stabilizer are fitted with removable nose portions.

The aircraft is controlled through a rigid duplex (from both pilots) control system. Axial aerodynamic balancing and balance tabs of ailerons and empennage are selected so as to exclude boosters in the control system. The elevator trim tabs have duplicating electrical and mechanical (cable) control systems. Aileron and rudder trim tab control is effected by electric actuators only.

Aircraft flaps are controlled through an electric mechanism consisting of two electric motors rotating a common output shaft through a common reduction gear, the output shaft being connected to the flap actuating cylinders.

The aircraft landing gear comprises three legs. Main legs are attached to the first detachable part of the wing and are retracted backwards into the L.G. wells. Each main leg ends in a four-wheel carrier fitted with 1100x330B wheels.

The nose leg carries two 900x275B wheels, the well being located behind the leg if looking upon the aircraft nose.

To improve the aircraft manoeuvrability on the ground, the nose leg wheels are made hydraulically controlled with the help of a handwheel on the pilots' control panel.

A retractable tail skid is installed to protect the rear cabin and the fuselage tail from shocking against the ground during landing. The skid is operated through an electro-mechanical control system, while the landing gear control (emergency control as well) is effected hydraulically.

To reduce the landing run, a container with two drag parachutes is installed in the fuselage tail portion . The drag parachutes are released at the moment the aircraft touches the ground, by the pilot depressing the corresponding push-button. After the movement is slowed, the pilot disconnects the drag parachutes from the aircraft hook. Both release and disconnection are effected by means of an electric control system.

The drag parachutes have a total drag area of 40 sq.m. which considerably reduces the aircraft landing run.

The aircraft hydraulic system is built up of two independent hydraulic lines: main hydraulic system and brake control hydraulic system. The total capacity of both systems together with the service tanks is approximately 115 or 120 lit.

Two hydraulic pumps (units 435B) installed on the engines create pressure in the main hydraulic system (150 kg/sq.cm.) to raise and to lower the landing gear, to actuate the bomb hatch doors and to turn the nose leg wheels.

The brake hydraulic system is used also to effect emergency lowering and retraction of the landing gear and emergency closing of the bomb hatch doors. An electric pump installed in the system buildsup a pressure of 150 kg/sq.cm.

III. POWER PLANT

Two engines of type РД-3М are mounted along the fuselage sides behind the first wing spar and are attached to fuselage frames Nos 43 and 46.

The air stream enters the intakes arranged on both sides of the fuselage ahead of the wings. The engines consume fuel(kerosene T-1 State Standards ГОСТ 4138-49 or fuel TC-1 State Standards ГОСТ 7149-54) from 27 tanks subdivided into 10 groups (5 groups per engine). The maximum amount of fuel filled into tanks at a rated take-off weight of 75800 kg is 34,260 kg (41,400 lit. of fuel T-1 and 43,750 lit. of fuel TC-1). When filled to capacity the aircraft fuel system contains 43,800 lit. of fuel. The fuel is consumed automatically in the following order:

Group No.	Left wing engine	Right wing engine
I	Tanks 1 and 2	Tank 5
II	Tank 4	Tank 3
III	Tanks from 7 to 11 (left)	Tanks from 7 to 11 (right)
IV	Tanks from 12 to 16(left)	Tanks from 12 to 16(right)
V	Tank 6	Tank 6

All tanks except tanks 1, 2 and 5 emptied in the first turn are self-sealing tanks.

The fuel from tank groups 1, 3 and 4 may be drained in case of emergency.

Each engine is provided with an independent oil system to lubricate friction parts. Oil used in the oil systems is grade МК-8 State Standards ГОСТ 6457-53 or transformer oil State Standards ГОСТ 982-53 (without admixtures).

A starting fuel system is provided on the aircraft to feed gasoline to the engines and turbostarters during starting. Used as starting fuel is pure aviation gasoline Б-70(without admixture P-9) State Standards ГОСТ 1012-54 with 1 per cent (in gravimetrical units) of oil used for engine lubrication.

For fire-fighting purposes the aircraft has an inert gas piping and an automatic fire-fighting system.

IV. AIRCRAFT EQUIPMENT

The equipment installed on aircraft allows for the aircraft to fly under any weather conditions in day-time and at night.

1. AERONAVIGATIONAL EQUIPMENT

The aircraft aeronavigational instruments include:
(a) flight-control instruments;
(b) engine-control instruments.

(a) Flight-Control Instruments

Installed in the pilots' and navigator's cabines are:
- celestial compass АК-53П;
- distant-reading celestial compass ДАК-ДБ-5;
- air position indicator НИ-50Б permitting to determine aircraft position in false coordinates;
- distant-reading gyro-magnetic compass ДГМК-7;
- magnetic compass КИ-I2;
- combined air-speed indicator КУС-I200;
- altimeter ВД-20;
- rate-of-climb indicator ВАР-30-3;
- artificial horizon АГБ-2;
- turn indicator ЭУП-53;
- Mach meter МС-1;
- accelerometer;
- aircraft sextant.

(b) Engine-Control Instruments

To control engine operation, the aircraft is provided with the following instruments:
- fuel low pressure gauge ЭДМУ-3;
- engine gauge ЭМИ-3Р to measure high fuel pressure, oil pressure and oil temperature;
- fuel flow meter РТС-16;
- starter tachometer ТУ-45;
- engine tachometer ТУ-5-2;
- exhaust gas temperature gauge ТВГ-II;
- fuel level indicator СЭТС-60М.

To ensure aircraft flight in any weather and facilitate conditions for pilots during long-distance flights, the aircraft equipment includes the electric auto-pilot АП-5-2М.

2. RADIO EQUIPMENT

All radio equipment installed on the aircraft falls under the following three divisions:

(a) Radio Communication Equipment

Radio communication equipment includes:

- short-wave radio set IРСБ-70 ensuring two-way communication with the ground;
- short-wave command radio set IРСБ-70 for command communication in flight and for communication with ground radio stations;
- ultra-short wave command radio set РСИУ-3М for plane-to-plane communication and for communication at starting;
- aircraft intercom set СПУ-IO used by aircraft crew in flight;
- emergency transmitting radio set АВРА-45 to transmit distress signals in case of a forced landing or distress.

(b) Radio Navigational Equipment

Aircraft radio navigational equipment comprises:

- automatic radio compass АРК-5 (Nos 1 and 2) used to fly the aircraft according to signals of homing and broad-casting stations and radio beacons and to calculate aircraft position and instrument landing (two compasses are installed to make the system more reliable and to take bearings of the aircraft relative to two stations or two beacons without re-adjusting compass No.1);
- low-range (РВ-2) and high-range (РВ-17М) radio altimeters to determine true altitude of flight;
- instrument landing system (localizer receiver КРП-Ф, glide slope receiver ГРП-2, transmitter and receivers of range finder СД-I and marker receiver МРП-48П).

(c) Radiolocation Equipment

Aircraft radiolocation equipment consists of:

- radar bomb sight РБП-4 used for spotting ground and sea surface targets under no-visibility conditions, for solving navigational problems by using ground stations and for performing precision bombing with automatic dropping of bombs at altitudes ranging from 10,000 to 15,000 m.; radar sight РБП-4 is electrically connected with optical sight ОПБ-IIр;
- IFF system comprising СРО transponder.

Depending on the tasks assigned every member of the crew can use or control aircraft radio facilities according to Table 1.

Table 1

Aircraft Radio Equipment Operation

Crew members	Radio equipment														
			АРК-5 radio compass						Instrument landing system						
	command set I-РСБ-70М	communication set I-РСБ-70	No.1	No.2	РСИУ-3М ultra-short wave radio set	РВ-2 low-range radio altimeter	РВ-17М high-range radio altimeter	РБП-4 bomb sight	ГРП-2 glide slope receiver	КРП-Ф localizer receiver	МРП-48П marker receiver	СД-I range finder	СРО transponder	ШРС-I radar gun sight	СПУ-IO aircraft intercom set
Navigator	+	+	+0	+0	+		+0	+							+
Left pilot	+0	+		+	+0				+	+	+				+
Right pilot	+	+	+0		+0	+0			+0	+0	+	+0	+0		+
Navigator-operator	+	+			+			+0							+0
Radio operator	+	+0			+										+
Tail gunner					+									+0	+

Notes: + means usage only.
+0 means usage and control.
++ stands to show that radio operator can operate the IPCБ-70M command set with the help of a key only (the set being tuned by the left pilot).

3. ELECTRICAL EQUIPMENT

All electrical consumers installed on the aircraft are supplied with:

(a) $28^{+0.5}$ V D.C. produced by four ГСР-I8000 generators and 12-CAM-55 storage battery connected in parallel. The generators are rotated through engine drives, their total continuous output being 72 kW.

The storage battery can also be used as a reserve power source.

(b) One-phase D.C. of $115 \pm 3\%$ V,400 c.p.s.,produced by two ПО-4500 inverters converting D.C. of $28^{+0.5}$V into A.C., the inverters being used alternately.

The aircraft electric system is a one-conductor system (aircraft frame being used as second conductor) employing screened and non-screened brass wire of БПВЛ type. To decrease the electric equipment weight, the D.C. distribution system is wired with aluminium wire of БПВЛА type.

Main consumers on the aircraft are:

- bomb and gun electric control systems;
- engine starting system;
- engine fuel system electric units (fuel pumps, pump control system, fuel shut-off cocks, fire-fighting equipment, fuel level and quantity gauge, etc.);
- aircraft control system units (auto-pilot, flap, trim tab and tail skid electric mechanisms, brake automatic system, etc.);
- flight-control and navigational electric devices (flight-control instruments, distant-reading gyro-induction compass, air position indicator, distant-reading celestial compass),
- heater and de-icer electric facilities (cabin heaters, tail unit and glass panel de-icers, etc.);
- sound and light signalling systems;
- inner and outer lighting systems;
- radio and radar equipment.

Total current intensity consumed by the above units amounts to approximately 1700 A (250 A for gun control systems, 470 A for tail unit de-icer system, 530 A for cabin and glass panel heater systems, etc.); all consumers when connected simultaneously use 70 per cent of total power produced continuously by ГСР-I8000 generators. Due to this the generators give some excess power thus providing for normal operation of the aircraft electrical equipment in case some power generators fail and maintaining stable voltage in the electric main at the moment some powerful consumers are connected to the circuit.

To increase aircraft endurance, the aircraft electric system is divided into three circuits:

(a) aircraft circuit to which all the four generators in any combination and the storage battery may be connected;

(b) emergency circuit which may be supplied from only one generator (No.2 or No.3) and the storage battery;

(c) two-source circuit which is automatically (by means of special change-over contactors) connected either to the aircraft circuit if it is under voltage or to the emergency circuit if the aircraft circuit is de-energized.

The above circuits supply current to the following bus bars:

(a) bus bars constantly connected to the aircraft circuit. These bus bars feed the consumers necessary under normal operating conditions but whose operation can be spared in case the aircraft circuit is damaged (auto-pilot, tail unit de-icer, etc.);

(b) two-source circuit bus bars which can be supplied both from the aircraft electric circuit and from the emergency circuit. These bus bars supply consumers which allow for the aircraft to fulfil the task and return to the air base even if the aircraft circuit is damaged(bomb control system, fuel pumps, flight-control instruments, ПО-4500 inverter, etc.);

(c) three-source bus bar which is normally connected to the two-source circuit. In case the aircraft and emergency circuits fail, this bus bar is manually connected to the storage battery.

The three-source bus bar supplies the consumers allowing to perform an emergency landing, such as:

- reserve artificial horizon, turn indicator and left impact pressure tube heater;
- distant-reading celestial compass;
- aircraft interoom set (СПУ-IO) circuit No.1;
- emergency lighting system (ultra-violet lamps of the pilot's instrument panel and of the navigator's instrument panel, КИ-I2 compass lamps, and inspection lamp plug connector in the pilots' cabin);
- brake automatic unit;
- drag parachute release and disconnection system;
- fire-fighting system;
- РСИУ-3 radio set;
- fuel shut-off and cross-feed cocks;
- in-flight starting.

Two consumers (emergency bomb release and transponder destruction circuits) are kept constantly connected to the storage battery, consequently they can be used at any moment without an additional connection or change-over of power sources.

Normally the emergency circuit is de-energized serving as a reserve circuit to be used only when the aircraft electric circuit fails.

As is clear from the above, the aircraft power supply system operates in one of the following ways:

1. Normal duty. Any consumer installed on aircraft is supplied from generators and the storage battery connected to the aircraft circuit.

2. Emergency duty (aircraft circuit de-energized). Only those consumers which are connected to the two-source or three-source bus bars supplied from generators No.2 or No.3 and storage battery are connected to the emergency circuit.

The circuit operational time is unlimited.

3. Operation with aircraft and emergency circuits de-energized.

The storage battery connected to the circuit supplies only vital consumers. Operational time is limited to 2 hrs (maximum).

Two ground connectors are provided in the nose wheel well to connect ground power sources: D.C. ground connector on the left wall of the well, A.C. ground connector on the right wall of the well.

4. PHOTOGRAPHIC EQUIPMENT

The aircraft photographic equipment includes:

1. Day camera АФА-33М/75 or АФА-33М/IOO for aerial reconnaissance and bombing control.

2. Day camera АФА-33М/50 for bombing control from low altitudes.

3. Night camera НАФА-8С/50.

4. Camera ФАРЛ-I for photographing images on the РБП-4 radar sight screen.

In case of a reconnaissance flight the aircraft may take 24 photo flash bombs (ФОТАБ) suspended in the bomb compartment.

5. ALTITUDE EQUIPMENT

The air for cabin pressurization and heating purposes is taken from the 7th stages of air compressors of both РД-3М engines. Maximum air consumption in each cabin is 500 cu.m/hr.

Total quantity of air taken from both engines constitutes 2000 cu.m/hr, so the cabins may be sufficiently supplied with air from only one engine.

The pressure in the cabins is regulated automatically by two air pressure valves of АРД-54 type provided in both cabins. The АРД-54 valves maintain:

- atmospheric pressure in the cabin at altitudes up to 2000 m., and constant pressure corresponding to 2000 m. at altitudes from 2000 m. to 7250 m.;
- constant pressure drop of 0.4 kg/sq.cm. relative to the outside pressure beginning from 7250 m.

When the aircraft enters the anti-aircraft fire zone or when it becomes engaged with enemy fighters, the pressure in the cabin is reduced manually, if the ККД cabin pressure cock is installed, or automatically in case of the АРД-54 valve to a drop of 0.2 kg/sq.cm. relative to the outside pressure. This is done with the purpose of preventing a sharp pressure drop in the event the cabin skin becomes damaged.

To ventilate cabins at low altitudes, a special system is provided with outside air intakes installed on the right side of the fuselage behind frame No.13 (for the front cabin) and in the leading edge of the fin (for the rear cabin).

The aircraft pressurized cabins ensure normal conditions for crew members in respect of temperature and pressure (cabin altitude).

To maintain normal conditions in the cabin in case the АРД-54 valve fails, the cabins have the ККД manual cabin pressure control cocks ensuring a drop of 0.05 to 0.43 kg/sq.cm.

6. OXYGEN EQUIPMENT

The aircraft is equipped with a liquid oxygen supply system of КПЖ-30 type having two oxygen bottles and oxygen breathing apparatus of КП-24м type (for each member of the crew). Besides, each member of the crew has a КП-23 parachute oxygen breathing apparatus.

7. DE-ICER EQUIPMENT

The wing leading edges are fitted with a heat de-icer supplied with hot air from the engines. The pipe lines of the left and right de-icers are interconnected to ensure normal hot air supply in case one of the engines fails.

The inlet part of the engine air duct, the air intake partition and the front edge of the starter air duct have a separate hot air de-icer preventing ice formation on these parts in flight or when the engine is running on the ground.

The leading edges of the fin and stabilizer are fitted with thermo-electrical de-icers.

The front glass panels of the pilots' cabin and the front sight glass panel of the navigator's compartment are defrosted with the help of inner electrical de-icers. Besides all windshields of the navigator's compartment and of the pilots' cabin, as well as blisters of the sights are blown with hot air.

8. LIFE-SAVING EQUIPMENT

For cases of ditching two inflation life-saving boats of ЛАС-5М type are stowed in the upper part of the fuselage at frames Nos 12 - 15 and 62 - 63. When dropped the boats become inflated with CO_2 from bottles secured to them.

Each member of the crew is provided with an individual first-aid kit, thermos and flight ration.

To protect pilots' eyes against sun rays,the canopy is fitted with light filters and visors. The navigator's canopy is protected with visors.

V. EMERGENCY ESCAPE EQUIPMENT

For emergency escape in the air all members of the crew are provided with ejection seats.

The pilots' seats are ejected upwards. Prior to ejection the seats must be shifted into the extreme rearward position, the canopy covers must be removed, and the control sticks must be swung forward.

Maximum overload during ejection equals 18 g, jettison initial speed V_0 = 20 - 22 m/sec. being sufficient for the pilots to clear the fuselage fin.

All other members of the crew (navigator, navigator-operator, radio operator and tail gunner) are jettisoned downwards after the emergency escape hatch covers are removed. Maximum overload reaches 3 or 5 g.

In ditching or in landing with the landing gear retracted, the crew of the front cabin leave the aircraft through the hatches in the canopy, while the crew of the rear cabin escape through the hatch of the rear cabin canopy.

The aircraft floatability is sufficient to give time for the crew to take seats in the life boats. The aircraft floatability may be considerably increased by switching on the fuel emergency draining before reaching the water surface.

VI. AIRCRAFT ARMAMENT

For purposes of strategic bombing the Ty-16 aircraft is provided with modern bombing equipment.

Gun armament of the aircraft provides means to repel the enemy in the air.

1. BOMBING EQUIPMENT

The Ty-16 aircraft has one bomb compartment equipped with a typical bomb release system.

Normal bomb load is 3000 kg, whereas maximum bomb load is 9000 kg.

Types of bombs used to calculate bomb load are given in Table 2.

The aircraft bomb release (including also bomb emergency release) is effected electrically.

Table 2

Types of Bombs Used to Calculate Bomb Load

Bombs M-46		
calibre, kg	quantity, pc	total weight, kg
100	-	-
250	24	6000
500	18	9000
1000	-	-
1500	6	9000
2000	-	-
3000	2	6000

The ЭСБР-49А electric bomb release installed on the aircraft ensures single and serial bomb release at all altitudes and all speeds.

The bomb equipment system is connected to the two-source electric circuit.

Bombing is performed with the help of the ОПБ-IIр optical sight with an automatic course-setting unit connected with the auto-pilot system. Due to this the aircraft course correction can be done automatically by the navigator at laying on the target.

When bombing through the overcast or at night the aircraft is aimed with the help of the РБП-4 radar bomb sight. As the ОПБ-IIр optical sight is connected with the РБП-4 radar sight and provides all necessary data for sighting, the accuracy of bombing increases in this case.

Bombing is performed by the navigator. Bombing can also be performed by the navigator-operator who will use a bomb release push-button for the purpose. The data for bombing will be set by the navigator.

The bomb compartment doors are actuated by the hydraulic system or by springs in case the hydraulic system fails. The door opening system is controlled electrically, the control being normally effected by the navigator.

In automatic bombing from the ОПБ-IIр sight the doors are opened by the sight immediately before bomb release.

The door emergency control in bomb emergency release is effected by the navigator and the left pilot. The closing of the doors in emergency may be performed by any of the pilots.

For night actions the aircraft can carry 12 signal flare bombs of ЦОСАБ-IO type. The bombs are suspended from two ДЯ-СС flare bomb carriers installed in the signal flare bomb hatches. These bombs are released by the navigator.

2. GUN ARMAMENT

The aircraft gun armament consists of seven АМ-23 23-mm guns installed on one fixed and three rotary mountings. All guns are provided with distant-control systems.

The fixed gun mounting installed in the nose part of the fuselage (to the starboard) is intended to effect the nose-on fire. It has 100 cartridges and is controlled by the left pilot. The gun is sighted with the help of the ПКИ collimator sight secured on a hinged mount.

All the three rotary mountings (top, bottom and tail) afford protection in the rear hemisphere, the top mounting also serves to conduct fire in the upper part of the front hemisphere.

(a) Top Gun Mounting

The top gun mounting fire sector is 360° along the horizon, $90^{\circ}{}_{-2^{\circ}}$ upwards and $3^{\circ}{}_{-1^{\circ}}$ downwards. The mounting is furnished with 500 shells. Normally the gun is controlled by the navigator-operator, in case of emergency the gun is controlled by the tail gunner.

(b) Bottom Gun Mounting

The bottom gun mount firing angles are: $95^{\circ}{}^{+1^{\circ}}$ to both sides from the aircraft centre line along the horizon (in the rear hemisphere), $2^{\circ} \pm 40'$ upwards and $90^{\circ}{}_{-2^{\circ}}$ downwards. Full ammunition supply is 700 shells.

Normally the gun is controlled by the radio operator from two sighting posts (left and right). In case of emergency the gun is controlled by the tail gunner.

(c) Tail Gun Mounting

The tail gun mounting firing zone is: $70^{\circ}{}_{-1^{\circ}}$ to both sides from the aircraft centre line along the horizon (in the rear hemisphere), $60^{\circ}{}_{-1^{\circ}}$ upwards and $40^{\circ}{}_{-1^{\circ}}$

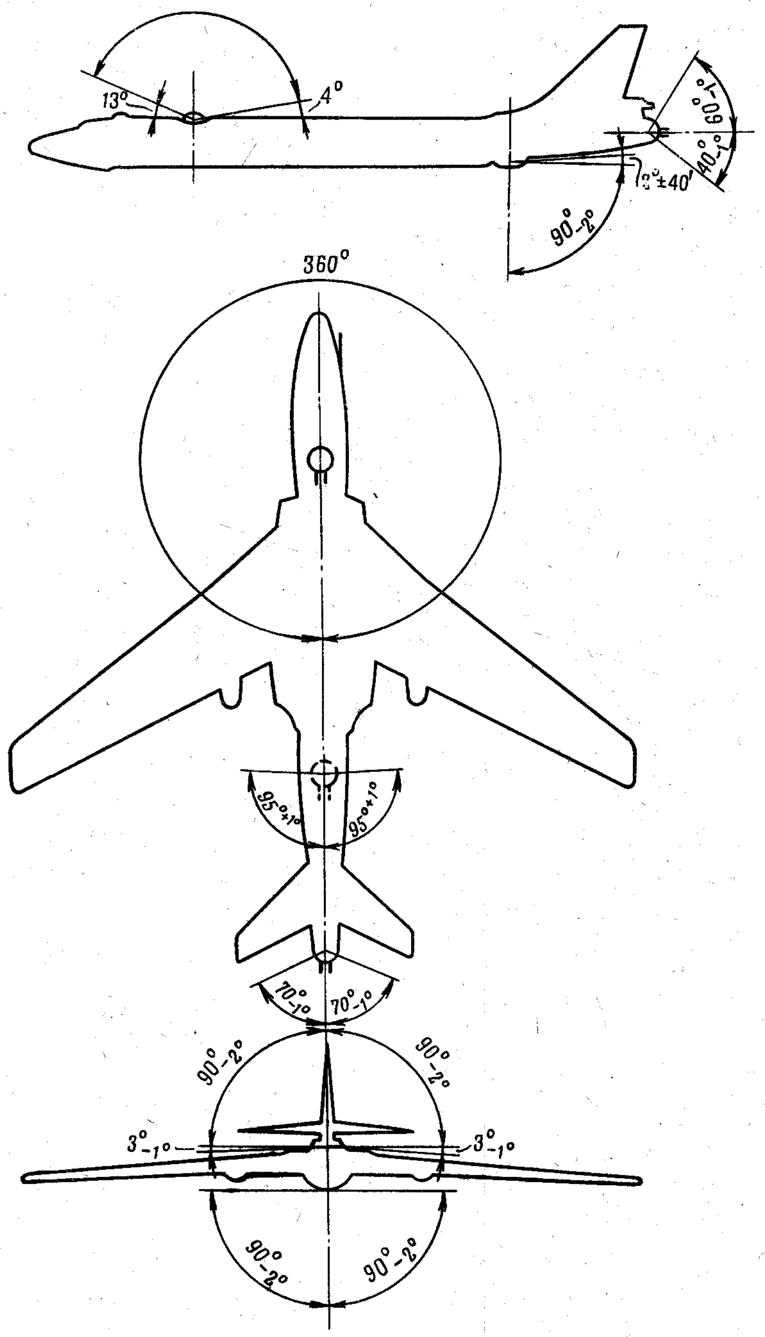

Fig. 5. Aircraft Gun Fire Sectors

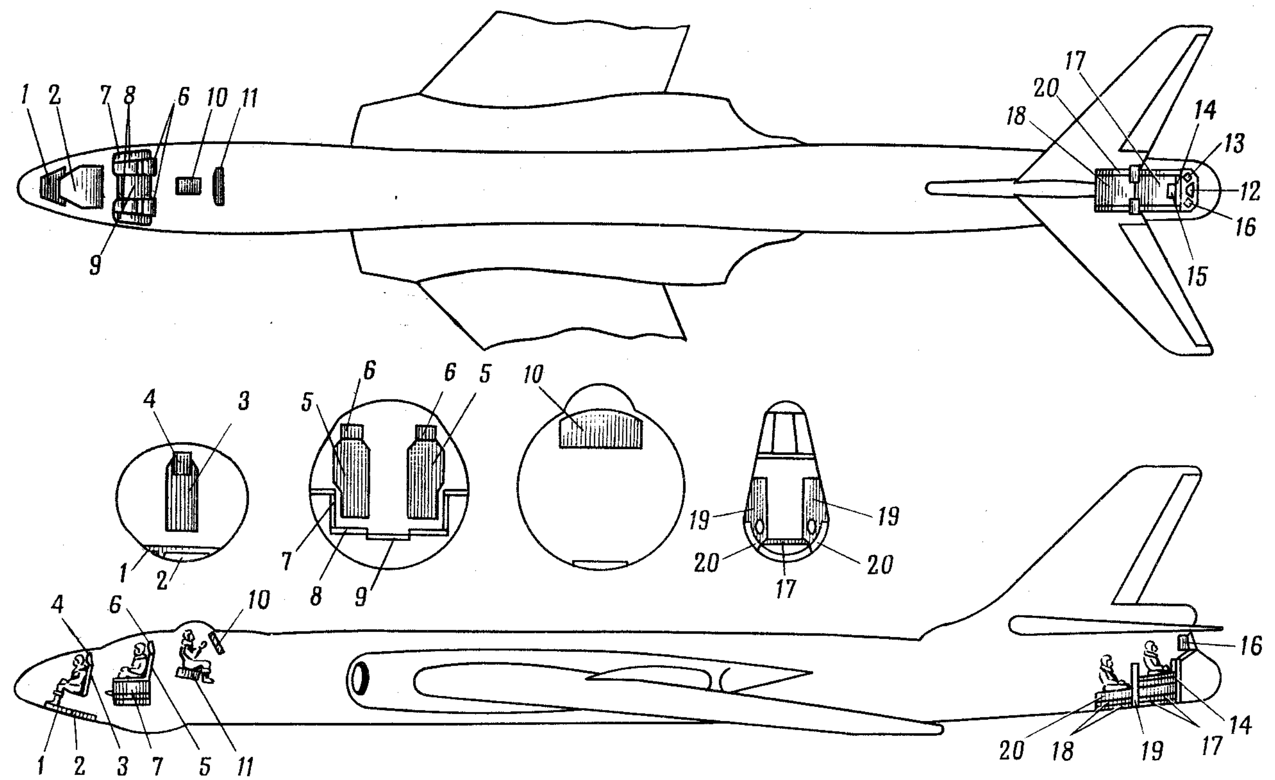

Fig. 6. Aircraft Armour Plating

1 – navigator's cabin floor; 2 – navigator's cabin door; 3 – back plate of navigator's seat; 4 – armoured head plate of navigator's seat; 5 – back plate of pilot's seat; 6 – pilot's seat armoured head plate; 7 – pilot's seat armoured side plates; 8 – pilots' cockpit armoured floor; 9 – pilots' cockpit armoured floor; 10 – navigator-operator's cabin armour plating; 11 – navigator-operator's seat bowl; 12 – rear cabin armoured windshield; 13 – rear cabin armoured glass side panels; 14 – tail gunner's cabin armour plate; 15 – tail sight armour plate support; 16 – tail cabin canopy frame; 17 – tail gunner's cabin door; 18 – rear cabin emergency escape door; 19 – radio operator's cabin armour plating; 20 – side armour plate.

downwards. Full ammunition supply is 500 shells.

The gun mounting is normally controlled by the tail gunner which acts as commander in charge of aircraft gun fire. For cases of emergency the tail gun control may be duplicated: in the upper sighting post by the navigator-operator and in the lower sighting post - by the radio operator.

The aircraft sighting posts are equipped with sighting stations of ПС-53 type.

To ensure firing under any conditions of visibility, the aircraft is furnished with the ПРС-I radar gun sight which is synchronized with the aircraft gun mounts.

The ПРС-I radar gun sight controls firing in the rear hemisphere through the ranges of 35° to both sides from the aircraft centre line along the horizon, of 35° upwards and 35° downwards.

The aircraft gun firing zones are shown in Fig.5. The distribution of ammunition is given in Table 5.

Table 5

Gun Ammunition Supply

Gun mount	Ammunition supply at normal take-off weight		Full ammunition supply	
	number of shells		number of shells	
	per gun	per mount	per gun	per mount
Nose gun mount	100	100	100	100
Top gun mount	250	500	250	500
Bottom gun mount	250	500	350	700
Tail gun mount	350	700	500	1000

VII. AIRCRAFT ARMOUR PROTECTION

The aircraft crew is protected against shell splinters and the fire of enemy fighters with armour plates (See Fig.6).

The list of armour plates installed on the aircraft is given in Table 6.

The aircraft armament and armour protection provide possibilities to carry out tasks under a heavy fire of the enemy anti-aircraft defence.

Table 6

Aircraft Armour Plating

Nos	Description	Quantity, pc.	Thickness, mm	Material
1	2	3	4	5
	Front cabin			
1	Navigator's floor	1	8	АПБА-I
2	Navigator's entrance door	1	8	АПБА-I
3	Navigator's seat back plate	1	24	АПБА-I
4	Navigator's seat head plate	1	10	Steel Ст. КВК-2/5Ц
5	Pilots' seat back plate	2	20	Steel Ст. КВК-2/5Ц
6	Pilots' seat head plate	2	25	Steel Ст. КВК-2/5Ц
7	Pilots' side plates	2	6	АПБА-I
8	Pilots' floor	2	8	АПБА-I
9	Pilots' floor	1	15	Glass textolite

1	2	3	4	5
10	Navigator-operator's plating	1	10	Steel Ст.КВК-2/5Ц
11	Navigator-operator's seat bowl	1	8	АПБА-I
	Rear Cabin			
12	Windshield	1	135	Bullet-resistant glass
13	Side glass panels	2	105	Bullet-resistant glass
14	Tail gunner's protection	1	24	Steel Ст.КВК-2/5Ц
15	Tail sighting station base plate	1	10	Steel СТ.КВК-2/5Ц
16	Canopy frame	1	10	Elektron
17	Tail gunner's entrance door	1	5+5	Elektron + АПБА-I
18	Emergency hatch cover	1	5+5	Elektron + АПБА-I
19	Radio operator's protection	2	14	АПБА-I
20	Side armour plate	2	5	АПБА-I
21	Armour plates under canopy Ф-6	5	10	КВК-2

VIII. AIRCRAFT PERFORMANCE CHARACTERISTICS

1. DIMENSIONS
(Fig.7)

(a) Linear dimensions

Wing span . . . . 32.989 m.
Stabilizer span . . . . 11.750 m.
Aileron span . . . . .2 x 5.3 m.
Flap span . . . . 2 x 6.87 m.
Mean aerodynamic chord .5.021 m.
Fuselage length . . . . 34.800 m.
Aircraft theoretical height . . . . 10.355 m.
Aircraft actual height . . . . 9.850 m.
Wheel track . . . . 9.775 m.
Longitudinal wheel base . . . . 10.913 m.

(b) Area dimensions

Wing surface area . . . . 164.65 sq.m.
Horizontal empennage area:
(a) total area . . . . 34.452 sq.m.
(b) elevator area (without ground-adjustable trim tabs). 8.646 sq.m.
(c) elevator balance tab area (without ground-adjustable trim tabs) . . . . 2.554 sq.m.
Aileron surface area (without ground-adjustable trim tabs) . . . . .14.77 sq.m.
Aileron axial compensating surface area (without ground-adjustable trim tabs) . . . . 4.9236 sq.m.
Vertical empennage area:
(a) total area . . . . 23.305 sq.m.
(b) rudder area . . . . .5.213 sq.m.
(c) rudder axial compensating surface area. . . . . .1.5 sq.m.
Fuselage middle section . . . . .4.9 sq.m.

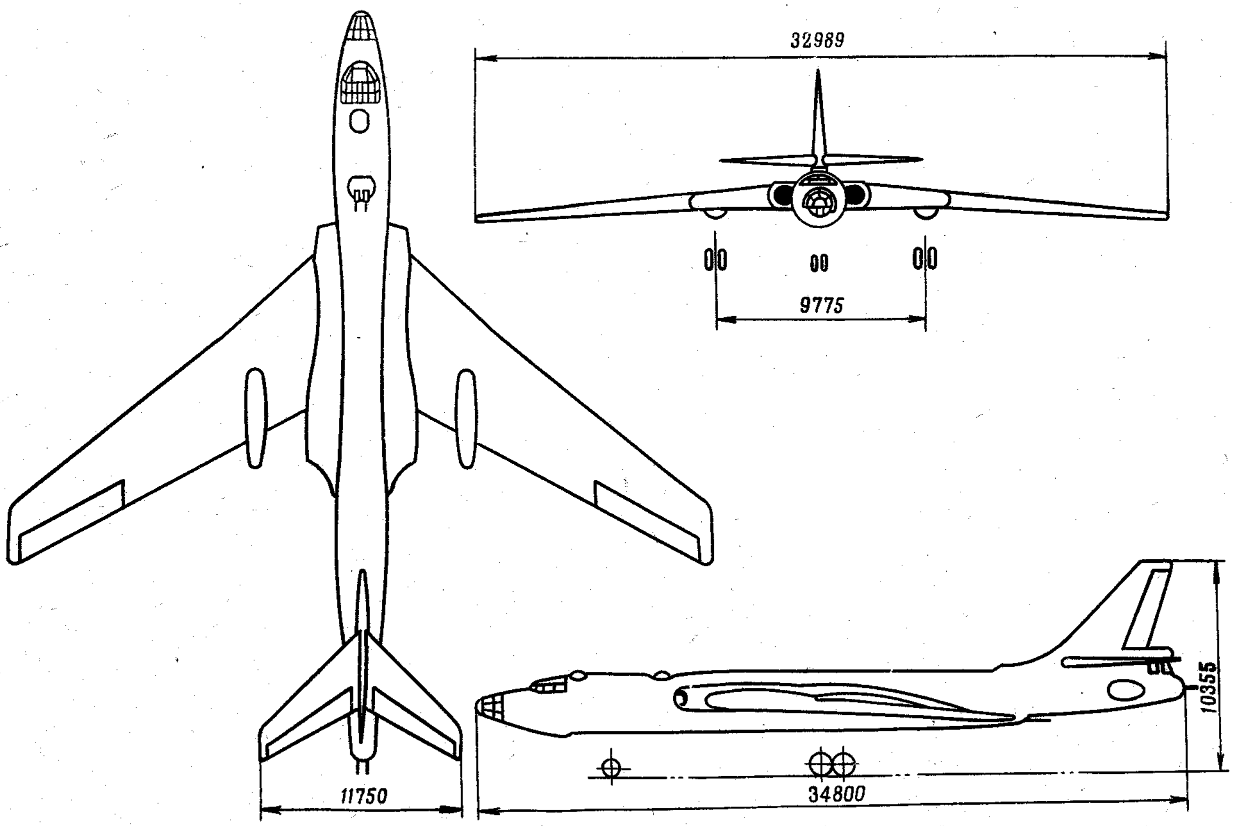

Fig. 7. Aircraft Dimensions Drawing

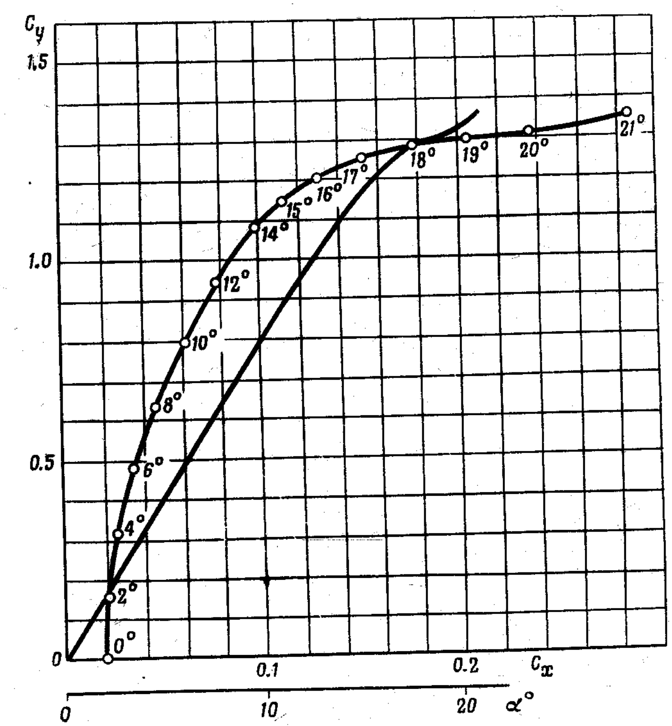

Fig. 8. Aircraft Polar Curve

(c) Basic Specific Values

Wing elongation 6.627
Wing plan sweep-back along aerodynamic centre line . . . . $+35^{\circ}$
Wing taper 2.416
Lateral dihedral in chord plane . . . . -3°
Wing setting angle . . . . $+1^{\circ}$
Aileron deflection angle . . . . $+15^{\circ}{}_{-1^{\circ}}$
Flap deflection angles:
during take-off. . . . . -20°
during landing . . . . -35°
Fuselage elongation 13.9
Stabilizer sweep-back along aerodynamic centre line . . . . $+42^{\circ}$
Rudder sweep-back along aerodynamic centre line . . . . $+42^{\circ}$
Stabilizer setting angle in relation to wing . . . . $-2^{\circ}30'$
Stabilizer arm (from 25% of wing MAC to 25% of stabilizer MAC). . 14.645 m.
Rudder arm . . . . 13.952 m.
Longitudinal static stability factor 0.61
Elevator deflection angles:
downwards . . . . $12^{\circ}{}_{-1^{\circ}}$
upwards . . . . $26^{\circ}{}_{-1^{\circ}}$
Rudder turn angle . . . . $\pm 25^{\circ}{}_{-1^{\circ}}$
Elevator trim tab deflection angle (from control panel handwheels) . . . . $\pm 12^{\circ}{}_{-2^{\circ}}$
Elevator trim tab deflection angle (from electric actuating mechanism) . . . . $\pm 8^{\circ}\ {}^{+1^{\circ}}$
Rudder trim tab deflection angle . . . . $\pm 7^{\circ} \pm 1^{\circ}$
Aileron trim tab deflection angle . . . . $\pm 5^{\circ}$
Directional static stability factor 0.06

The aircraft polar curve for maximum speed and the curve $C_y = f(\alpha)$ are shown in Fig.8.

2. WEIGHT AND FLIGHT LIMITS

1. Aircraft maximum take-off weight is 75,800 kg.
2. Aircraft normal weight taken as the weight of the aircraft over the target at a maximum technical range equals 55,000 kg.
3. Permissible landing weight equals 48,000 kg.

In cases of emergency it is allowed to land the aircraft weighing 55,000 kg provided the aircraft is landed over a concrete runway with utmost care displayed on the part of the pilot.

4. The speeds given below may be attained when flying the aircraft with the flaps deflected:

(a) 400 km/hr (indicated speed) with flaps deflected at angles up to 20°;
(b) 340 km/hr (indicated speed) with flaps deflected at angles above 25°.

5. The aircraft landing gear may be actuated at speeds up to 400 km/hr (indicated speed).

3. TACTICAL FLIGHT CHARACTERISTICS
(Test data)

1. Maximum speeds at engine take-off rating ($n = 4700 \pm 50$ r.p.m.) with flying weight equalling 55,000 kg:

at altitude of 6250 m. . . . . 992 km/hr
at altitude of 10,000 m. 938 km/hr

2. Maximum speeds at engine rated duty ($n = 4425 \pm 25$ r.p.m.) with flying weight equalling 55,000 kg:

at altitude of 6250 m. . . . . 958 km/hr

at altitude of 10,000 m. . . . . .915 km/hr

3. Service ceiling at engine rated duty ($n = 4425 \pm 25$ r.p.m.) with take-off weight equalling 57,000 kg . . . . .12,800 m.

4. Service ceiling at engine rated duty ($n = 4425 \pm 25$ r.p.m.) with take-off weight equalling 71,560 kg . . . . .11,300 m.

5. Time necessary for attaining service ceiling with take-off weight of 57,000 kg . . . . 31 min.

6. Time necessary for attaining service ceiling with take-off weight of 71,560 kg . . . . 38 min.

7. Maximum flying range with take-off weight of 71,560 kg(including G_{bomb} = 3000 kg) in service ceiling flight . . . .5640 km.

8. Maximum flying range with take-off weight of 72,000 kg (including G_{bomb} = 3000 kg) in ceiling flight . . . . 5760 km.

9. Take-off run and take-off distance (up to 25-m.altitude) at engine take-off duty ($n = 4700 \pm 50$ r.p.m.) with flaps at 20°:

with take-off weight of 57,000 kg . . . . from 1140 to 1885 m.

with take-off weight of 71,560 kg . . . . .from 1900 to 3165 m.

10. Take-off speed:

with take-off weight of 57,000 kg . . . . .250 km/hr

with take-off weight of 71,560 kg . . . . .280 km/hr

11. Time of take-off run:

with take-off weight of 57,000 kg . . . . .28.7 sec.

with take-off weight of 71,560 kg . . . . .45 sec.

12. Landing run and landing distance with landing weight of 44,000 kg, with flaps at 35°:

without drag parachute . . . . from 1655 to 2785 m.

with drag parachute . . . . .from 1050 to 2180 m.

13. Time of landing run with landing weight of 44,000 kg:

with drag parachute . . . . 28.5 sec.

without drag parachute . . . . .34.5 sec.

14. Landing speed with landing weight of 44,000 kg . . . . 223 km/hr

4. FLIGHT CHARACTERISTICS

Take-off weight . . . . .75,800 kg

Fuel weight . . . . .34,460 kg

Crew weight . . . . .600 kg

Bomb weight . . . . .3000 kg

Ammunition supply weight . . . . 700 kg

Aircraft basic weight (trapped fuel, starting fuel and oil included) . . . . .37,040 kg

<u>Take-Off:</u>

$G = 75{,}800$ kg; $n = 4700 \pm 50$ r.p.m.; $\delta_{flap} = 20°$;

$L_{take\text{-}off\ run} = 2180$ m.; $V_{take\text{-}off} = 288$ km/hr; $L_{take\text{-}off\ distance} = 3375$ m.

The aircraft take-off and landing performance is shown in Fig. 9.

Aircraft flying technical range (until fuel is completely used up) is 6430 km. (See Fig.10).

Maximum flying range with 5% fuel reserve is 5970 km.

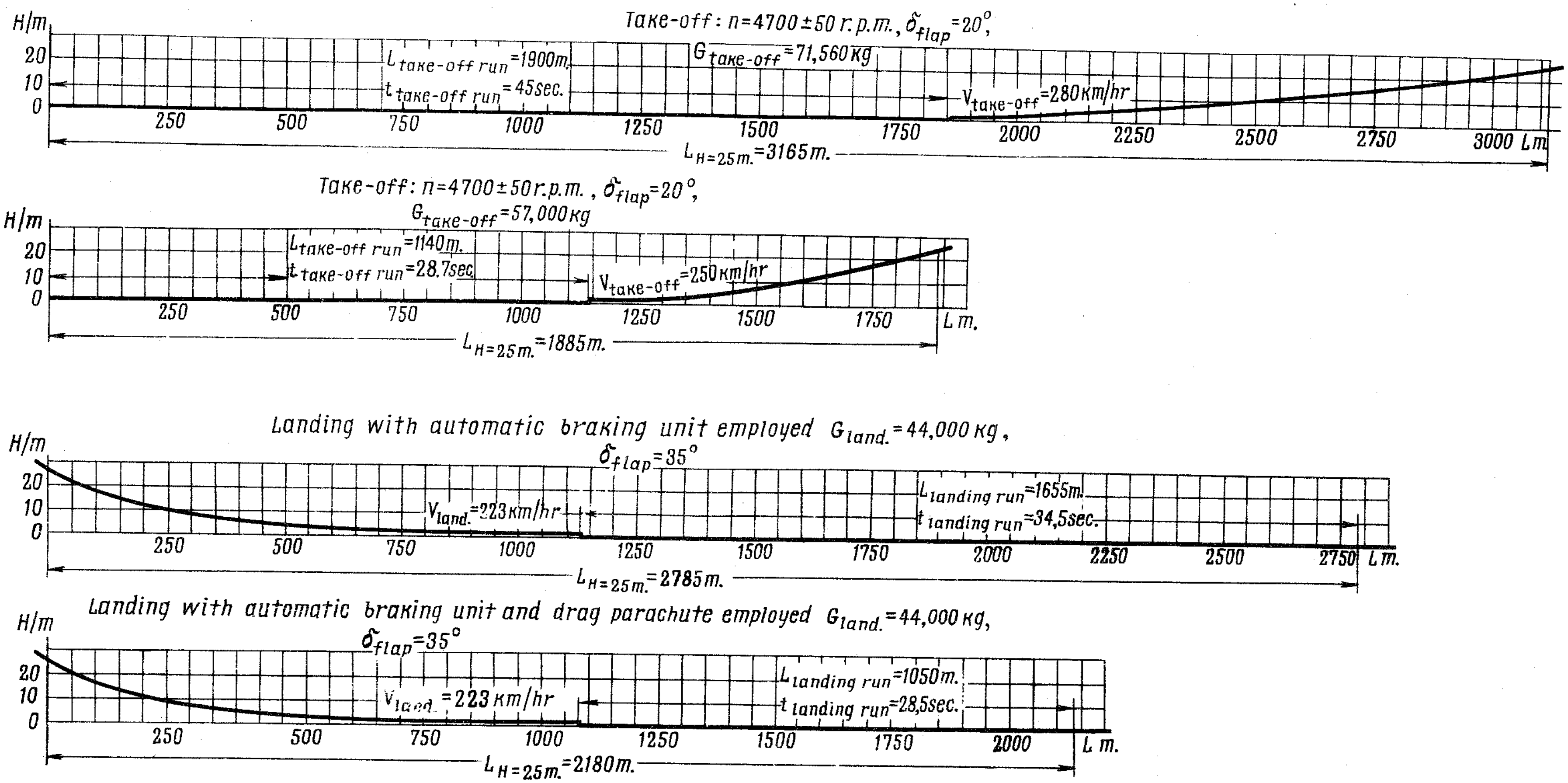

Fig. 9. Aircraft Take-Off and Landing Performance

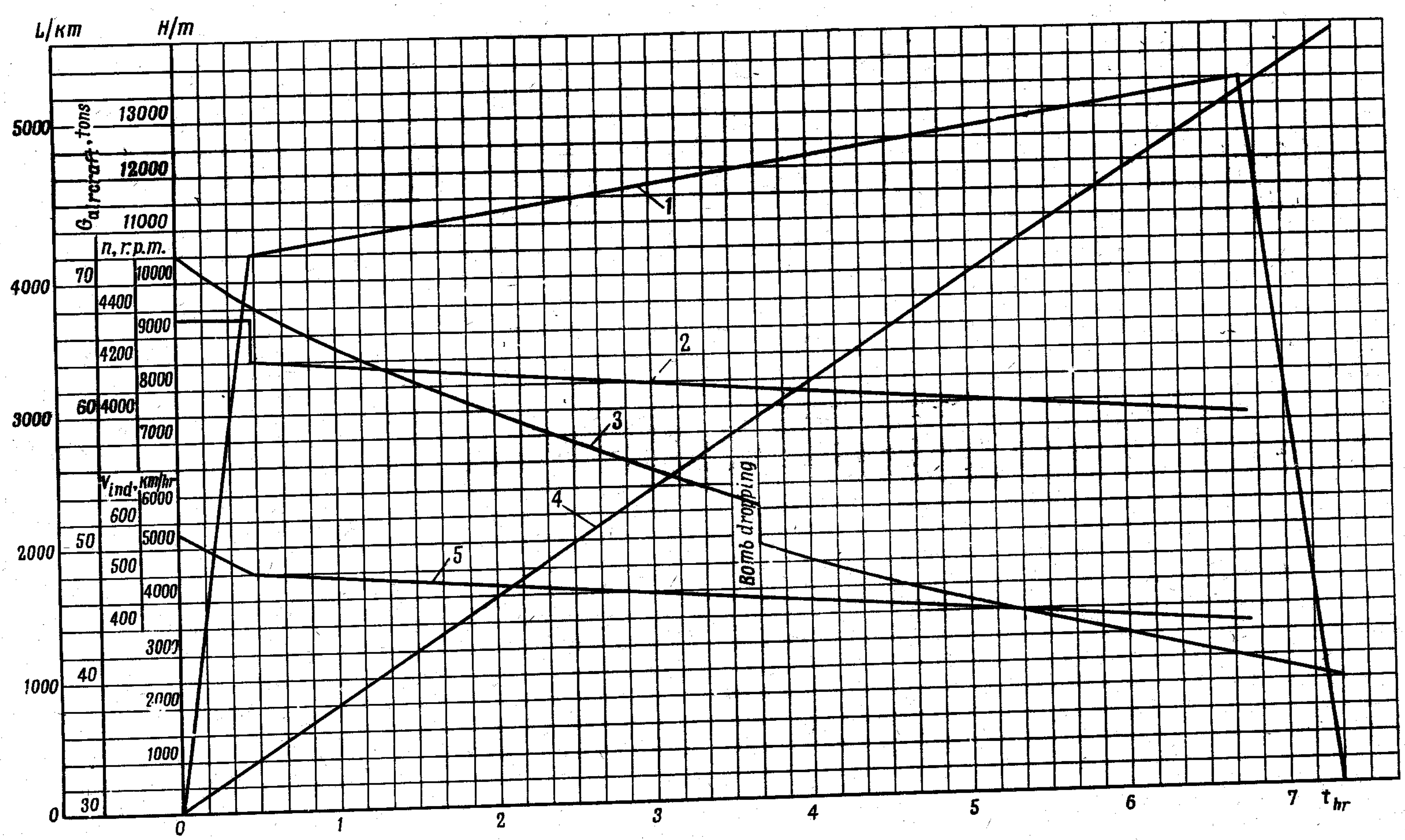

Fig. 10. Technical Flying Range Curve

1 – aircraft flight curve; 2 – engine r.p.m.; 3 – change in aircraft weight; 4 – indicated speed; 5 – technical range of flight.

IX. AIRCRAFT WEIGHT AND BALANCE DATA

1. WEIGHT DATA

(a) Normal flying weight . . . . 55,000 kg
Load . . . . 18,400 kg
Aircraft basic weight (oil, starting fuel and trapped fuel excluded) . . . . .36,600 kg

Load

Crew (six members) . . . . 600 kg
Fuel . . . . 14,050 kg
Oil . . . . .50 kg
Bombs . . . . .3000 kg
Ammunition supply (1800 shells) . . . . .700 kg
(b) Rated take-off weight . . . . .72,000 kg
Load . . . . 35,400 kg
Aircraft basic weight (oil, starting fuel and trapped fuel excluded) . . . . 36,600 kg

Load

Crew (six members) . . . . 600 kg
Fuel . . . . 31,050 kg
Oil . . . . .50 kg
Bombs . . . . .3000 kg
Ammunition supply (1800 shells) . . . . .700 kg

2. AIRCRAFT BALANCE DATA

(a) Position of Coordinate Axes and Wing MAC

The origin of coordinates is the intersection point of the aircraft datum line and centre wing second spar axis.

The fuselage datum line is axis X, its positive progress being towards the aircraft tail. Axis Y coincides with the axis of fuselage frame No.33, it being positive upwards from the zero point.

The MAC of the wing is considered to be parallel to the fuselage datum line due to the insignificantly small angle of wing wedging angle.

The length of the MAC is 5021 mm.

(b) Position of MAC in Coordinate Axes System

The wing MAC originates at a distance of 968 mm away from the centre wing second spar (See Fig.11).

The aircraft balance is calculated according to the following formula:

$$X\%_{MAC} = \frac{X_o - 968}{5021} 100,$$

where:

$$X_o = \frac{\Sigma M}{G_{aircraft}}.$$

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(c) Aircraft Balance Calculation
(Tables 7, 8, 9)

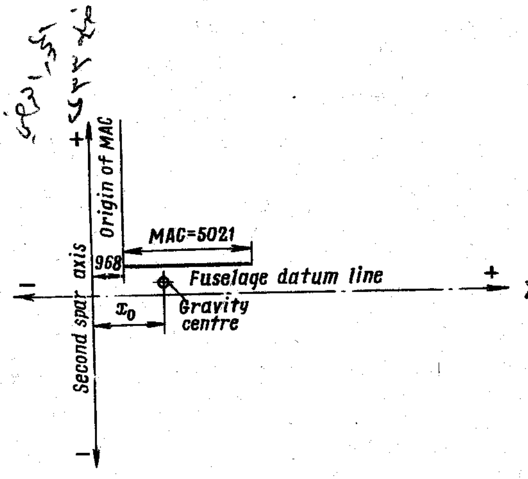

Fig. 11. Relative Position of Coordinate Axes and MAC

Table 7

Take-Off Weight = 72,000 kg (G_{fuel} = 31,050)

Description	P x, kg-m	X, m.	P, kg	Balance, % of MAC
Aircraft basic weight (L.G. extended)	98,500	2.688	36,600	34.3
Front cabin crew	-4420	-11.05	400	
.ear cabin crew	3563	17.816	200	
Ammunition supply	4070	5.82	700	
Oil	70	1.4	50	
Bombs	7530	2.51	3000	
Fuel, 5th group tanks	-7620 / -7160	-1.7	4480 / 4210	25.4 x) / 25.9
Fuel, 4th group tanks	15080 / 14190	2.98	5060 / 4760	26.9 / 27.2
Fuel, 3rd group tanks	3480 / 3270	0.358	9720 / 9130	20.5 / 21.1
Fuel, 2nd group tanks	16730 / 15730	3.13	5350 / 5030	22.4 / 22.9
Fuel, 1st group tanks	10300 / 12670	1.6	6440 / 7920	21.5 / 21.6
Total (L.G. extended)	147283 / 148013	2.047 / 2.053	72000 / 72000	21.5 / 21.6
L.G. retraction	3234			
Total (L.G. retracted)	150517 / 151247	2.09 / 2.10	72000 / 72000	22.5 / 22.6

x) Refer to numerator when the aircraft is filled with fuel T-1 (specific weight is 0.83) and to denominator when the aircraft is filled with fuel TC-1 (specific weight is 0.78).

Table 8

Flying Weight = 55,000 kg (G_{fuel} = 14,050 kg)

Description	P x, kg-m	X, m.	P, kg	Balance, % of MAC
Aircraft basic weight (L.G. extended)	98500	2.683	36,600	34.3
Front cabin crew	-4420	-11.05	400	
Rear cabin crew	3563	17.816	200	
Ammunition supply	4070	5.82	700	
Oil	70	1.4	50	
Bombs	7530	2.51	3000	
Fuel, 5th group tanks	-7620 / 7160	-1.7	4480 / 4210	25.4 x) / 25.9
Fuel, 4th group tanks	15080 / 14190	2.98	5060 / 4760	26.9 / 27.2
Fuel, 3rd group tanks	1613 / 1818	0.358	4510 / 5080	23.7 / 23.6
Total (L.G. extended)	118386 / 118161	2.154 / 2.150	55000 / 55000	23.7 / 23.6
L.G. retraction	3234			
Total (L.G. retracted)	121620 / 121395	2.210 / 2.207	55000 / 55000	24.8 / 24.7

x) Refer to numerator when servicing aircraft with fuel T-1 (specific weight is 0.83) and to denominator when servicing aircraft with fuel TC-1 (specific weight is 0.78).

Table 9

Landing Weight = 44,000 kg (G_{fuel} =6750 kg)

Description	P x, kg-m	X, m.	P, kg	Balance, % of MAC
Aircraft basic weight (L.G. extended)	98500	2.688	36,600	34.3
Front cabin crew	-4420	-11.05	400	
Rear cabin crew	3356	17.816	200	
Oil	70	1.4	50	
Fuel, 5th group tanks	-7620 / -7160	-1.7	4480 / 4210	23.6 x) / 24.1
Fuel, 4th group tanks	6760 / 6970	2.98	2270 / 2540	24.5 / 24.8
Total (L.G. extended)	96646 / 97316	2.197 / 2.210	44000 / 44000	24.5 / 24.8

x) Refer to numerator when servicing aircraft with fuel T-1 (specific weight is 0.83) and to denominator when servicing aircraft with fuel TC-1(specific weight is 0.78).

C O N T E N T S