INFORMATION REPORT INFORMATION

CENTRAL INTELLIGENCE AGENCY

S-E-C-R-E-T
NO FOREIGN DISSEM

COUNTRY USSR

REPORT

SUBJECT English-Language Manual on the Soviet VK-1F Aircraft Engine

DATE DISTR. 16 October 1963 50X1-HUM

NO. PAGES 1 50X1-HUM

REFERENCES

DATE OF INFO.

PLACE & DATE ACQ

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1. 238-page, English-language manual on a Soviet aircraft engine, entitled Technical Description of the VK-1F Engine. The date 1958 appears on the cover of the manual but no other publishing data are given. The document is classified SECRET by the Soviets. Page 230 is missing in the original. 50X1-HUM

2. The VK-1F engine is described as a version of the VK-1A, one of the modifications being the addition of an afterburner which increases the take-off thrust by 25 percent over the older model. 50X1-HUM

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INFORMATION REPORT INFORMATION REPORT

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TECHNICAL DESCRIPTION OF THE VK-1F ENGINE (English Language) 1958

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COPY No.

TECHNICAL DESCRIPTION

OF WK-1F ENGINE

PAGE 1 - 230

- 1953 -

TECHNICAL DESCRIPTION

OF WK-1F JET ENGINE.

C H A P T E R I.

GENERAL INFORMATION ABOUT THE ENGINE.

In the present book is given the technical description of the aircraft jet engine WK-1F with afterburner, which has a guarantee life of 100 hours and is a version of the WK-1A engine.

As compared with the WK-1A engine the design of WK-1F engine has some substantial modifications, connected with burning of additional fuel injected after the turbine as follows:

1. On the front side of the turbine disc ring a step is provided and in the labyrinth sealing of the turbine is added the fourth comb for limiting the gas flow into the space of engine rear bearing.

2. The turbine body has no centering collar and for lightening it has milled groeves between the holes on flanges for bolts. Analagous milled grooves are on the rear flange of outer ring of the gas guide vane ring.

Instead of the jet pipe, extended jet pipe and discharge nozzle to the body of the turbine through the telescopic joint the afterburner is fastened with a remote controlled discharge nozzle, having a hydraulic control system. The thermocouples for measuring of the exhaust gases temperature are placed in the afterburner.

4. Engine auxiliaries drive box is calculated for mounting of fuel pumps PN-9MA and PN-14A. The box has a deaerator on the side wall with a draining neck, the box cover is of oval form. The parts of auxiliaries drives and of the centrifugal separator are assembled as independent assemblies and the front support of the central shaft is placed in the box body.

5. On the bracket, mounted on the upper part of engine auxiliaries drive body, is mounted the aircraft auxiliaries drive box type DM or D2M.

6. On the body of oil pumps box instead of the throttle cock DK-6K is fastened the fuel distributor ART-14A and the electromechanism MG-2, connected with the latter through a reducing gear, is fastened on the front wall of the box body. The driving wheel of the oil pumps is reinforced by increased length of the teeth.

7. For operation of the main propulsion fuel system on the engine the upper fuel pump PN-9MA is mounted. The pump is plunger type, has an all range regulator and a throttle cock.

8. Delivery of fuel into afterburner /additional fuel system/ is secured by the lower pump PN-14A of plunger type, with barometrical regulator and electromagnetic valve for disengaging of afterburner.

9. Engaging and disengaging of fuel supply system for the afterburner is performed by ART-14A distributing automat, which also engages the afterburner ignition system circuit breaker and the hydraulic drive of the extensible jet nozzle.

10. The filtering element of the fuel strainer of engine, which is common for both systems, consists of single mesh sections, assembled into a set.

11. The collector of electric leads has an additional line and a connector SzR-7S for feeding of electric equipment of the afterburner

12. The electric system of the afterburner is independent on the engine electric system. The engaging and disengaging system of afterburner consists of: electromechanism type MG-2, circuit breaker, ignition plug SD-92, mounted in the afterburner, the ignition coil KPM-1A and electrohydraulic actuator GA-13M/3, mounted in the aircraft.

Design Principles.

The engine WK-1F is an air-reaction jet engine with compressor and gas turbine, the thrust of which can be increased by additional burning of fuel after the turbine /afterburner/. The WK-1F engine is calculated for increase of the take-off thrust of the basic engine WK-1A by 25 per cent in ground conditions. The general view of the engine is given in fig.5.

The WK-1F engine consists of the following assemblies: auxiliaries gear box with oil pumps drive box, accessories of fuel system and electric equipment, one-stage centrifugal compressor with two-sided intake of air, nine direct-flow combustion chambers, placed round the bodies of the centre and rear bearings, engine rotor, one-stage gas turbine with guide vanes and afterburner. The shaft of engine rotor consists of three parts: the front and rear shaft of the compressor and the turbine shaft. On the rear shaft of the compressor is placed a centrifugal fan for air cooling of the centre and rear bearings and of the turbine disk. The front shaft of the compressor is coupled with the central shaft of engine auxiliaries drive box, which has flanges for fastening of auxiliaries of the engine and of the aircraft auxiliaries drive box.

The stressed, fastening part of the engine consists of housing of the front, centre and rear bearing, of compressor housing and of two frames-the front and the rear one. The mentioned parts form the surface shell of the engine, inside of which are mounted the compressor inlet branches, the rotor of the compressor and the rotor of turbine.

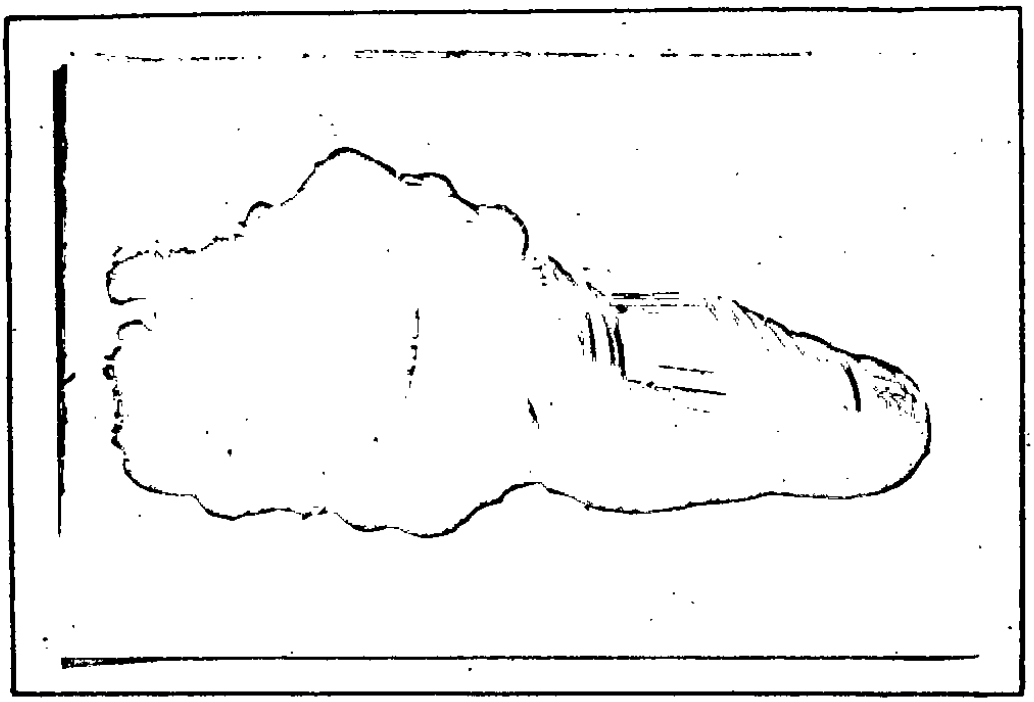


Fig.1. VK-1F Engine, View From Front Right Side.

Fig.2. VK-1F Engine, Front View.

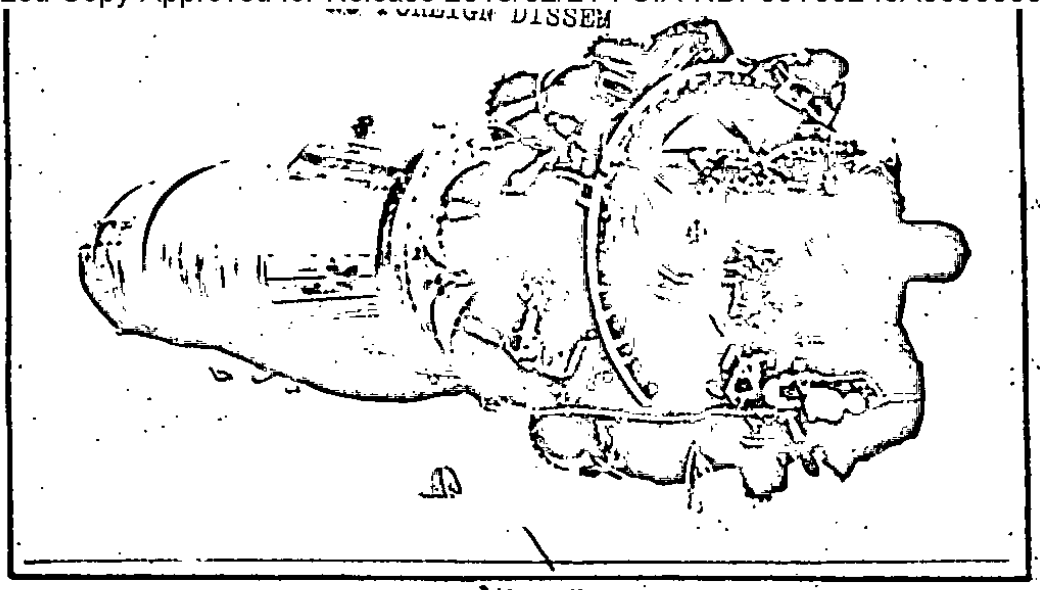


Fig.3. VK-1F Engine
/View from front left side/

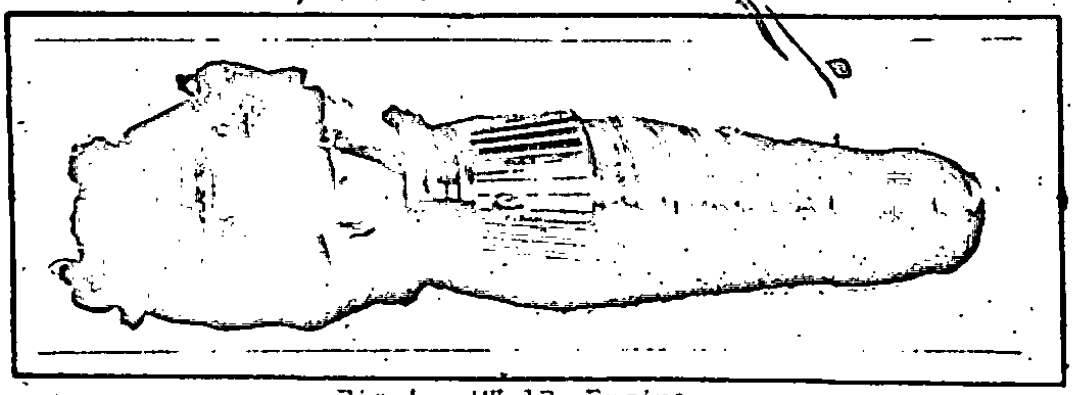


Fig.4. VK-1F Engine
/View from rear right side/.

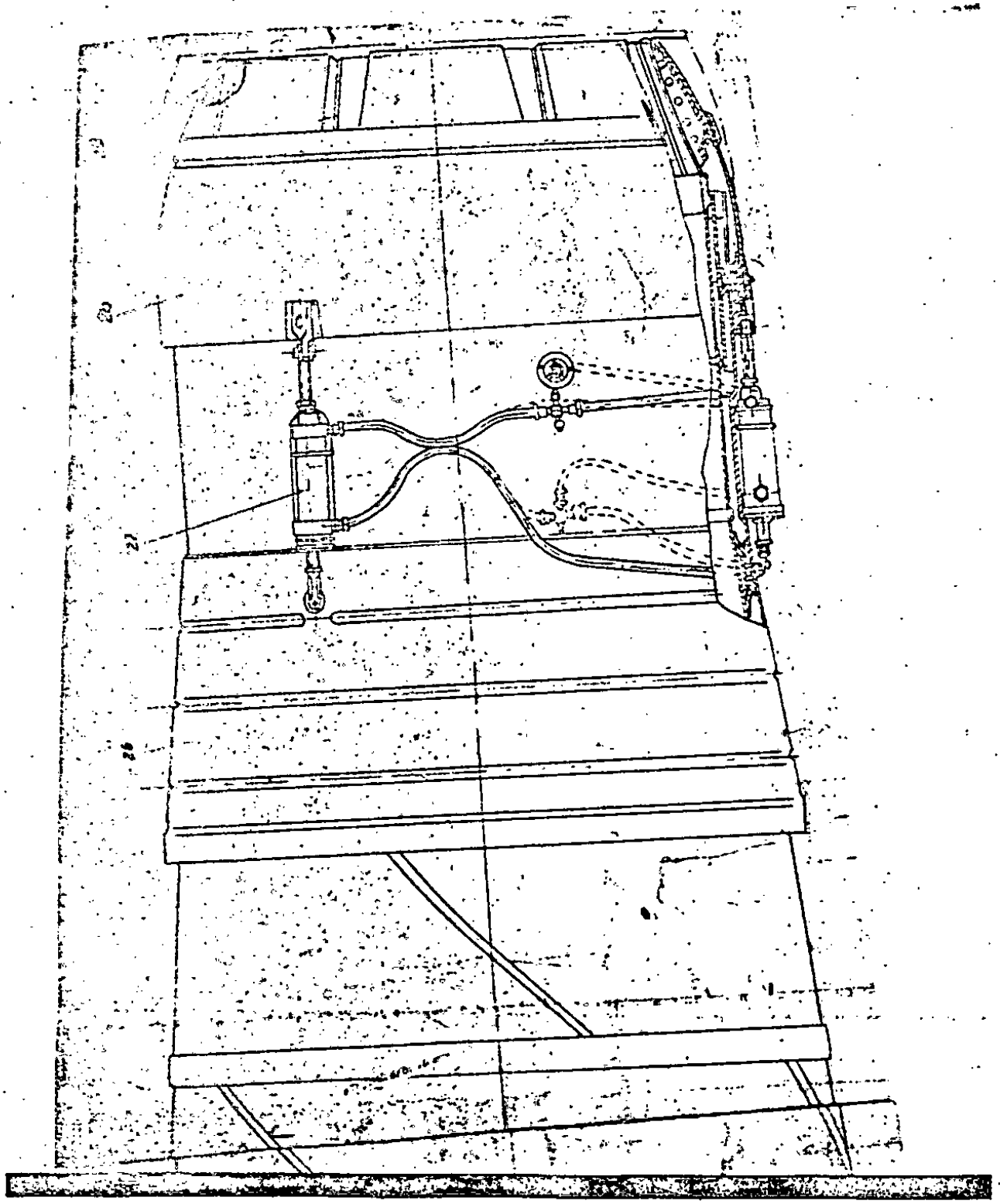
The afterburner consists of a widening, cylindrical and tapering part. The tapering part is ended by an extensible jet nozzle, allowing to regulate the discharge cross-sectional area of exhaust gases for engine running with and without afterburner. The extensible jet nozzle is controlled by hydraulic system.

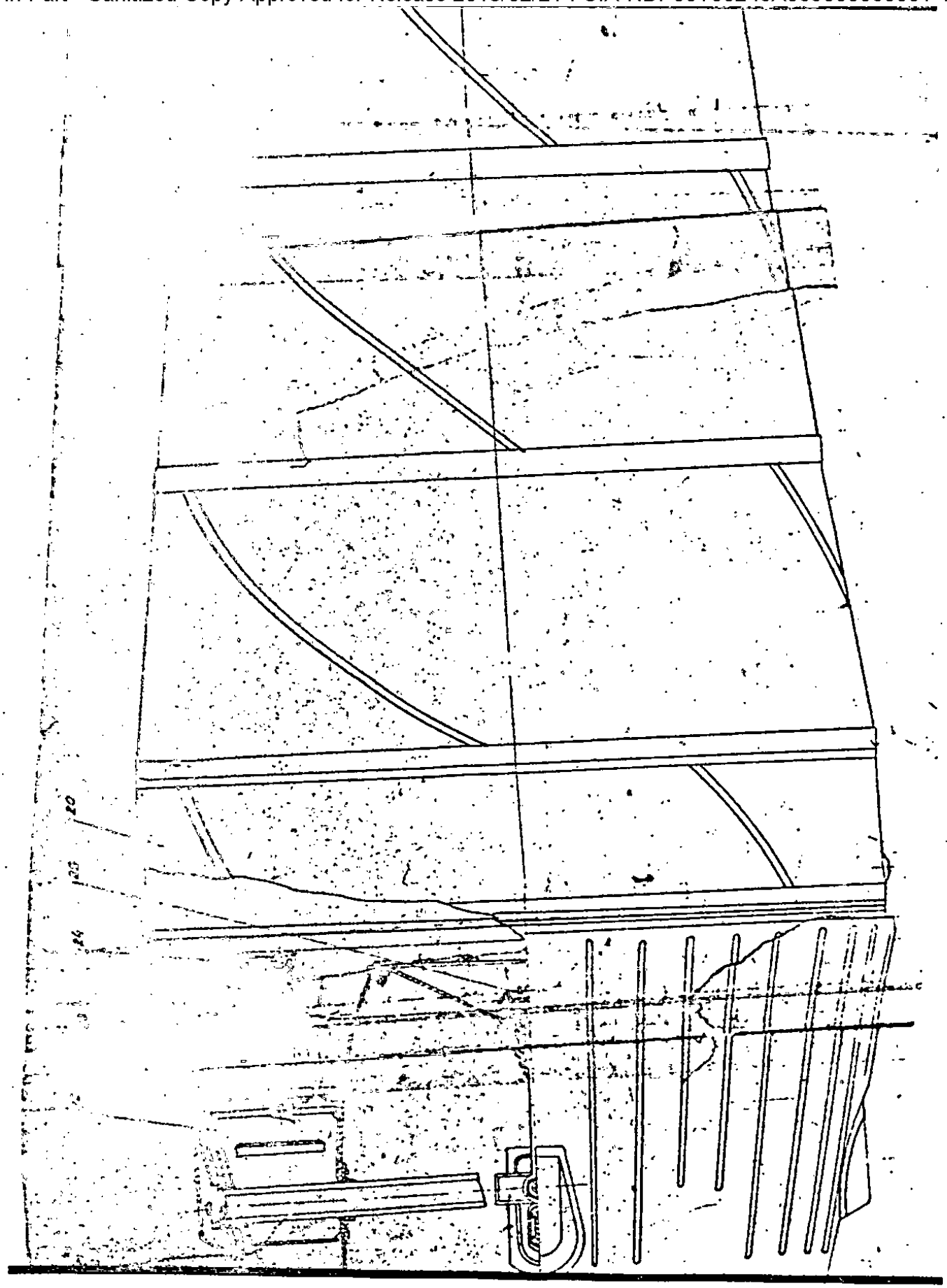
The hydraulic system consists of three hydraulic power jacks, the electro-hydraulic valve and pipelines, connected to the airplane hydraulic system. In the widening part of the afterburner are placed burners, injecting the additional amount of fuel and further the equipment, securing the ignition and reliable and stable burning of the injected fuel.

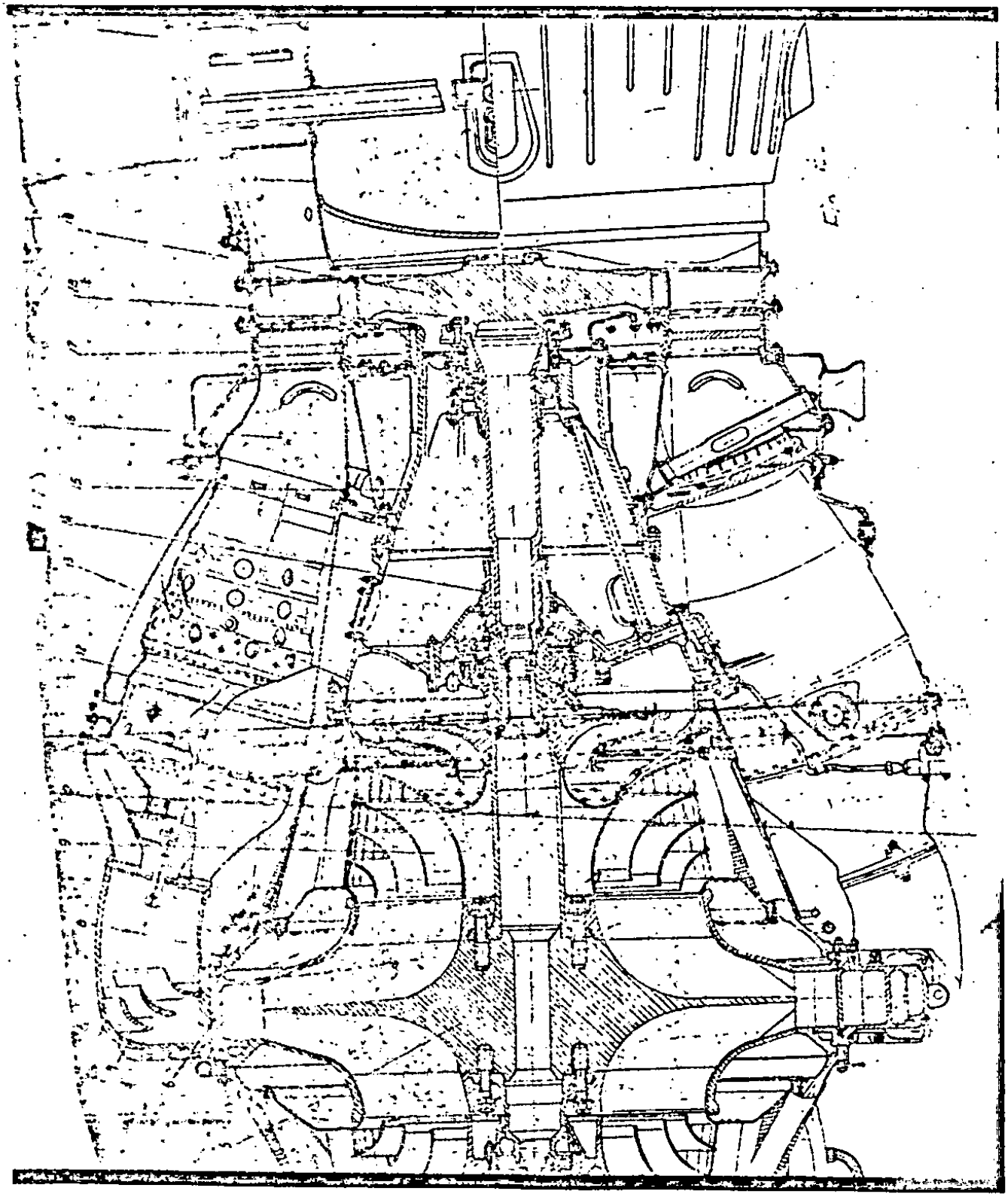
DESCRIPTION TO FIG.5.

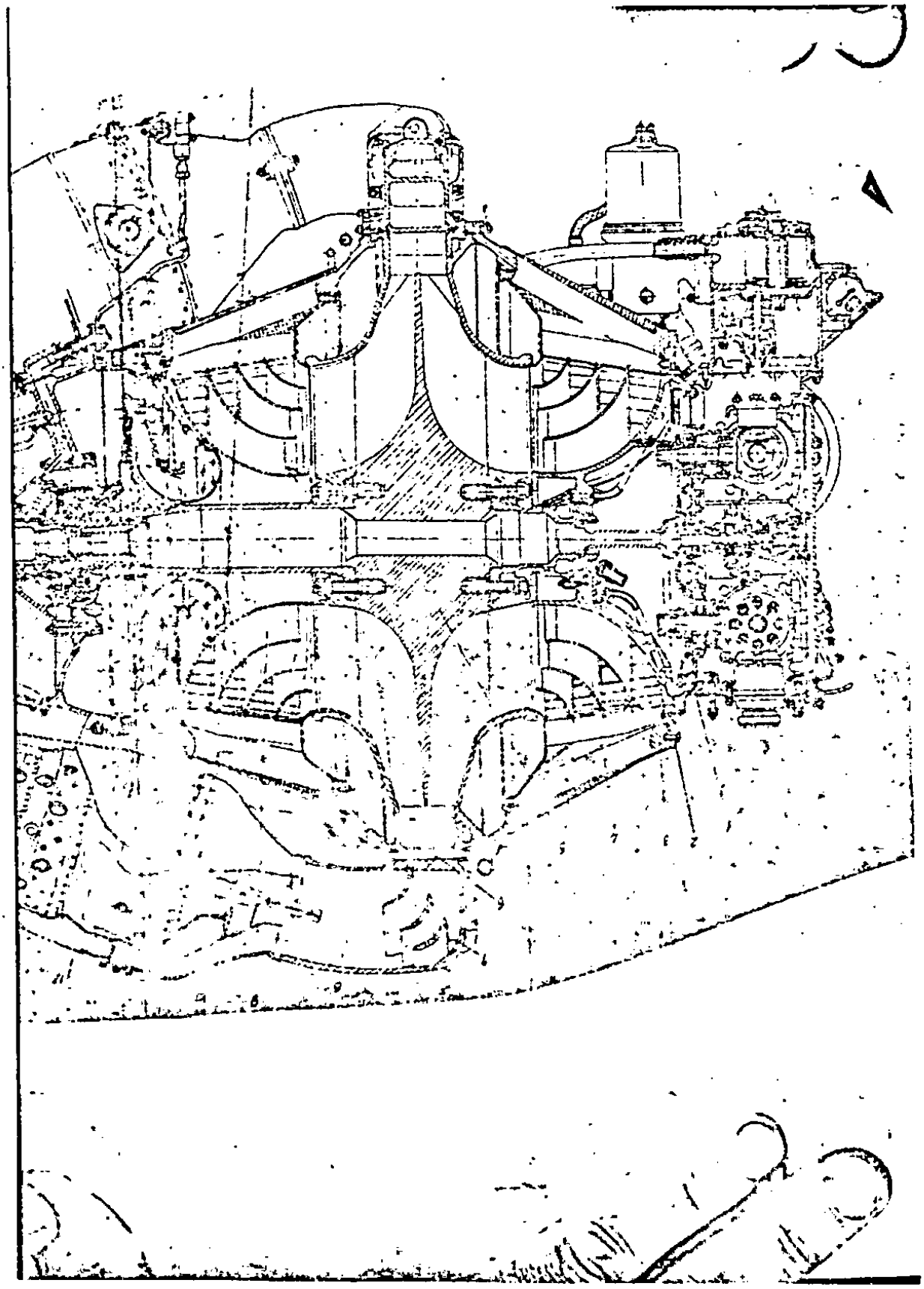
SECTIONAL VIEW OF THE ENGINE.

1. Engine auxiliaries drive box.
2. Housing of the front bearing
3. Front frame
4. Front inlet branch
5. Rotor of the compressor
6. Housing of the compressor
7. Inlet elbow of combustion chamber
8. Rear frame
9. Rear inlet branch
10. Operating burner
11. Combustion chamber
12. Fan
13. Housing centre bearing
14. Connecting clutch
15. Housing of rear bearing
16. Gas collector
17. Guide vanes
18. Housing of the turbine
19. Rotor of the turbine
20. Afterburner
21. Inner cone
22. Shield of fastening bolt
23. Heat-insulating cover
24. Ring-type stabilizer with fuel collector
25. Ignition coil
26. Vent jacket
27. Hydraulic jack
28. Ring housing of extensible jet nozzle
29. Oil...









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Principle of function of the Engine.

The air enters the compressor 4 through the front and rear intake branches 2 /fig.6./ each of them has three guide vanes, serving for diminishing of air flow losses on the intake and for a proper directing of the air flow. Thereafter the air runs into the intakes of blade wheel and farther into channels of compressor blade wheel 4, where it is compressed. When coming therefrom, air with great speed runs into the diffusor, where the speed energy of air is transformed into pressure energy. From the compressor the compressed air runs into the combustion chambers 6 of engine through nine inlet elbows of combustion chambers, in each of them there are three guide vanes 3, placed in a row and serving for bowing of the air flow and for lessening of losses of air flow energy in the place where the air flow bows.

Fuel is injected under pressure through the working burners into the inner shells, mounted inside the combustion chambers. During burning of the fuel there if consumed approximately 25 per cent of air, coming into the combustion chambers. The remaining quantity of air, mixed with the products of burning, lowers the gas temperature to the value, at which the engine runs reliably. Fuel is completely burnt in the combustion chambers and the gases originated by the burning, flow through the guide vanes to the turbine blades. The greater amount of energy of gases is absorbed for driving of the compressor 4 by intermediary of the turbine. From the turbine are driven also the cooling fan 5 and the auxiliaries, mounted on the engine auxiliaries drive box 1 and on the aircraft auxiliaries drive box. The remaining energy of the

gases is used for generation of thrust. As compared with other jet engine, the WK-1F engine has afterburner 11 instead of the jet pipe. Fuel, intended to be burnt in the afterburner, is injected by 24 burners against the direction of the gas, flowing out of the turbine. The reliable burning of fuel in the gas stream after the turbine is impossible without additional equipment - flame stabilizers. The stabilizers are necessary for keeping the flames front and their surface and thus for securing a steady and continuous burning. The stabilisation of the burning in the afterburner of the engine WK-1F is secured by formation of return streams of gas in the tear-off zone, behind the ring shaped stabilizer 10 and inner cone 9, mounted in the widening part of the afterburner. The injected fuel begins to burn after the stabilizer and ends in general before the gas passes through the jet nozzle. The gas temperature increases by this up to 1300-1500 degree Centigrade.

As the afterburner has a widening part 665 mm long, the air flow is allowed to decrease its speed in the combustion zone and thus, in spite of a relatively short afterburner a complete combustion of fuel is secured. The afterburner is engaged, i.e. fuel is injected and burnt there only an when an increased thrust must be secured. During the remaining time, the afterburner serves as a jet pipe. In accordance with it, the conditions of operation of the afterburner are varying. In order to secure in both cases a stable gas temperature after the turbine, the afterburner is provided with an extensible jet nozzle 12, which has two cross-sectional areas. When the additional fuel injection is OFF, the extensible jet nozzle is set into the position with minor cross-sectional area.

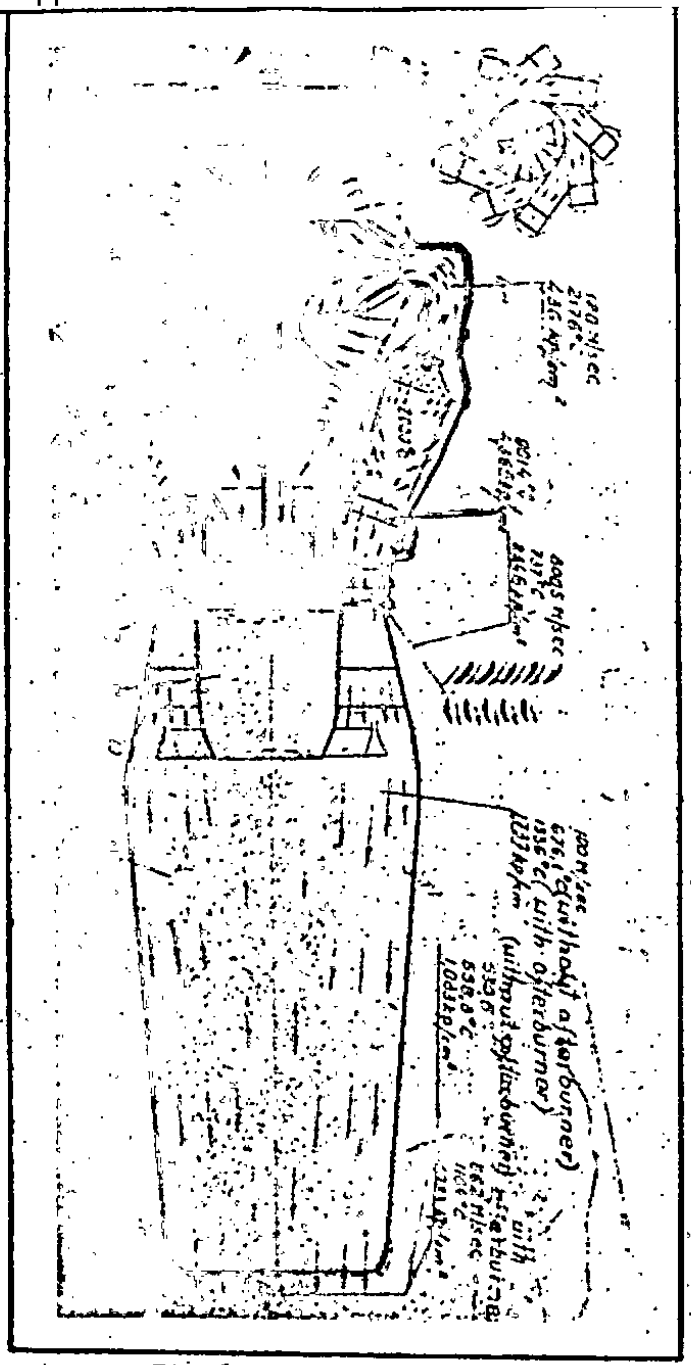


Fig.6. The Flow-diagram of the Engine

/values indicated for take-off rating with and without afterburner on the ground/.

1-auxiliaries drive box, 2-inlet branches, 3-guide vanes of combustion chambers intake elbows, 4-compressor, 5-fan, 6-combustion chamber, 7-guide vanes before turbine, 8-turbine, 9-inner cone, 10-ring shaped stabilizer with fuel collector, 11-afterburner, 12-extensible jet nozzle.

When the engine runs with combustion of additional quantity of fuel /with afterburning/, the extensible jet nozzle is set into position with greater cross-sectional area, as the exhaust gases have a higher temperature and consequently a lower density and greater volume. Owing to this, the gas flow values on the outlet from the turbine remain stable both with afterburner or without afterburner.

Main Data of the Engine :

MARK of the engine	WK-1F / LIS-5 /
Type of the engine	turbo-jet
Compressor	centrifugal, one-stage with two-sided intake
Sense of rotation	counterclockwise, if observed from behind
Number of combustion chambers	9
Layout of combustion chambers	around the rotor axis on cone evolvent
Order of numbering of the combustion chambers	Clockwise, if observed from behind upper chamber being No.1.
Number of blades of compressor blade wheel	29 on each side
Type of turbine	axial, one stage
Number of turbine disc blades	62
Number of turbine guide vanes	54
Gear ratio of drives to the engine rotor	a/starter-motor 2,8 b/tacho-dynamo 0,25 c/auxiliaries drive box-0,4
Type of afterburner	direct flow

Type of jet nozzle	Extensible, with hydraulic actuators, operating on hydraulic pressure from aircraft system
Thrust in take-off and combat rating - kg	2650 - 2 per cent
Thrust in take-off and combat rating with afterburner	3380 - 2 per cent
Rotational speed at take-off and combat rating /with or without afterburner/ r.p.m.	+ 40 11560 - 20
Specific consumption of fuel at take-off and combat rating	max. 1,15 kg per kg thrust/hour
Specific consumption of fuel at take-off and combat rating with afterburner	max. 2,0 kg per kg thrust/hour
Maximum mean exhaust gas temperature, measured by four thermocouples at take-off and combat rating with or without afterburner - maximum	720 degree C. in altitudes above 14000 metres maximum 745 degree Centigrade
Mean corrected temperature of exhaust gases /without afterburner/	max.720°C
Permissible total time of continuous operation at take-off and combat rating with or without afterburner on ground at zero speed	maximum 6 minutes, of which 3 minutes max.with after - burner on
Permissible time of continuous operation with afterburner on during flight	in altitude up to 7000 metres maximum 3 minutes,from 7000 metres up - maximum 10 minutes /after - burner is engaged only at take-off and combat rating of the engine
Thrust at nominal rating, kg	2300 - 2 per cent
Rotational speed at nominal rating, r.p.m.	11200
Specific consumption of fuel at nominal rating	maximum 1,12 per kg thrust/hour
Mean corrected temperature of exhaust gases at nominal rating.	max.685°C

Permissible time of continuous operation at nominal rating during flight	maximum 60 minutes
Thrust at maximum cruising speed, kg	2080 - 2 per cent
Rotational speed at maximum	10870 r.p.m.
Specific consumption of fuel at maximum cruising rating	maximum 1,09 kg per kg thrust/hour
Mean corrected temperature of exhaust gases at maximum cruising speed, maximum.	645° C
Time of operation at maximum cruising rating	unlimited
Thrust at low power rating	max.80 kg
Rotational speed of low power rating	2500 r.p.m. 100
Maximum fuel consumption at low power rating	450 kg of fuel per hour
Mean corrected temperature of exhaust gases at low power rating	max.540° /At surrounding air temperature +15° and higher temperature of exhaust gases no more than 555°/
Permissible time of operation at low power rating	maximum 10 minutes
Time of acceleration from 5000-100 r.p.m. to 11560 r.p.m.	maximum 15 sec. /when throttle lever is opened in 1-2 sec /
Time of obtaining thrust with afterburner ON	maximum 6 sec.

Fuel System

Mark of operating fuel	Kerosene T-1. Permissible to use kerosene T-1 or TS-1 with addition of 0,8 - 1,2 weight per cent of oil mark MS-20 or MK-22
Specific weight of fuel	0,800 - 0,850 g/ccm
Upper fuel pump for main fuel system	Plunger type with whole range regulator and throttle cock - PN-11MA
Maximum fuel pressure after main system fuel pump	max. 80 kg per sq.cm.

Lower fuel pump for afterburner fuel system	Plunger type with barometric regulator PN-14A
Maximum fuel pressure after PN-14A /afterburner system/	110 kg per. sq.cm.
Gear ratio for the upper pump	0,25
Gear ratio for the lower pump	0,4333
Sense of rotation of the pumps /from the side of drive flange/	Left hand
Fuel pressure behind the fuel filter before the fuel pumps	1,1 - 1,5 kg per sq.cm.
Fuel pressure distributor with shut-off valve and accelera - tion automat for main fuel system	ART-8W
Fuel pressure distributor with slide valve shutter of afterburner system	ART-14A
Operating burners	with separate channels - the main and the auxiliary one /9 pieces/
Burners of afterburner system	26 one-channel burners,two of them with ignition equipment
Fuel pressure as measured be- fore burners in auxliary line at n - 2500±100 r.p.m.	7 - 12 kg per sq.cm.
Fuel filter	with mesh-type filtering assembly
Fuel pressure before burners in auxliary line at engine rotational speed 11560 r.p.m. - corrected	45± 6 kg per sq.cm.

Lubricating System.

Lubricating system	Oil under pressure is led to the front,centre and rear bearing of the engine rotor and to the auxi- liaries drive box.
Oil	Transformer type or MK-8.Permis- sible to use transformer oil with addition of WTI-1 /paraoxyl diphe- nylamin/ in quantity 0,003-0,001 per cent and depressator AZNII-max 0,2 per cent or oil MK-8 with ad- dition of WTI-1 in quantity of 0,001-0,01 per cent.

Consumtion of oil /litres per hour/	max.0,7
Oil pressure on inlet into engine after reducing valve at an - 10870 r.p.m. or more	minim.1,4 max.3,5 kg per $sq.cm$
Oil pressure on inlet into the engine after reducing valve at n-2500±100 r.p.m.	minim. 0,2 kg per $sq.cm$.
Maximum temperature of oil in oil pump box	max. 90°C.
Minimum temperature of oil in oil pump box	minim.40°C below zero
Quantity of oil, poured into oil pump box	6 litres
Oil filters	One high pressure filter on inlet of engine,two mesh-type filters before suction and high pressure oil pumps. Each oil nozzle of engine rotor bearing its mesh filter.

Starting System.

Starting system	Starting is made by electric starter-motor by means of automatic starting system.The autonomuos starting /without ground battery car/ is performed by electric starter-motor ST-2-48W with starting automat PS-W from storage battery type 12SAM-28.The charging of the storage battery in the aircraft is provided from the power generator,fitted on the engine. It is allowed to perform starting from ground power sources /ground battery car/ according to the technical requirements for the starter motor.
Electrostarter	Compound type ST-2-48W
Priming pump	PNR-45B
Starting burners /2/	Low pressure with electromagnetic valve
Starting spark plugs	Type SD-55ANM

Starting automat	PS-27
Starting coil /double/	KR-1
Afterburner engaging system	Automatical. Consists of switch K112-908, ignition coil, ignition spark plug SD-12, electromagnetic hydraulic valve GA-13M/3 ignition coil KPM-1A and electromechanism MG-2

Engine Cooling System.

Cooling system of engine	Air cooling from centrifugal one-stage fan
Temperature of air, cooling the turbine disk	maximum 350 degree Centigrade
Cooling of the afterburner system	air cooling
Quantity of air necessary for cooling of afterburner, in kg per sec.	2,5-3,0 /secured on testing bed from special fan, in flight - from dynamic pressure/.

Overall Dimensions of Engine.

Dry weight of the engine in kg in the weight are included the after-burning combustion chamber and all accessories fitted on the engine, besides the aircraft accessory drive box with accessories, besides the speed indicator and its generator, thermocouples, fuel and oil pressure indicators, drain container, fuel rejector, hose with damper and pullrod with idle movement	910.24 + 2 per cent
Engine dimensions, mm	a/ maximum diameter 1273,5 b/ maximum height 1273,5 c/ full length of engine with afterburner 4720
Gyroscopic moment of engine rotor at n-11560 r.p.m. and of aircr.-3,5 $\frac{1}{sec}$ in kgm	3070
Position of C.G.	C.G. is determined with account of weight of vent jacket and of electromechanism MG-2 /see fig.7/

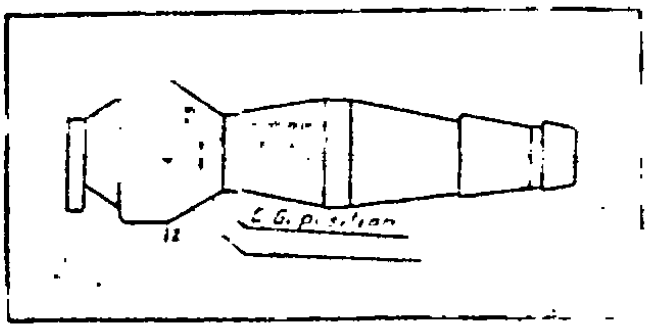


Fig.7.
Position of Engine C.G.

Life Data.

Guaranteed life of engine 100 hours

NOTICE: 1. The data given for thrust and specific consumption of fuel at the take-off and normal rating /with and without burner/, are the nominal and maximum cruising speeds are calculated for standart atmosphere.

2. The measured main data of engine are corrected for standard atmospherical conditions according to the following formulae:

Rotational speed $n_{cor.} = n_{measured} \sqrt{\frac{288}{T_o}}$ in r.p.m.

Gas temperature $T_{m.cor.} = T_{m,meas.} \sqrt{\frac{288}{T_o}}$ in ^{o} absol.

Thrust $R_{cor.} = R_{meas.} \frac{760}{B_o}$ in kg

Specific consumption of fuel $C_{Rcor.} = C_{R} \sqrt{\frac{T_o}{288}}$ in kg of fuel per kg of thrust/hour

Fuel pressure before burners:

$$P_{t.cor.} = P_{t.meas.} \frac{288}{T_o} \left(\frac{760}{B_o}\right)^2 \text{ in kg per sq.cm.}$$

where T_o - measured temperature of ambient air in abs.degree

B_o - measured barometrical pressure in mm mercury

index "cor" means corrected

index "meas" means measured.

3. Typical characteristics of the engine for rotational speed of the rotor are given in fig.8. and the calculated altitude characteristics - in diagram 1.

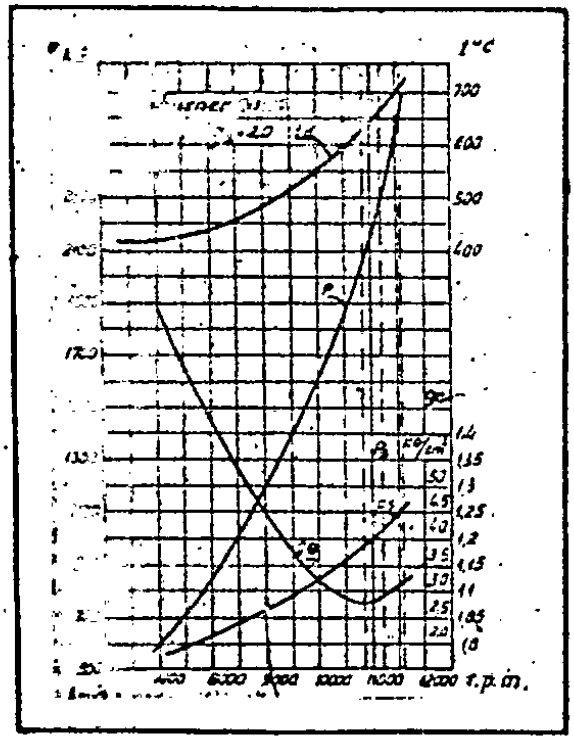
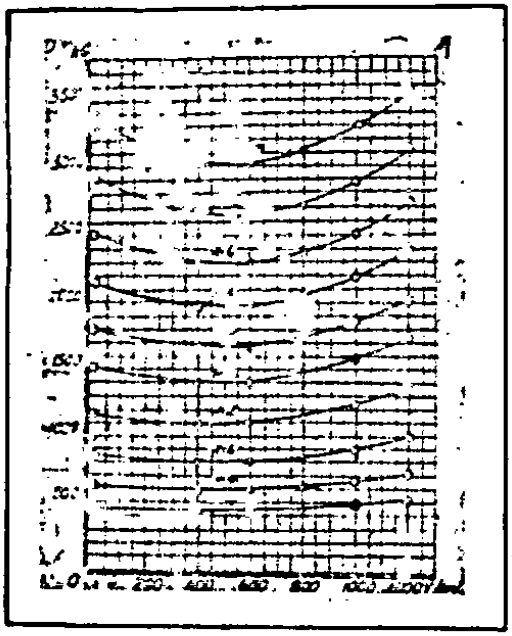


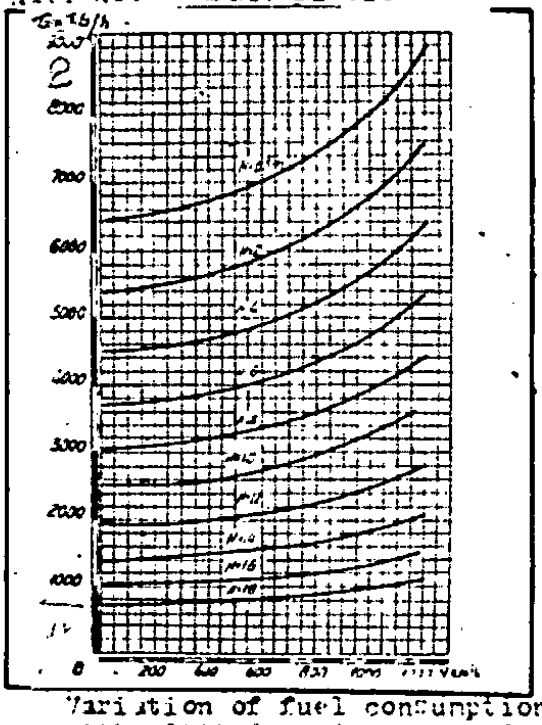
Fig.8. Typical Characteristics of Engine.

4. The service limits and instruction for preventive inspection in service, which must be observed for securing the stated life of the engine, are listed in a special instruction for servicing of VK-1F engine and are not given in this book.

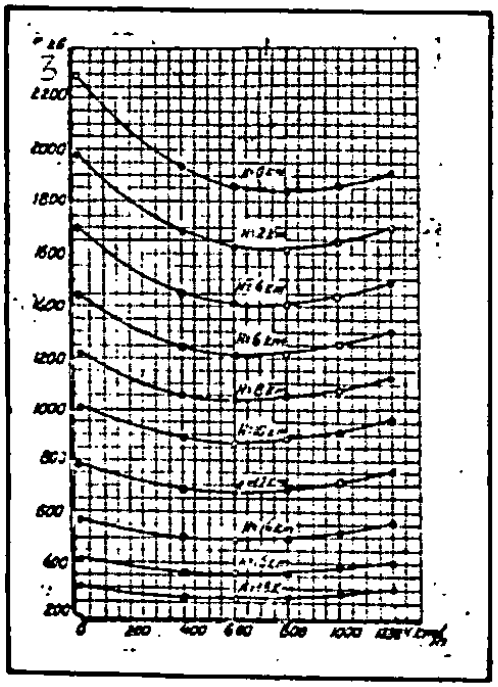
Diagram 1. R. Calculated Altitude Characteristics.



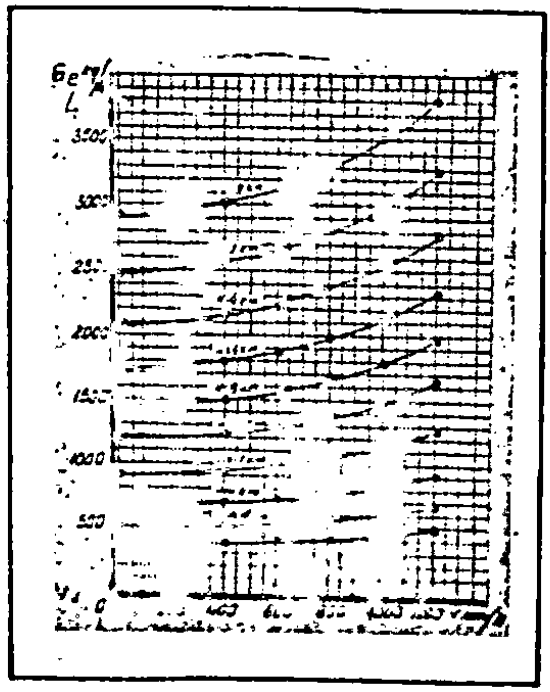
Variation of thrust with altitude and speed of flight. Flight with afterburner n=11560 r.p.m.



Variation of fuel consumption with altitude and air speed. Flight with afterburner n=11560 r.p.m.

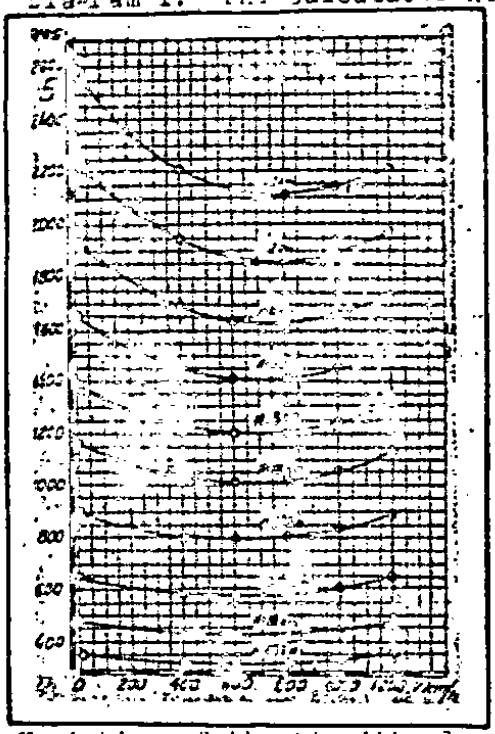


Variation of thrust with altitude and air speed. Take-off rating n=11560 r.p.m.

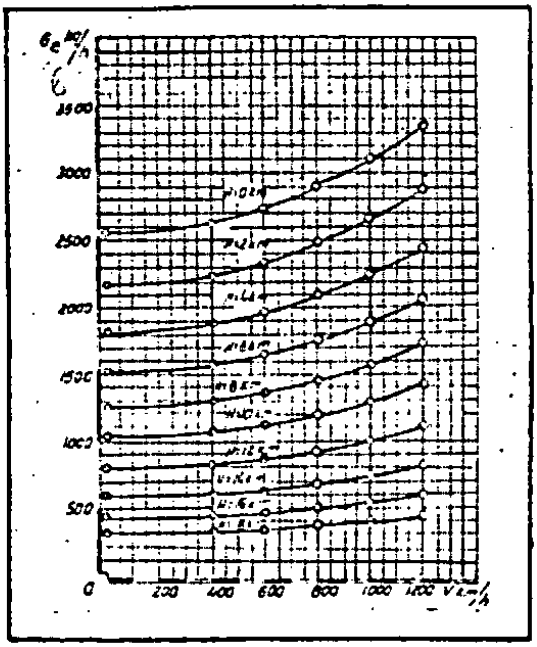


Variation of fuel consumption with altitude and air speed. Take-off flight at n=11560 r.p.m.

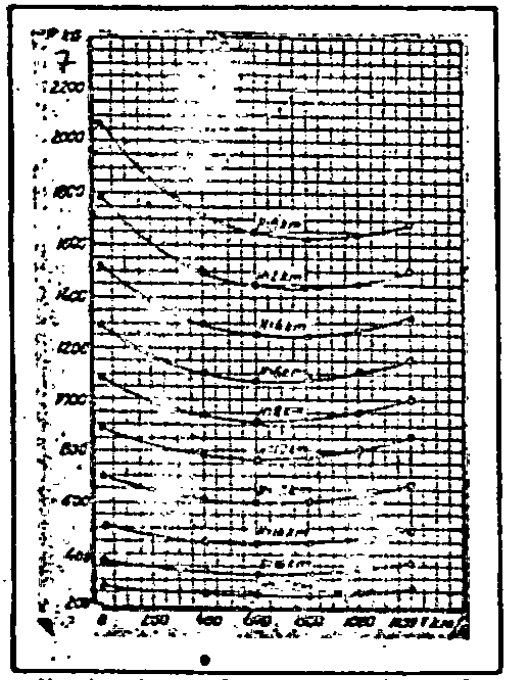
Diagram 1. The Calculated Altitude Characteristics.



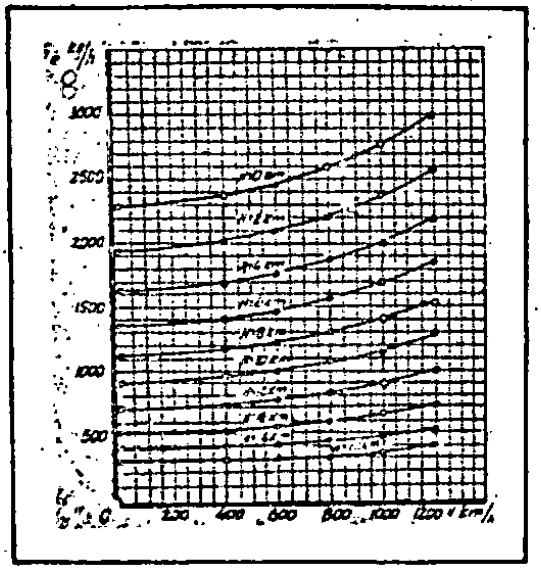
Variation of thrust with altitude and air speed. Nominal rating at 11200 r.p.m.



Variation of fuel consumption with altitude and air speed. Nominal rating at 11200 r.p.m.



Variation of thrust with altitude and air speed. Maximum cruising rating at 10670 r.p.m.



Variation of fuel consumption with altitude and air speed. Maximum cruising rating at 10670 r.p.m.

C H A P T E R II.

ENGINE ROTOR.

The engine rotor consists of rotor of the compressor, rotor of the turbine, clutch, which connects both rotor, and bodies of the bearings: the front, centre and rear one, which serve as supports for rotor of compressor and of turbine. The rotors of the compressor and turbine rotate in three bearings, two of which are roller type /the front and the rear one/, and which allow for an axial dilatation of the shafts and bodies during operation of the engine, and one is ball-type /the centre one, which holds the rotors of compressor and turbine in the axial direction and which receives the axial load from the turbine.

Rotor of the Compressor.

Rotor of the compressor /fig.1/ consists of a blade wheel of the compressor 11, two air intakes /revolving guide apparatus/ 10 and 12, the front and the rear /7 and 14/ shaft of compressor and the fan blade wheel. The front shaft of the compressor is hollow, made of steel alloy. In front of the shaft a journal is provided for the front roller bearing 4 and the thread for its fastening by the nut 1, on the rear end there is a conical stripe for fitting of the front intake 10 and a flange, which together with the flange of the front intake is fastened by eight stud bolts 9 to the compressor blade wheel. Inside, from the side of the bearing, the shaft has evolvent splines, through which, by intermediary of the splined end the revolution is transmitted to the cogged wheels of the engine auxiliaries drive box. The rear shaft of compressor is made of steel alloy and is also hollo-, On its surface it has splines with rectangular cross section for

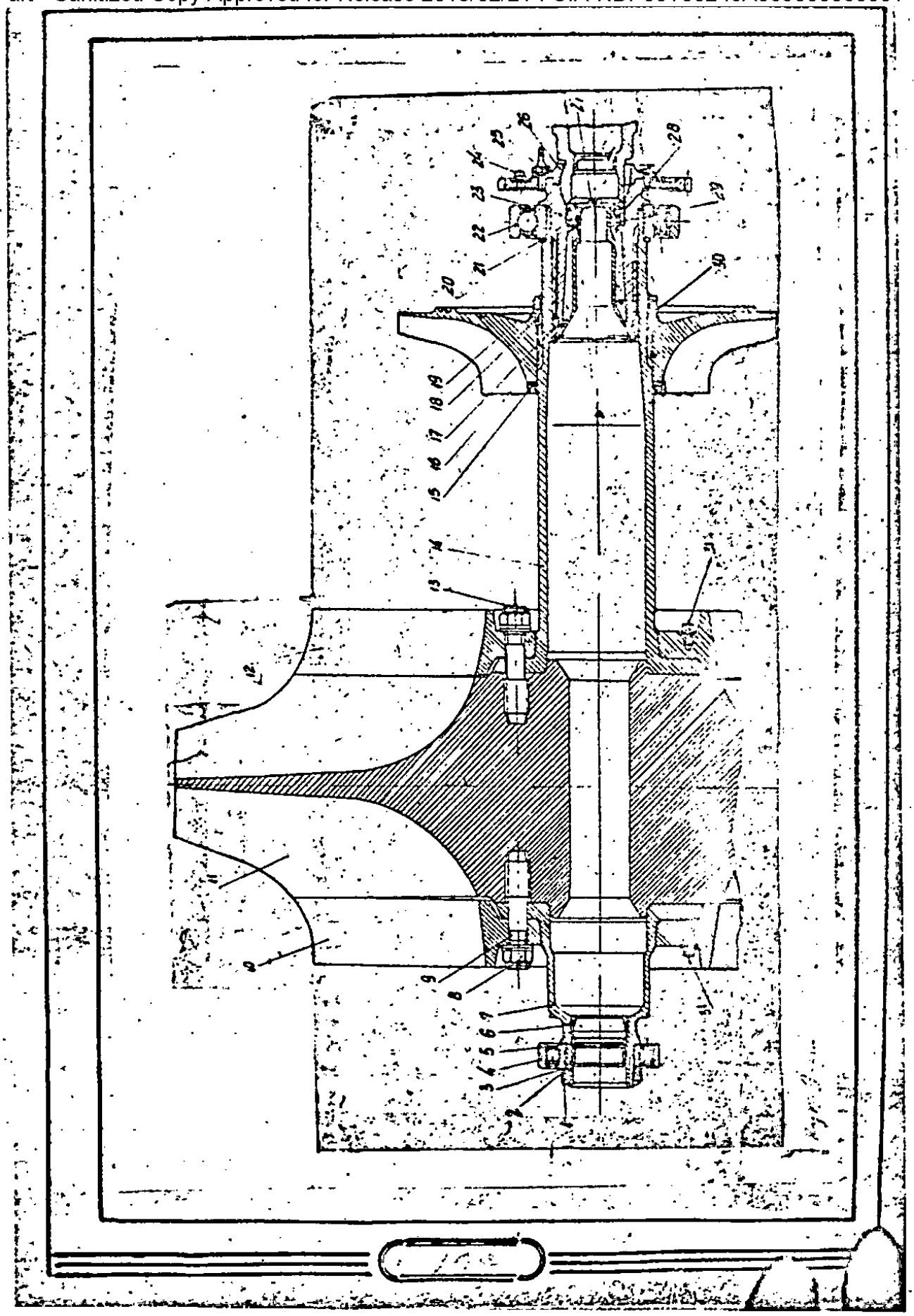


Fig.3. Rotor of the Compressor.

1. Nut
2. Stop ring
3. Lock washer
4. Roller bearing
5. Lock ring
6. Plug
7. Front shaft of compressor
8. Nut
9. Stud bolt
10. Intake of blade wheel-front
11. Blade wheel of compressor
12. Rear intake of blade wheel
13. Split pin
14. Rear shaft of thecompressor
15. Regulating ring of fan blade wheel
16. Stop ring
17. Stop bush of fastening screw
18. Stop bush of fan blade wheel
19. Nut
20. Fan blade wheal
21. Regulating ring
22. Ball bearing
23. Driven splined bush
24. Balancing screw
25. Fixator
26. Cover of ball support
27. Fastening screw
28. Nut
29. Stop ring
30. Stop ring
31. Balancing [illegible]

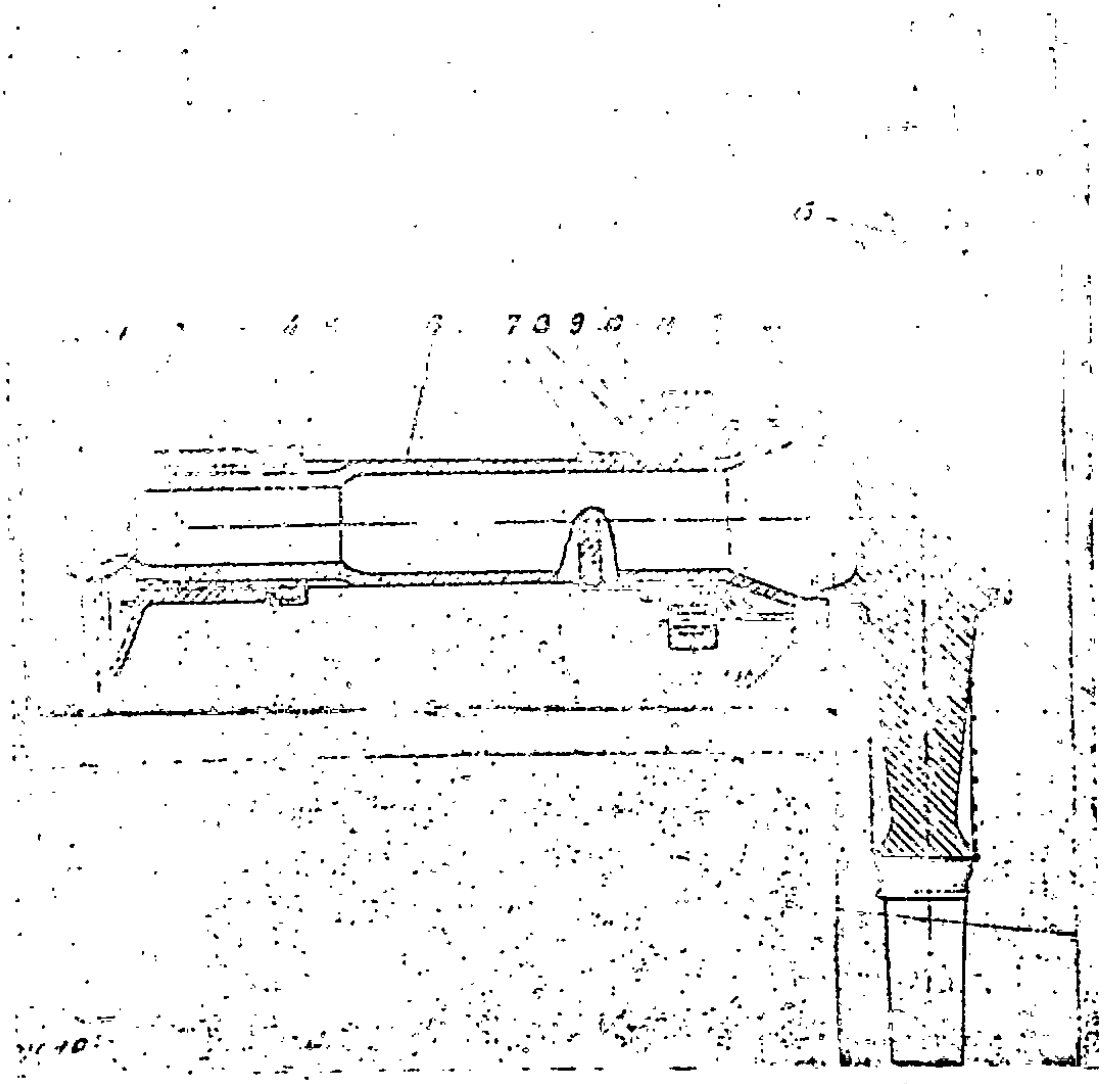


Fig.10. Rotor of the Turbine.

1 - plug, 2 - ring, 3 - driving splined bush, 4 - fixator, 5 - fixating bush, 6 - turbine shaft, 7 - bush of turbine shaft, 8 - lock washer, 9 - nut, 10 - stop ring, 11 - roller bearing, 12 - fastening bolt of turbine disc, 13 - lock washer, 14 - nut, 15 - turbine disc, 16 - turbine blade, 17 - plate type lock, 18 - balancing pegs.

fitting of fan blade wheel 20, inside it has rectangular splines for fitting of driven splined bush 23. For fastening of the driven splined bush in the inner cavity of the shaft is pressed in a support bush 17, serving as a stop for the fastening hollow screw 27. The screw is protected against falling out by a fixator ring 16. The rear shaft, on the conical stripe of which the intake 12 is fitted, is fastened to the compressor blade wheel in the same way as the front shaft.

At the end opposite the flange the shaft has a hournal for fitting of the centre ball bearing 22. Disbalance of the rotor is removed at its balancing by balancing pegs 31, screwed in into threaded holes in the hubs of the intakes and by balancing screws 24, fitted into the disc of driven splined bush also by machining off metal between blades of the fan blade wheel 20.

Rotor of the Turbine.

Rotor of the turbine /fig.10/ consists of turbine disc 15 with blades 16, turbine shaft 6 and turbine shaft bush 7. The turbine shaft is connected with the disc by evolvent splines by eight fastening bolts, by which simultaneously the turbine shaft bush is fastened to the shaft. The turbine disc is matched into its position on the shaft by special stripe. The turbine shaft is made of steel alloy, it is hollow, on the front end it has a spherical support with three grooves for connection with the driven splined bush and rectangular splines for fitting in the driving splined bush. The turbine shaft bush in its front part has a fitting stripe for the rear roller bearing, on the rims of which are placed s rfaces for oil labyrinth. The bush is fitted on the shaft on two planes: one, placed at flange of the shaft, the other, having spiral cutouts, in the shaft middle part. The bush, when

fitted on the shaft, forms with the latter an annular space, through which air is blown for cooling of the inner ring of the rear roller bearing. On the flange of the bush 16 radial grooves are made for passage of the cooling air. Disbalance of the rotor of turbine is removed, when balancing is performed, by balancing pegs 18, screwed in into the turbine shaft flange and into the turbine disk flange and also by removing metal from the maximum outer diameter of the driving splined bush 3.

C l u t c h.

The clutch serves for connection of the rotor of compressor with turbine rotor and consists of the driving and driven splined bushes. The driving splined bush 3 /see fig.10/ is connected with the turbine shaft by splines, its axial position is precised by two collars. Any axial shifting of the driving splined bush is made impossible by the fixating bush 5. The fixating bush has two stripes with inner splines: the broad splines, entering the annular cavity on the driving splined bush and the narrow splines, equalling the width of splined zone of turbine shaft, entering the annular cavity on the splines of turbine shaft. The fixation of the driving splined bush on the turbine shaft is secured by a simultaneous leaning of the fixator bush grooves on the corresponding projection of turbine shaft splines and of the driving splined bush. In this position the fixating bush in secured by the spring fixator 4, mounted in the seat of the driving splined bush and entering by its locking stripe into the opening of the fixating bush.

For dismounting of the turbine it is necessary to push the fixator and to turn the fixating bush so as to align the projections of the narrow splines of this bush with the splines of the turbine shaft; after this the driving splined bush can be

disengaged from the meshing with the driven splined bush by shifting the former on the shaft towards the side of turbine disc. The driven splined bush 23 /see fig.9/ by its rectangular splines enters the inner splines of the compressor rear shaft. It is fastened on the shaft by a fastening bolt 27, leaning by its flange on the stop bush 17, pressed in into the inner cavity of the shaft. The fastening bolt on the threaded side has two grooves, which get into mesh with projections of the inner collar of the driven splined bush, thus being made impossible any turning of the bolt. For receiving of the axial load, formed by the turbine and for formation of the axial support for the turbine rotor there is provided the ball joint of turbine shaft with the rotor of the compressor. This joint consists of a ball terminal of the turbine shaft with three grooves and of an inner sphere, formed by the driven splined bush and by the ball support cover 26, having also three grooves /for assembly of the joint/.

The cover of the ball support is fastened on the driven splined bush by six bolts 25. Three of them have alongated heads, by which the correct connection of the turbine shaft with the driven splined bush is secured.

Housing of the Front Bearing.

Housing of the front bearing 1 /see fig.11/ is made of aluminium alloy, in front its has a flange, by which the housing is fastened on the front frame 12. To the front face of the flange the engine auxuliaries drive box is fastened. At the rear the housing has a seat, in which a steel bush is pressed in for the front roller bearing 7. In order to prevent oil from leaking from the front bearing cavity into the compressor cavity, to the

rear face of the housing seat the body 13 of labyrinth sealing of the front bearing is fastened by eight stud bolts. Lubricating oil for the front bearing is delivered through the pipe 10 to the oil neck 8; through the opening of the neck oil is sprayed on the rollers of the bearing.

Housing of the Centre Bearing.

The housing of the centre bearing 8 /fig.12/ is cast of aluminium alloy, has form of a cut-off cone with two flanges. By its larger flange the body with the fan body is fastened by studs to the rear frame. To the minor flange on the same stud bolts the housing of the rear bearing and the housing of the gas collector are fastened..

Inside the housing of the bearing on an annular conical diaphragm with eight windows there is a seat cover 7 and a closed cavity for the clutch. In the cover there is a cavity with a steel bush 6 for the outer ring of the ball bearing 5. Both the housing and the cover have labyrinths, preventing oil from leaking from the oil cavity into the air cavity of the housing. The eight windows in the diaphragm of the housing serve for by-passing of oir, cooling the rear bearing and the turbine disc.

In the bottom part of the housing two elbow fittings with necks are fitted by stud bolts, to which are connected the outer pipelines of the oil pressure and scavenging lines. From each elbow fitting two channels are ducted for delivery of oil to the cover of the housing of centre bearing. In the cover there is also a channel, through which the oil from the high pressure oil line runs through the by-passing bush into the neck 4 for lubrication of the ball bearing. Through the additional opening in the cover and through a jet the oil flows for lubrication of the svolvent splines of the clutch.

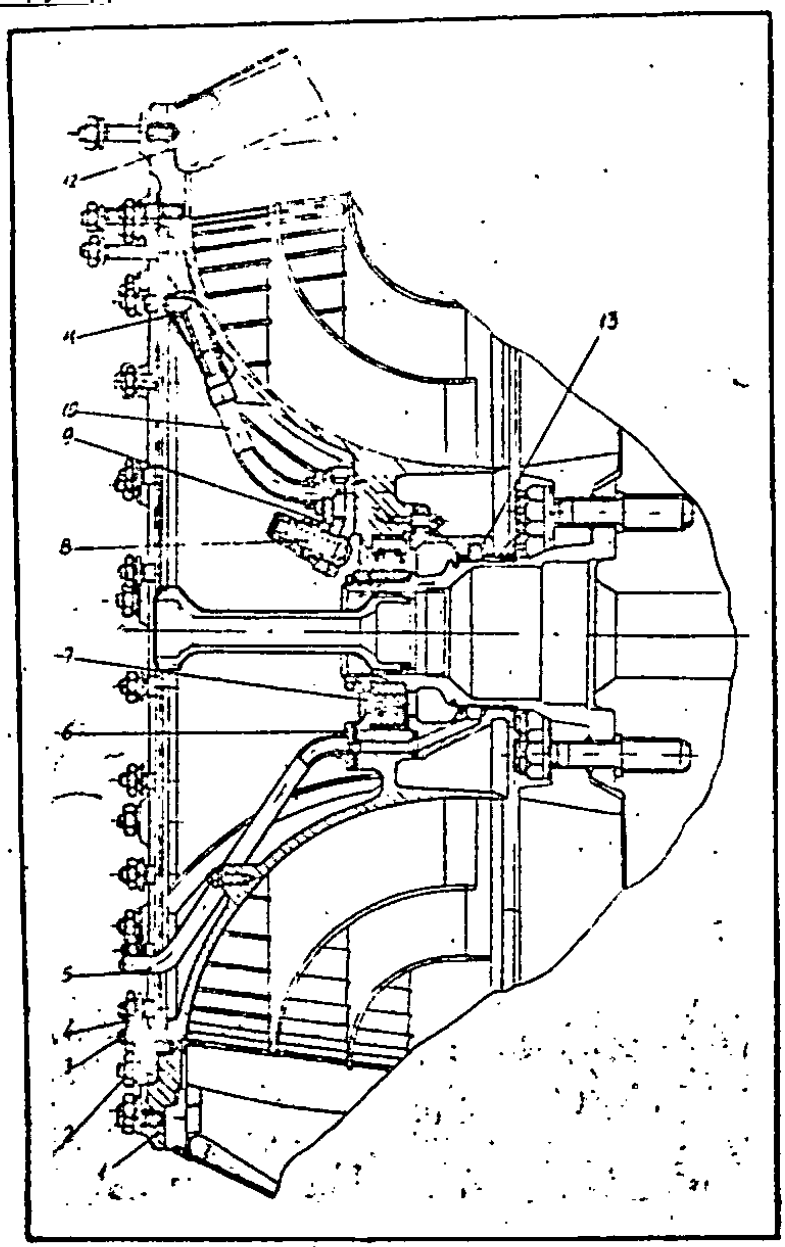


Fig.11. Front Bearing.

1-body of front bearing, 2-peg, 3-stud bolt, 4-nut, 5-pipe of air duct of the front bearing, 6-bush, 7-roller bearing, 8-oil neck, 9-body of oil neck, 10-pipe of oil duct of the front bearing, 11-elbow of the oil duck pipeline, 12-front frame, 13-body of front bearing sealing.

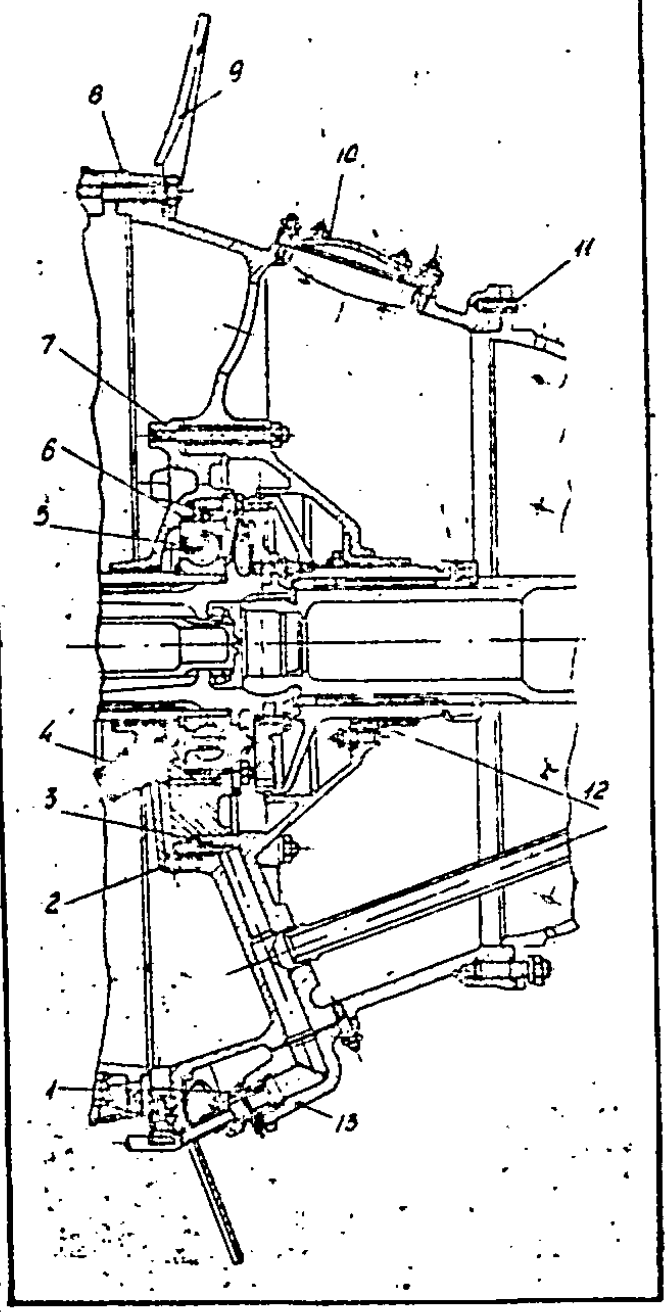


Fig.12. Centre Bearing.

1-neck, 2-bush of oil pressure pipeline,-3-sealing ring, 4-oil neck, 5-ball bearing, 6-bush of centre bearing body cover, 7-cover of centre bearing body, 8-body of centre bearing, 9-deflector, 10-access door of centre bearing housing, 11-peg, 12-bush of sealing of the centre bearing, 13-oil pipeline elbow.

From the cavity of centre bearing cover oil is led away through the inclined hole, which is placed in the lower part of the cover, into the inner cavity of housing of the centre bearing, from where it is scavenged by a scavenging pump. For outlet of condensed humidity and oil on the housing of the centre bearing in its centre part /on the side of the larger flange/ in the bottom a neck is provided, from which a pipe is led to the draining valve of the combustion chambers. For access to the clutch in the housing of the centre bearing three access holes are proveded, covered with three covers 10.

Housing of the Rear Bearing.

The housing of the rear bearing 1 /fig.13/, which is also cast of aluminium alloy, has in the front part a conical form and its rear part a cylindrical form. Inside the housing, in the cylindrical part, on the longitudinal ribs an annular seat with bush 3 is placed for the roller bearing 4. The seat is closed from both sides by bodies 2 and 5 of the labyrinth sealing. The front body of the sealing 2 prevents the outer ring of the bearing from longitudinal motion and has an oil nozzle from a channel in the body of the centre bearing through the pipe 9. For scavenging of oil from the cavity of the rear bearing on the lower port of its seat two windows are placed, connecting the cavity of the bearing with the horizontal channel, through which the oil flows through pipe 10, placed inside the bodies, to the outlet channel in the centre bearing housing. In order to limit the leakage of oil the labyrinth sealing of the housings of bearings of the engine rotor have a spiral thread, directed against revolution of the shaft. Besides that, to the labyrinth sealing of the front bearing from the diffosor of the compressor through an outer pipe branch air stream is directed, which forms a counterpressure.

The counterpressure in the labyrinth sealing of the centre and rear bearings is formed by cooling air, delivered by the fan at a pressure of 0,3 kg per sq.cm.

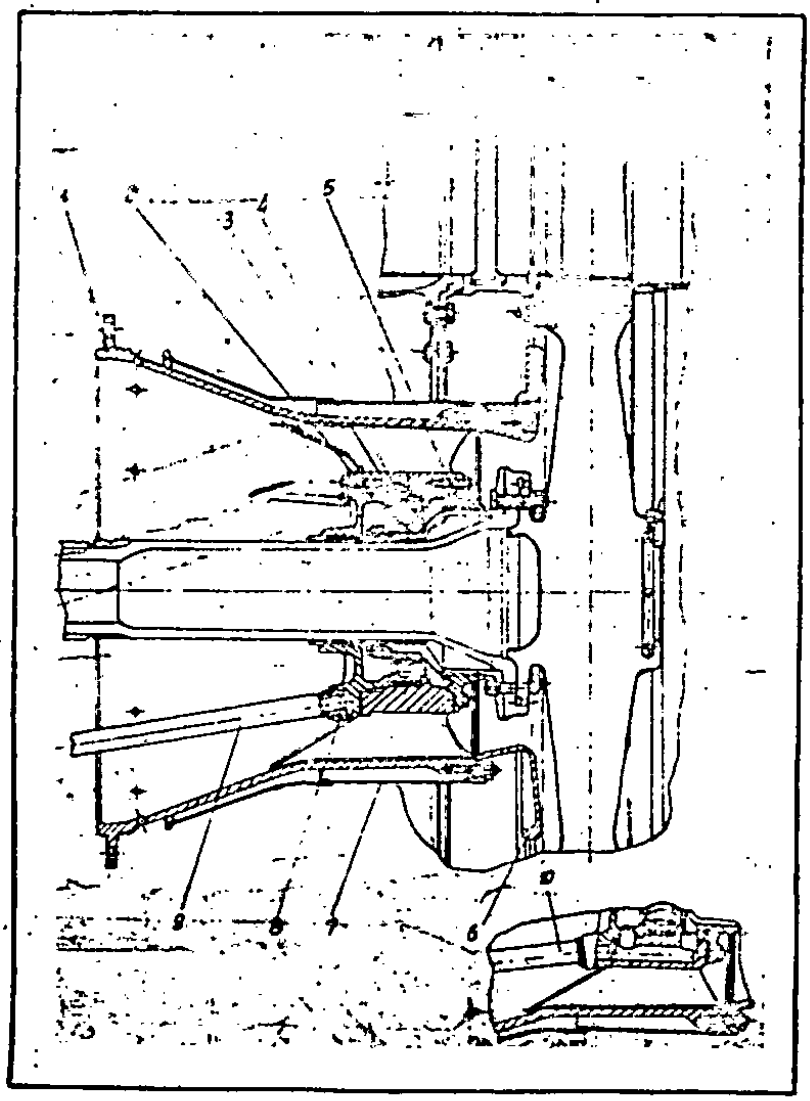


Fig.13. Rear Bearing.

1-housing of the rear bearing, 2-front sealing body, 3-bush of the body, 4-roller bearing, 5-rear sealing body, 6-vent defleckter, 7-heat insulator, 8-sealing ring, 9-oil pressure pipeline, 10-oil scavenging pipeline.

System of Air Cooling.

For lowering of temperature of the centre and rear bearing and of the turbine disc, there is an air cooling system provided in the engine /fig.14/.

To the centrifugal fan air is led through windows 1 in the rear frame. The blade wheel of the fan 2 delivers the air through the diffusor 3 and windows 4 in the diaphragm of centre bearing housing into the cavity of the centre and rear bearing.

Fig.14. Diagram of Air Cooling.

1-windows in the rear frame, 2-fan blade wheel, 3-fan diffuser, 4-windows in diaphragm of centre bearing, 5-opening in rear bearing body, 6-heat insulator, 7-centering strip of turbine shaft with spiral cutouts, 8-longitudinal diaphragms, 9-vent deflector of turbine disc, 10-turbine disc, 11-air pipelines, 12-air outlet box, 13-air outlet neck.

In the housing of the rear bearing a part of the air escapes between the longitudinal diaphragms 8 and by blowing around the seat, it lowers the temperature of the outer ring of the roller bearing. The remaining volume of air passes through clearances between the turbine shaft and bush of the turbine shaft, cools the inner ring of the roller bearing. After having passed from the housing of the rear bearing, air passes between the vent deflector 9 and the turbine disc 10 and takes off some heat from the turbine disc. In oder to prevent the rear bearing housing from being heated by this air, there is fitted a heat insulation 6 on the housing of the rear bearing. To improve the circulation of air between the heat insulator and housing of the rear bearing an additional volume of air is brought from the hole 5 in the conical part of the housing of the rear bearing. Farther the air flows through the annular cavity through nine air pipes into the air outlet box 12, placed in the centre part of the gas collector. In the lower part the air outlet box has an outlet neck 13, through which the air escapes into the atmosphere. The blade wheel of the fan 4 /fig.15/ is made of aluminium alloy with one-soded intake and has 29 radial blades, bent on intake in the direction of rotation and rectangular splines for meshing with the rear shaft of the compressor 6. In order to secure the necessary clearance between the blade wheel and body of the fan between the collar of the compressor rear shaft and the front face of the collar of the compressor rear shaft and the front face of the blade wheel of the fan a regulating ring 5 is fitted. The fan body 2, cast of aluminium alloy, is fastened between flanges of the rear frame 1 and body of the centre bearing 10.

The blades of the diffusor are cast as one piece with the rear wall of the fan 3, which is fastened to the body of the fan on stud bolts, protruding through holes in the blades.

The three concentrical projections, placed on the rear surface of the bland wheel, enter into the corresponding annular grooves in the rear wall of the fan, thus forming a labyrinth sealing, preventing a possible passing of air from the cavity of centre bearing body into the diffusor.

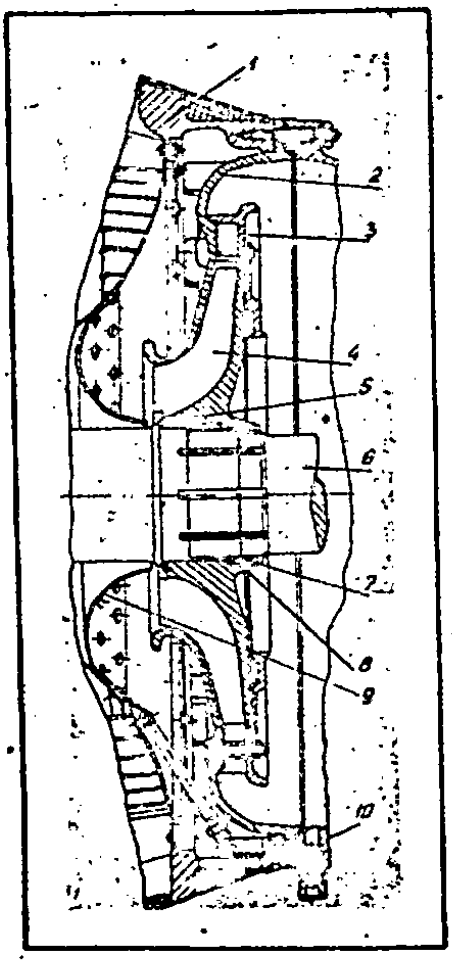


Fig.15. Air Cooling Fan.

1-rear support, 2-body of the fan, 3-rear wall of the fan, 4-blade wheel of the fan, 5-regulating ring, 6-rear shaft of compressor, 7-nut, 8-stop bush, 9-guide shield of fan, 10-housing of the centre bearing.

C H A P T E R III.

Compressor.

The engine compressor is a one-stage, double-entry centrifugal type with a compression ratio of 4,42.

The purpose of the compressor is to compress the air before entering the combustion chambers. The maximum output of the compressor at n-11560 r.p.m. and a temperature of + 15°C is 48,2 kg/sec. The maximum number of revolutions of the compressor impeller is 11560 r.p.m. The compressor rotor is being rotated during the starting procedure by means of an electric starte motor, during the operation - by means of the turbine rotor.

The air flows through two air entry vanes, the front and the rear one, into the ducts of the compressor impeller. From the impellet the air proceeds through a vaned diffusor and nine compressor discharge elbows into the combustion chamber.

Front entry vanes /fig.17/ consists of three straightening cones 3, ring 4, wall 1 and 48 straightening vanes 2, placed at the inlet. These vanes serve for preliminary straightening of air with the purpose of decreasing the relative velocities and diminishing air stream losses of air passing onto the rotating entry vane of the compressor impeller.

To the rear wall of the entry vanes a straightening wall 5 of the cooling fan is riveted on, together with which the cooling fan casing forms a duct for feeding air to the cooling fan impeller.

Details of the front and rear entry vanes are manufactured from aluminium - magnesium alloy sheet.

Front grid /fig.19/ is cast of aluminium alloy and consist of two flanges interconnected by 18 ribs.

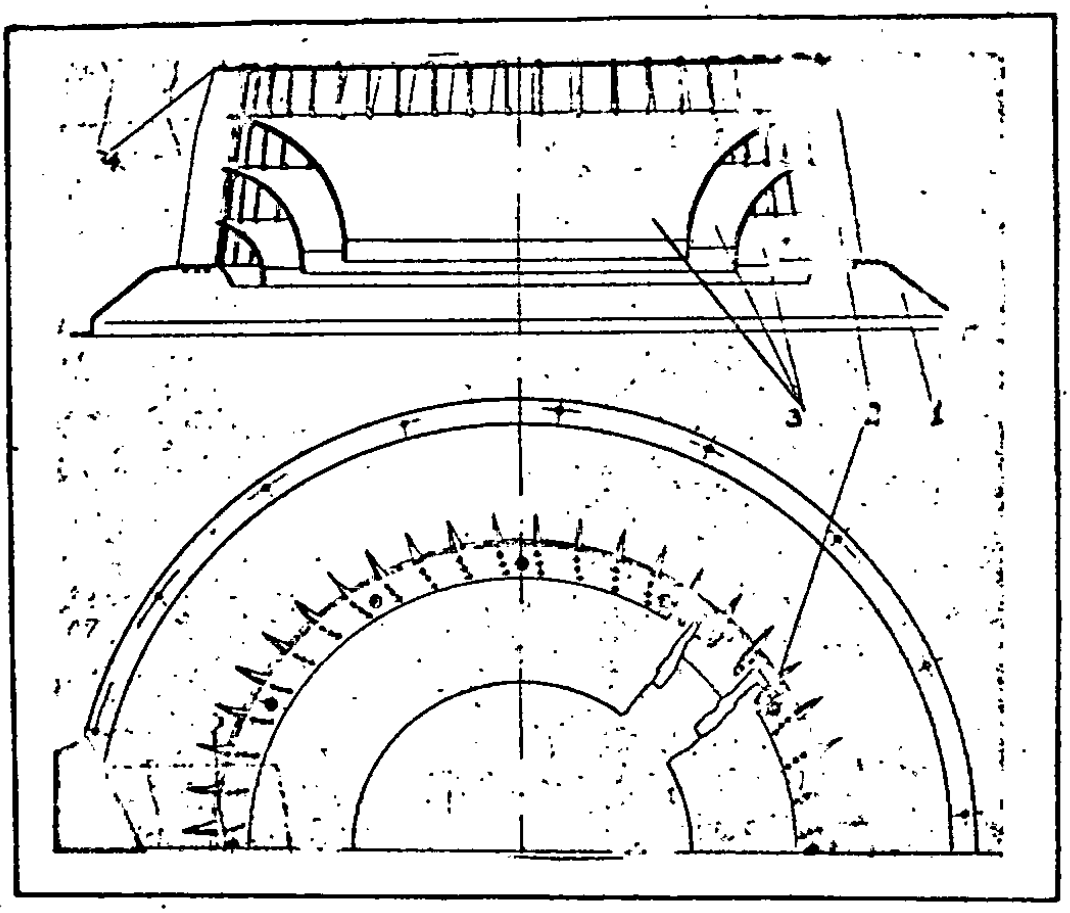


Fig.17. Front Entry Vanes.

1-wall, 2-straightening,vanes, 3-straightening cone, 4-ring.

By its great flange the grid is attached to the compressor casing together with its cover. Inward of the grid the front air entry vanes are fixed, to the small flange of the grid - the front bearing housing and to it - the accessory drive box with accessories

Rear grid /fig.20/ is also cast of aluminium alloy and has two flanges interconnected by 18 ribs.

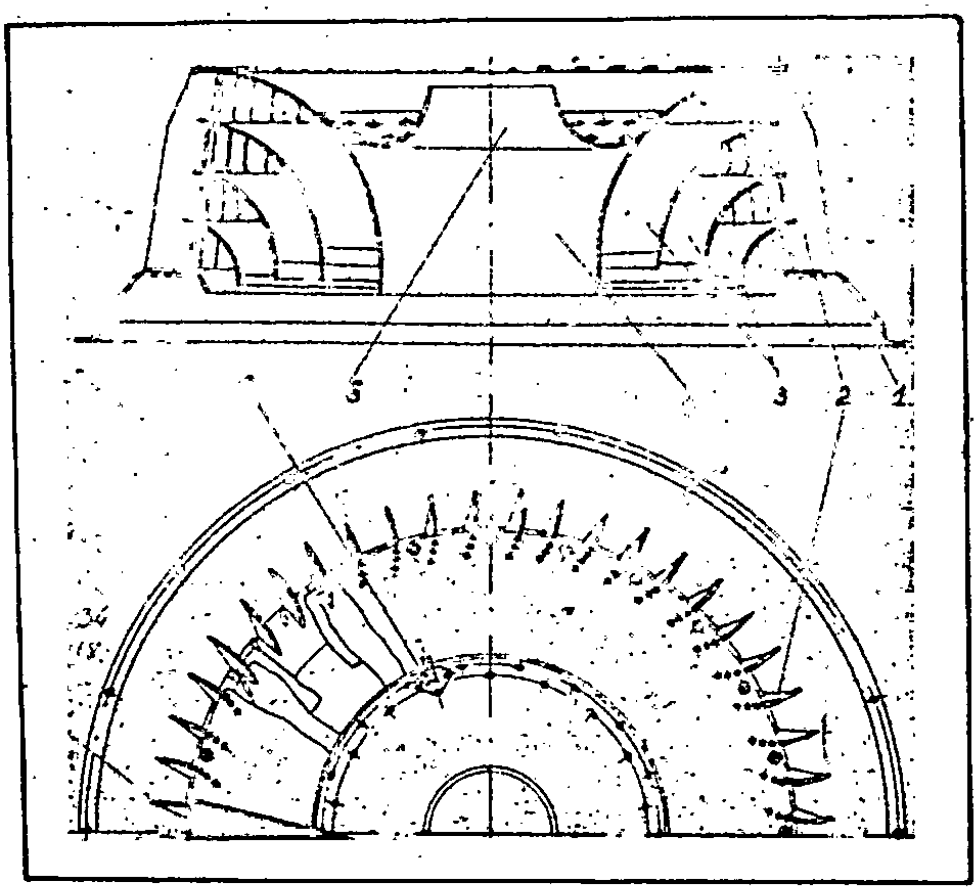


Fig.18. Rear Entry Vanes.

1-wall, 2-straightening vanes, 3-straightening cones, 4-wall, 5-straightening wall of the cooling fan, 6-eye.

By its great flange the grid is immediately attached to the compressor casing. To the smaller, rear flange of the grid a common cooling fan housing and the centre bearing housing are being attached. To the centre bearing housing the rear bearing housing is being attached and together with it the whole rear section of the engine.

Inside the grid the rear air entry vanes are attached. In its rear section the grid has 18 slots for air passing to the cooling fan.

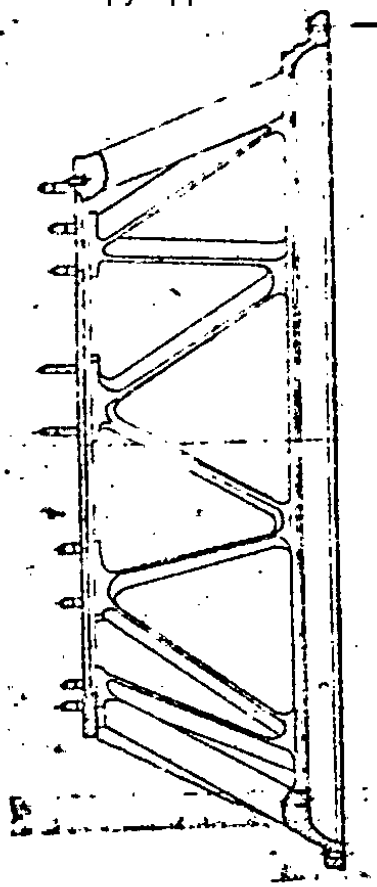


Fig.19. Front Grid.

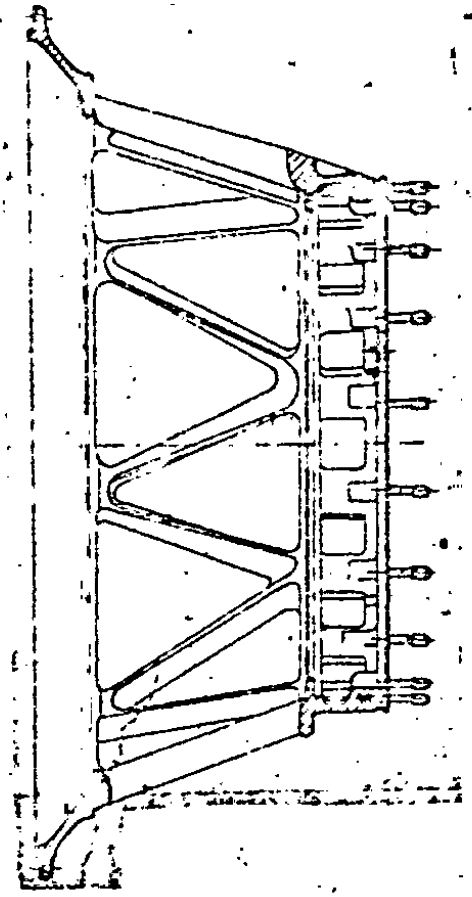


Fig.20. Rear Grid.

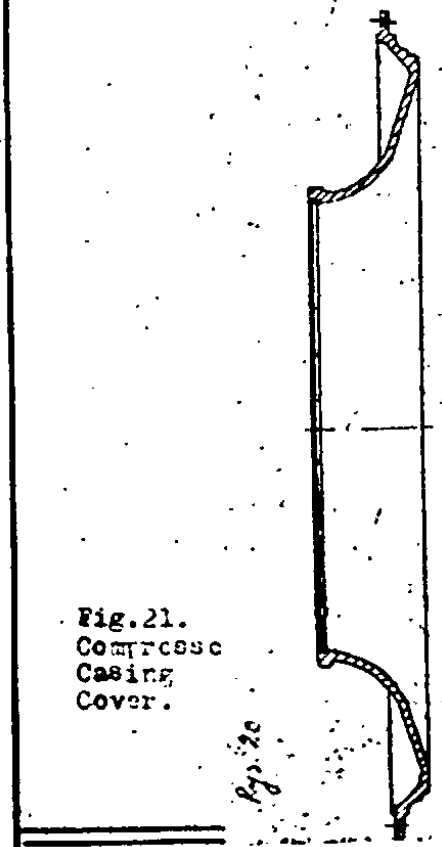


Fig.21. Compresse Casing Cover.

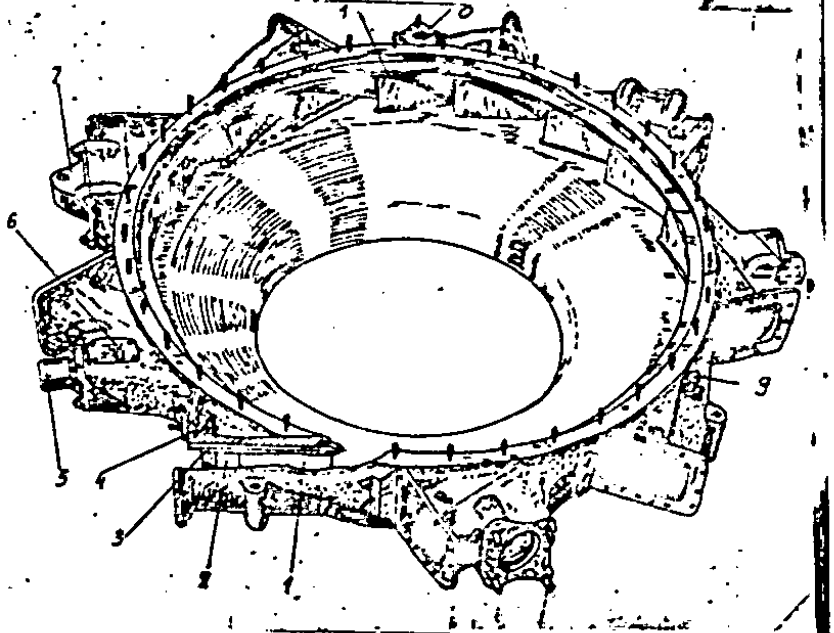


Fig.22. Compressor Casing.

1-diffuser vane, 2-trailing part of the vane, 3-diffuser vane rest, 4-fastening nut of the rests, 5-supporting piece 6-engine badge, 7-suspension bracket, 8-air blood for aircraft purposes,

9 - restricting orifice for feeding air to the labyrinth seal of the front bearing and of the accessory drive box, 10-lower suspension.

The front and the rear grid are covered by screen protecting the flowing section of the compresor and of the cooling fan from being soiled.

Compressor Casing is the mein part of the engine and consists of two parts: the cover of the compressor casing /fig.21/ and the proper compressor casing /fig.22/, which forms the working chamber of the compressor impeller. The casing and the compressor casing cover are cast from aluminium alloy their inner surfaces are carefully machined and polished. The cover is being fastened to the casing together with the front grid by nuts on studs.

On the compressor casing are 9 discharge necks at the same pitch on the periphery. The discharge necks of the compressor casing are being counted clockwise, looking from the rear, the top discharge neck being counted as the first.

Off the sixth and nineth discharge neck air is being bled from the compressor /on the side of the cover/, from the sixth discharge neck through a restricting orifice 9 to the front bearing for the air labyrinth seal, and from the nineth discharge-neck through hole 8 for the pilot's pressurised cockpit.

On the third and seventh discharge neck are flanges for fastening the main suspension trunnions 5 of the engine and on the second, fifth and eighth discharge neck flanges for auxiliary sus pensions 7 and 10, which serve to fixing the engine in the aircraft. On the third discharge neck, on the side of the cover, the engine badge 6 is fixed on.

On the first and nineth discharge neck two hoisting eyes

are fitted for hoisting the compressor casing and the engine as a whole during the transport.

In the compressor discharge necks a vaned diffuseor is located, which consists of eighteen vanes, nine of which are cast integrally with the casing and pass immediately into the walls of the discharge necks, and other nine vanes 1 with steel terminations 2 are to be inserted. The inserting vanes and their terminations are located in slots, which are in the walls of the compressor casing discharge necks and are held down by special supports 3.

The inserted and cast vanes are profiled and are located in such a manner, that they form eighseen divergent ducts, in which the velocity energy of the air stream is being trenformed in pressure.

The sum of the flow section area of the diffuser of each discharge neck /two ducts/ is at the centry $84,31 \pm 0,3$ cm^2 and the ratio of the flow section area at the outlet in respect to the flow section area at the entry into the duct equals $1,46 \pm 0,015$.

To the flanges of the compressor casing discharge necks nine compressor discharge elbows are attached from aluminium alloy /fig.23/, through which the compressed air streams to the combustion chambers. For diminishing hydraulic losses there are in each discharge elbow in the place of bending the air three profiled straightening vanes 1 manufactured of duralumin.

Compressor impeller consists of three parts: impeller 11, /see fig.10/ and two rotating entry vanes - the front one 10 and the rear one 12.

The compressor impeller is double-sided, manufactured from duralumin, and has on each side 23 radially placed vanes.

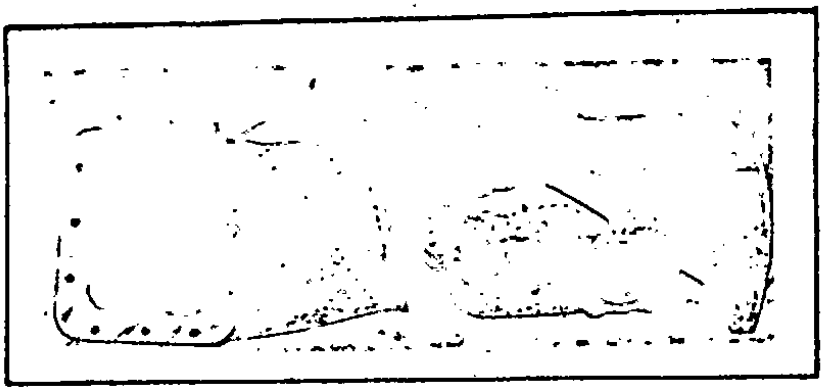


Fig.23. Compressor Discharge Elbow

1 - straightening vanes.

The impeller rotating vanes are also from duralumin and each of them has 29 vanes which correspond with vanes of the compressor impeller. The leading edges of the rotating entry vanes are bent in the sense of rotation for engaging air into the impeller.

The rotating entry vanes are being fastened to the impeller together with the compressor shaft /See annex 3/. In the hubs of the rotating entry vanes are sixteen threaded holes for balancing plugs.

The clearance between the compressor impeller and the casing cover of the compressor is 3-0,5 + 0,2 mm; between the impeller and the compressor casing wall is C - 1,5 + 0,2 mm at the impeller being pressed on the wall included in measuring /See the scheme of assembly clearances, fig.24/. The axial clearance of the compressor rotor D is maximum 0,65 mm.

The clearance between the walls and the impeller of the compressor rotor is adjusted by an adjusting washer, which is on the rear shaft at the face of the centre bearing cover.

C H A P T E R IV.

Combustion Chambers.

The air from the compressor flows through compressor discharge elbows into nine single combustion chambers mounted between the compressor casing and the gas nozzle box.

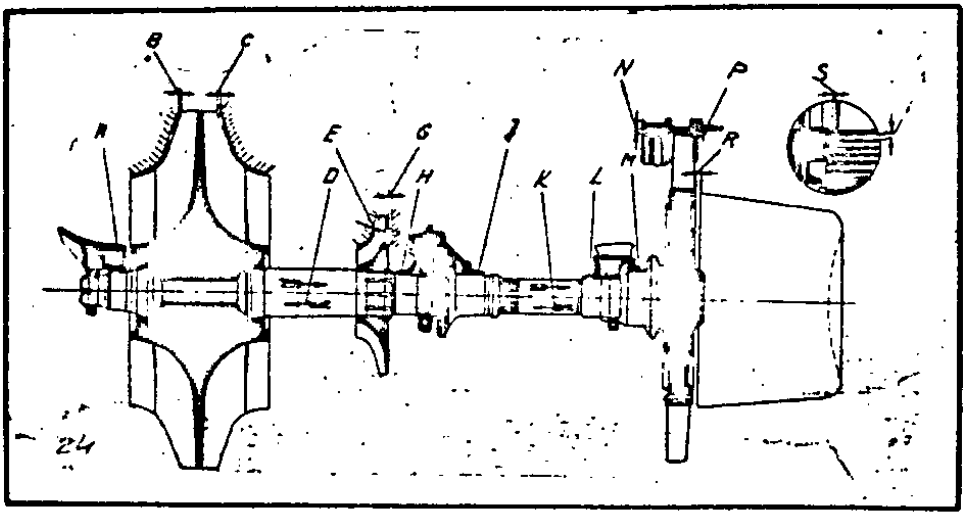


Fig.24. Scheme of Main Assembly Clearances of the Engine.

A - clearance in the front bearing labyrinth, 0,288-0,352 mm,
B - clearance between the housing cover and the compressor impeller, 0,500-0,700
C - clearance between the casing and the compressor impeller 1,5-1,7 mm
D - axial clearance of the compressor impeller, max.0,65 mm.
E - clearance between the casing and the cooling fan impeller, minim.1,5 mm.
F - clearance between the rear wall and the cooling fan impeller, minim.1,2 mm
G - clearance in the front labyrinth of the centre bearing, 0,240-0,[illegible] mm.
H - clearance in the rear labyrinth of the centre bearing, 0,389-0,454 mm.
J - axial overlap of the engine rotor max.0,670 mm
K - clearance in the front labyrinth of the rear bearing 0,36-0,[illegible] mm
L - clearance in the rear labyrinth of the rear bearing, 0,314-0,460 mm
M - clearance between the blade fases and the outer shroud ring of the nozzle guide vanes, min. 1,[illegible] mm

N - clearance between the blades and the turbine housing 2,5-2,8 mm
O - clearance between the turbine disc and the jet pipe cone, minim.3,5 mm.
P - axial clearance in the turbine labyrinth, 2,7-2,9 mm
R - radial clearance in the turbine labyrinth 1,1-1,25 mm.

Each combustion chamber /fig.25/ consists of a dome, of an outer casing and a flame tube.

The air in the combustion chamber is divided into two streams: primary and secondary one. The primary air flows into the flame tube through an entry cone 3, then through the swirler 7, and through a hole in the partition wall 5 and in the flame tube cone 6. The primary air immediately acts at the combustion. The secondary air flows into an annular space between the flame tube and the outer casing. Greater portion of this air flows into the flame tube in three streams. Through two rows of holes of the first cylindric section 22, through holes of the cuf 25 and four rows of holes in the second section of the flame tube 26. Other portion of air flows through the annular gap between the outer casing and the flame tube nipples and cools the junction pipe of the gas nozzle box and the nozzle guide vanes and turbine blades. The secondary air, flowing into the holes of the first section of the flame tube, assists at burning fuel.

The air flowing into other holes, cools the flame tube walls and joints to combustion products and lowers their temperature to a value necessary for normal turbine running.

The combustion chamber dome 2, of aluminium alloy, is being fastened by a small flange through two bolts to the compressor discharge elbow flange.

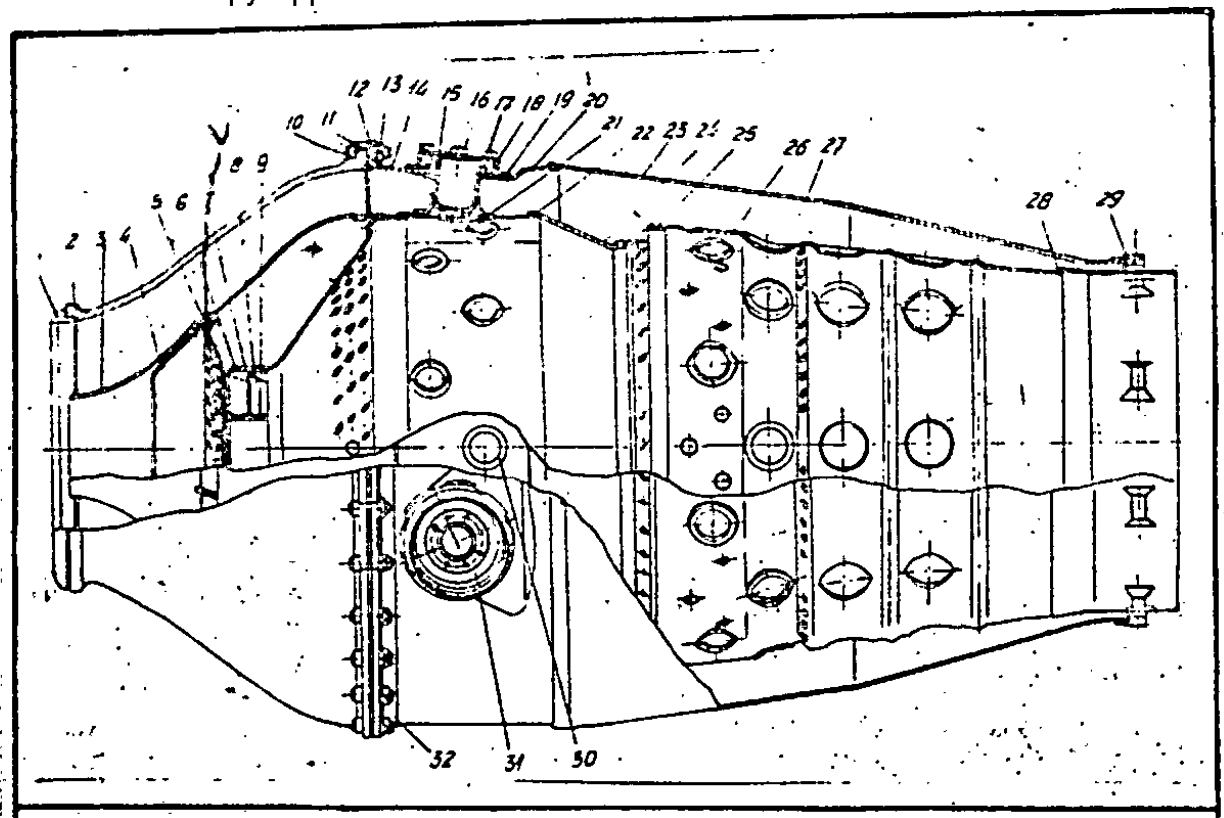


Fig.25. Combustion Chamber.

1-spherical joint, 2-dome, 3-entry cone, 4-flame tube dome, 5-partiton wall, 6-cone, 7-outer shroud of the swirler, 8-swirler vane, 9-fuel burner shroud, 10-bolt, 11-gasket, 12-flange of the combustion chamber outer casing, 13-nut, 14 and 20 - first part of the outer casing, 15-fastening insert, 16-bolt, 17-tab washer, 18-packing, 19-fastening insert sleeve, 21-hinge sleeve, 22-first part of the flame tube, 23-second part of the outer casing, 24-centre part of the flame tube, 25-centre part cuff of the flame tube, 26-second part of the flame tube, 27-stiffener, 28-cuff of the second part of the flame tube, 29-packing ring of the combustion chamber, 30-stiffener, 31-telescopic sleeve, 32-double washer.

Between the flanges a ball joint 1 is fitted, which prevents leakages at a possible misalignement of flanges. By its great flange the dome is being fastened through bolts to the outer casing flange 12. On domes of combustion chambers No 4,5,6 and 7 are bosses for connecting the flanges for fastening the drain piper, on the dome of combustion chamber No 1. is a boss with a threaded hole for union for measuring the pressure of air flowing into the combustion chamber, and in operation, according to an

agreement with the angine manufacturer, for bleeding air for aircraft purposes. Besides this there is on the dome of the sixth combustion chamber a boss with a threaded hole for bleeding air into the automatic fuel pressurising valve AKT-8M.

The combustion chamber outer casing is manufactured from mild steel sheet and consists of two brazed or welded sections drawn in one piece: from the first section - cylindric one 14 and the other tapered one 23. To the front section of the outer casing a flange is brazed on 12 for connection with the dome; to the rear section a sealing ring 29 is welded on, which has a spherical external surface. By this ring the combustion chamber fits with a smaller interference into the steel chromium plated intermediate flange of the gas nozzle box. Due to such a joint the combustion chamber can move in axial direction extending due to heating, without interrupting the joint tightness. On the cylindrical section of the outer casing three flanges are welded on, one for fastening insert 15 of the flame tube and two for telescopic sleeves 31.

In the outer casings of combustion chambers No.3 and 8 are welded on flanges for fixing the flame igniters, and on the outer casing of combustion chambers No, 3,4,5,7 and 8 flanges for fixing the flanges fastening the drain pipes and flexible hoses,

The flame tube is manufactured from heat resistant steel sheet and consists of a batch of parts, interconnected each to other by a seam weld.

The front section of the flame tube consists of an entry cone 3 and a dome 4. Inside a dome is a cone 6 with holes. To the a partition wall 5 is fastened equally with holes.

Into the cylindric section of the cone the swirler assembly is welded in, which consists from a ring 7, sleeve 9 and vanes 8.

Into the sleeve of the swirler the fuel burner is being fitted.

The centre section of the flame tube consists from the first cylindric section 22 and the centre section 24. In the cylindric sectionare two rows of holes with fitted into them stiffeners 30 for pasing air inside the flame tube. To this section three sleeves are welded on for fixing the flame tube in the outer casing. On flame tubes of combustion chambers No,3 and 8 sleeves are welded on for flame igniters. To the centre section a cuff 25 is welded on with holes for passing the air.

The rear section of the flame tube is formed by the second tapered section 26 and a cuff 28. The tapered section of the flame tube has two border seams as stiffeners, and four rows of holes, first two rows of them having stiffeners 27 and second two rows having a bordered rim. Between the second and the third row of holes a small recess is carried out with small holes for passing air. The cuff has 8 lugs with a brazed on stellit. By these lugs /nipples/ the flame tube is being centered in the outer casing.

The combustion chambers are interconnected by balance pipes /teleskopic sleeve/ /see fig.26/. The telescopic sleeves serve for balancing the pressure in combustion chambers and for propagating the flame /during the engine starting procedure/ into combustion chambers, which have no flame igniters /two flame igniters are placed only in combustion chambers No.3 and 8/.

The telescopic sleeve consists of outer 7 and inner 4 and 8 balance pipes, brazde each to other. The outer pipes fit into the outer casing flanges 11, the inner ones into the flame tubes 9 and serve as two points for suspending the tubes; the third suspension point is a fixing insert.

The telescopic sleeves of two adjoining combustion chambers are being tightened by connection nuts 2 and 6. Between the flanges of telescopic sleeves washer 5 is being fitted.

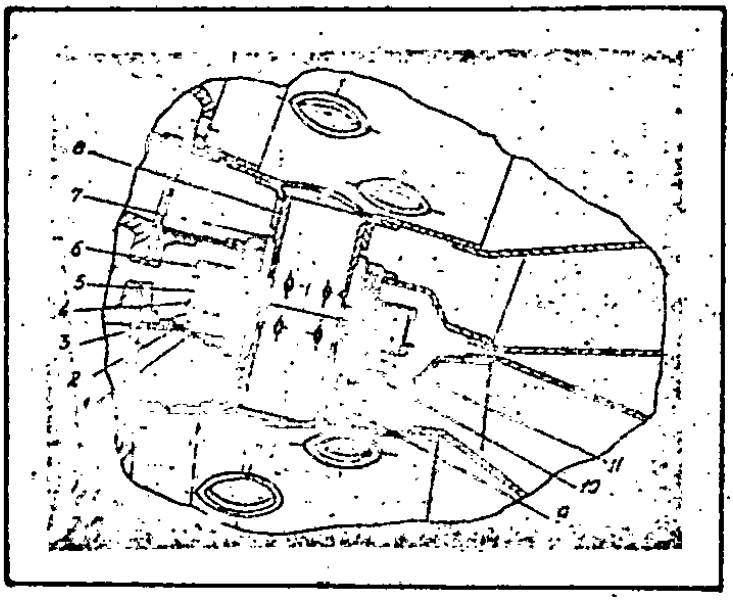


Fig.26. Telescopic Sleeve of the Combustion Chamber.

1-first part of the outer casing, 2-nut of the telescopic sleeve, 3-tab washer, 4-inner sleeve of the telescopic connection, 5-washer, 6-connection nut, 7-outer sleeve of the telescopic connection, 8-inner sleeve of the connection, 9-fastening insert, 10-packing ring, 11 flange of the telescopic sleeve.

C H A P T E R V.

Gas Nozzle Box.

From nine combustion chambers the gases flow through nine junction pipes of the gas nozzle box into the nozzle guide vanes.

The gas nozzle box /fig.27/ consists of a gas nozzle box casing 1, nine flanges 2, nine junction pipes 20, gas nozzle box drum 19, casing cover 7, nine air pipes 6 and cooling air muffle 8.

The gas nozzle box casing is from cast iron and is being fixed by the front flange on studs of the centre bearing housing.

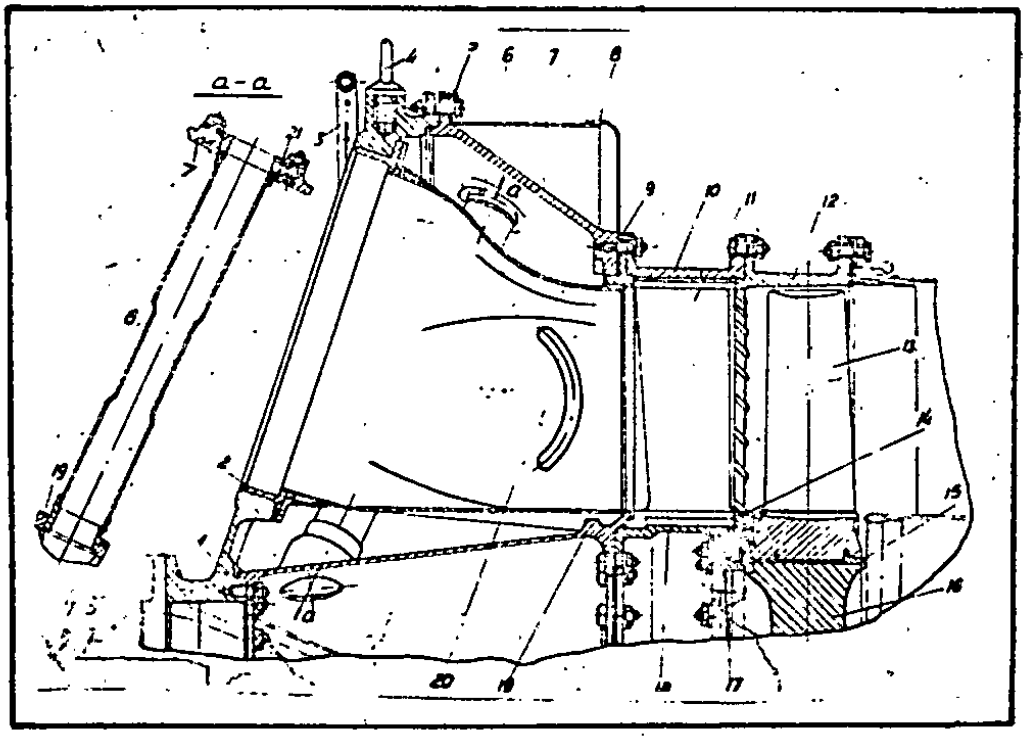


Fig.27. Gas Nozzle Box with Nozzle Guide Vanes.

1-gas nozzle box casing, 2-intermediate flange, 3-fire extinguisher manifold, 4-hoisting eye, 5-shim, 6-air pipe, 7-gas nozzle box cover, 8-cooling air muffle, 9-straightening ring, 10-outer rim of the nozzle guide vanes, 11-nozzle guide vane, 12-turbine casing, 13-turbine blade, 14-labyrinth seal, 15-tab washer, 16-turbine disc 17-spacer ring, 18-inner rim of the nozzle guide vanes, 19-gas nozzle box drum, 20-gas nozzle box junction pipe, 21-flange.

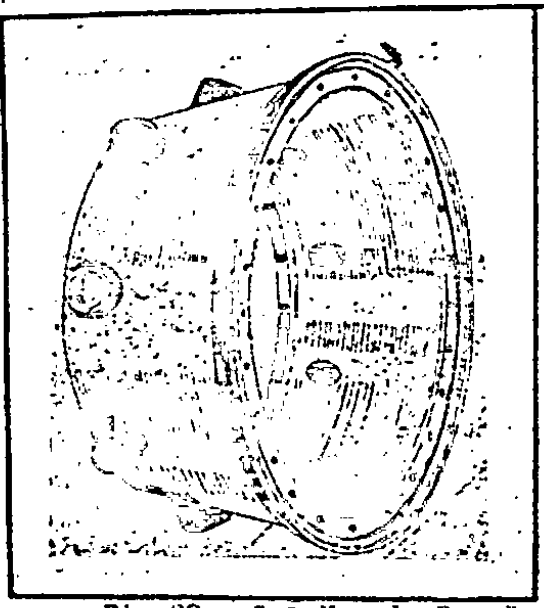


Fig.28. Gas Nozzle Box Drum.

On the top of the casing is a hoisting eye 4 for lifting the engine, in the bottom a union for draining the condensation of fuel.

In the wall of the casing are nine holes. Into the holes are fitted intermediate flanges 2, into which protrude the sealing rings of combustion chambers.

The cover of the gas nozzle box is equally from cast iron, in a shape of truncated cone. By its great flange the cover is together with the cooling air muffle being fastened through studs to the flange of the gas nozzle box casing. To the small flange the other side of the cooling air muffle and the ring 9 of the nozzle guide vanes 10 are being fixed.

On the wall of the cover are nine flanges with holes for fitting the air pipes.

The gas nozzle box drum /fig.28/ is cast from heat resistant steel and has welded on lugs for fixing and packing the air pipes. By its smaller flange the drum is being fastened on studs by means of a seating rim to the inner flange of the gas nozzle box casing. To the great flange of the drum is being fastened by studs the inner shroud ring of the nozzle guide vanes.

Fig.29. Gas Nozzle Box Junction Pipe.

The junction pipe of gas nozzle box /fig.29/, manufactured from heat resistant steel, consists of two sections, the cuff and the flange.

The entry section of the junction pipe has the shape of the circle, the sicharge section has a shape of the circular section.

The cuff with welded on flange, is welded to the junction pipe. Between the flange and the junction pipe is an annular clearance connected to the inner space of the gas nozzle box cover by thirty cutouts on the cuff. Into this gap flows from the combustion chamber outer casing air which cools the junction pipe.

By their discharge ends the junction pipes are placed between the ring of the gas nozzle box and the spacer rim of the drum. The junction pipes are fixed by their flanges together with steel intermediary flanges by studs to gas nozzle box casing.

The cooling air muffle 8 /see fig.27/ is manufactured of steel sheet.

In the lower section of the muffle is a discharge neck of the cooling air.

The nine air pipes 6 /see fog.27/ are manufactured from heat

resistant steel sheet. On the ends of these pipes spherical terminations are welded on. Nine air pipes are disposed among the gas nozzle box junction pipes and are fitted by one of their terminations into the drum bosses and by their other termination into the holes on the gas nozzle box cover. The pipes are being locked by special flanges 21, screwed on to the gas nozzle box cover.

Fire Extinguisher Manifold.

The fire extinguisher manifold 3 /See fog.27/ consists of two halves, carried out in a shape of semi cirles, the ends of which are connected in two three-way unions. The three-way unions and auxliar clamps are firmly fastened on studs of the gas nozzle box.

The circular pipes have bores of the same pitch on their circumference, for spraying the extinguishing stream directed to junction spots of the combustion chamber with the gas nozzle box and into the combustion chambers.

Nozzle Guide Vanes.

The nozzle guide vanes consist from an inner rim, the outer rim and 54 guide vanes located between the rims /shrouds/ in their slots. The small faces of guide vanes have in their front section a lug, which fits into a recess in the gas nozzle boxdrum and the centering rim of the inner shroud ring of the nozzle guide vanes. This lug ensures the positioning of the nozzle guide vanes.

The nozzle guide vanes /fig.30 are manufactured in two sets 36 pieces from the alloy BL7-45U and 18 pieces from the alloy LK-4 a strengthened profile section, The vanes with the strengthened profile section are being fitted always two at once into

the warmest zone of the gas stream; the guide vanes with a normal profile section are being fitted always *four* pieces at once in the zone of lowered gas temperatures.

By fitting the guide vanes into the shroud ring grooves their free motion in all directions is being achieved according to limits of clearances.

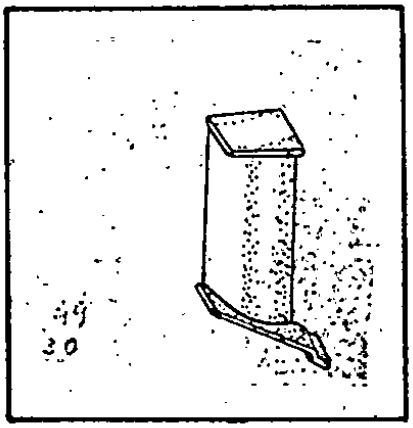


Fig.30. Nozzle Guide Vane.

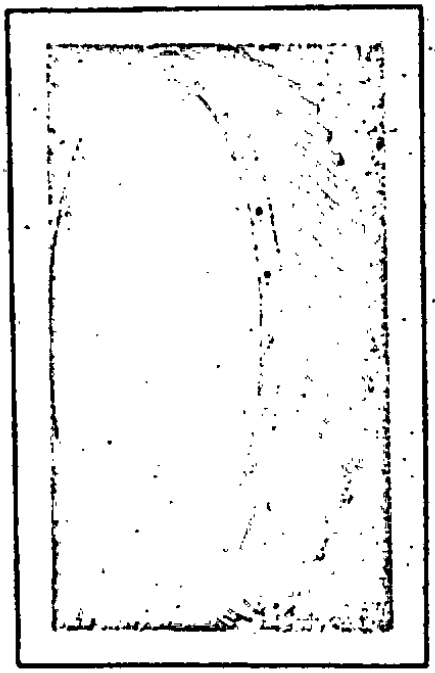


Fig.31. Inner Ring of the Nozzle Guide Vanes.

In this manner a reliable work of guide vanes is being ensured at high temperatures causing a great extension of guide vanes.

The inner shroud ring of the nozzle guide vanes /fig.31/ has on its outer side 54 inclined slots for placing small sockets of guide vanes and two flanges. By the front flange the shroud ring is being fastened to the drum of the gas nozzle box by bolts. To the rear edge of the shroud ring the labyrinth seal ring /fig.32/ is being fixed by bolts, the labyrinth having

a shape of a ring with four cams on its face. For adjusting the axial clearance of the labyrinth a spacer ring 17 /fig.27/ of necessary thickness is being mounted on.

The outer shroud ring of the nozzle guide vanes /fig.33/ has on its inner side 54 slots for great sockets of the guide vanes and two flanges. By its front flange, through the straightening ring of the gas nozzle box the shroud ring is being fixed by studs to the cover of the gas nozzle box. To the rear flange the turbine casing is fitted by bolts. The labyrinth seal ring, the inner and outer shroud rings of the nozzle guide vanes are machined of heat resistant steel.

Turbine Casing.

The turbine casing is represented by a shroud ring from heat resistant steel /fig.34/, limited by two flanges. By one of its flanges the casing is fastened to the outer ring of the nozzle guide vanes, and to the second flange is fixed through bolts the propelling nozzle. To make possible dismounting of the casing without dismantling the turbine rotor, there are in the front section of the casing 62 slots according to number of turbines blades.

Turbine Rotor.

The turbine rotor /see fig.11/ consists of a shaft 6 with a spline flange on its end, to which the turbine disc 15 is fixed with turbine blades 16.

The turbine disc machined from steel, has 62 turbine blades fitted into fir tree serrations. The turbine blade /fig.35/, from heat resistant steel, has the lower section in form of fir tree type root, by which it is fitted into a serration of similar

shape in the disc. The turbine blades are being fitted to the stop by their spacer pin into the front face of the disc and are being locked against axial shifting by plate tongues /see fig.11/ the borders of which are being bent into the rear face of the disc

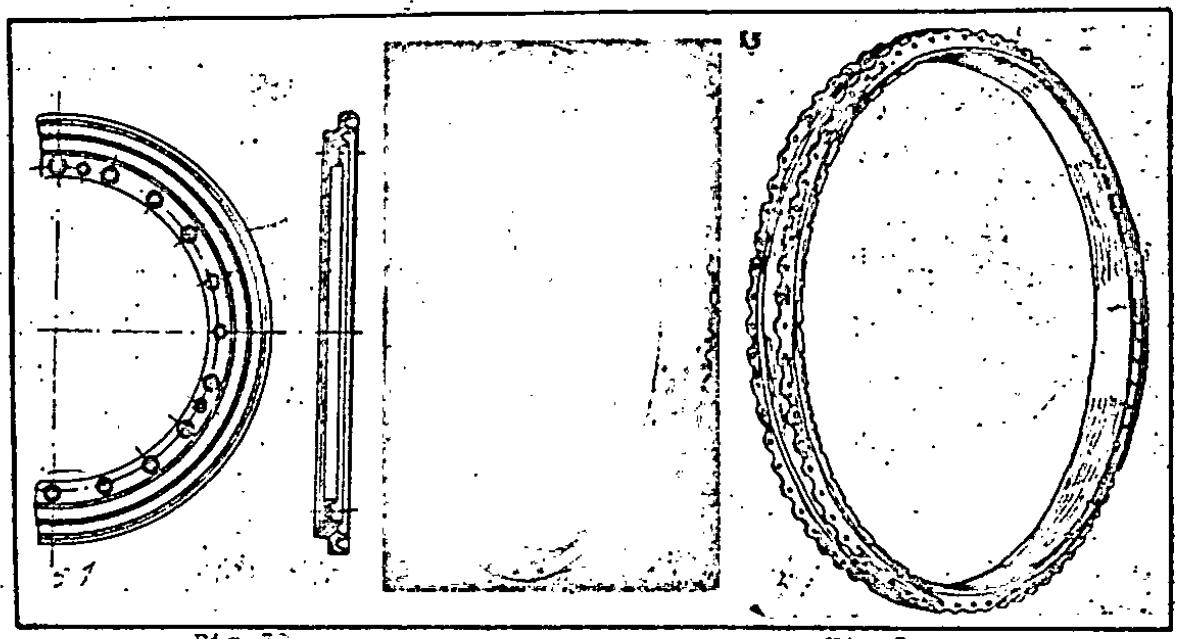


Fig.32.
Labyrinth Seal

Fig.33.
Outer Ring of the Nozzle Box Guide Vanes.

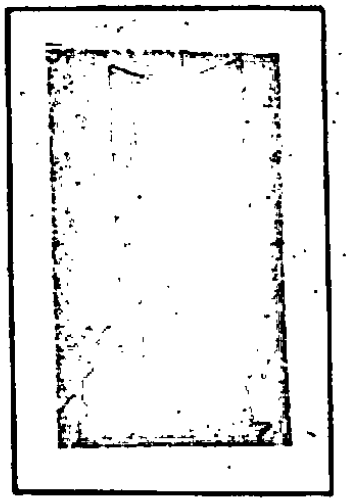


Fig.35.
Turbine Blade.

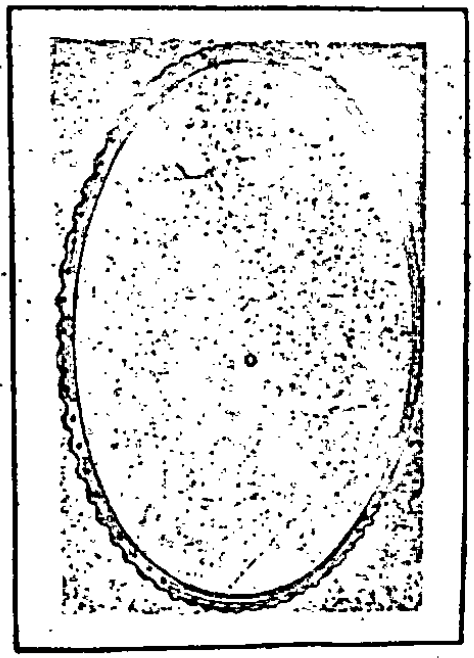


Fig.34.
Turbine Casing.

The turbine blades fit in the disc serrations with a clearance, which admits oscillations in the tangential direction inside the limits of 0,8-1,5 mm along the upper edge of the turbine blade.

The turbine rotor is being dynamically balanced in the factory and during the operation does not subject to any disassembly.

In the front section of the turbine disc with turbine blades are labyrinth recesses coverd by cams of the labyrinth seal.

The labyrinth prevents the gas from leaking off the nozzle guide vanes into the bearing hollow.

C H A P T E R VI.

AFTERBURNER.

The afterburner serves for obtaining an additional thrust of the engine by additional combustion of fuel, injected into the afterburner. The afterburner is a pipe, made of heat-resistant steel 1Ch18N9T and consists of three parts welded to each other: the widening part 1, the tapering part 2 and the cylindric part 3 /fig.36/.

The Widening Part of the Afterburner.

In the widening part 1 the gas stream speed is reduced and the additional quantity of fuel is ignited and burnt here. The widening part of the afterburner is a cut-off cone, which by its smaller base is fastened through a telescopic joint to the body of engine turbine. The telescopic joint allows mutual axial shifting and deflection of the afterburner axis from the engine axis both at engine run and at assembling /fig.37/. The telescopic joint consists of a cylindrical flange 4, which together with the annular deflektor 5 is fastened to the rear flange of turbine body, and of the ring 6, welded to the afterburner. The flange of the telescope and the annular deflector have each 72 holes for fastening bolts 7 and 72 milled grooves for reduction of weight.

The annular deflector 5 protects the telescopic joint against the gas gusts. On the widening part of the afterburner on the outer surface a heat-insulating cover 8 is put for reducing of heat transmission into the neighbourhood. On the outer surface of the widening part on the periphery four flanges 11 are welded on for the fastening bolts of the inner cone /fig.36/.

The heat insulating cover /see fig.38/ is a cut-off hollow cone made of steel sheet 1Ch18N9T and has 40 stiffening channels

"a" on the periphery which serve for stiffening of the cover. To the inner surface of the cover three bands "b" are welded for increasing of stuffness.

On the front part of the heat insulating cover there are four holes "v" placed equally on the periphery, which serve for mounting of the thermocouples for measuring of exhaust gas temperature and connecting fittings for the thermocouples. Between the holes for the thermocouples in the insulating cover four holes are provided for the fastening bolts of inner cone of the afterburner. In order to prevent piercing of gases the holes are covered by plates "g" riveted to the insulating cover.

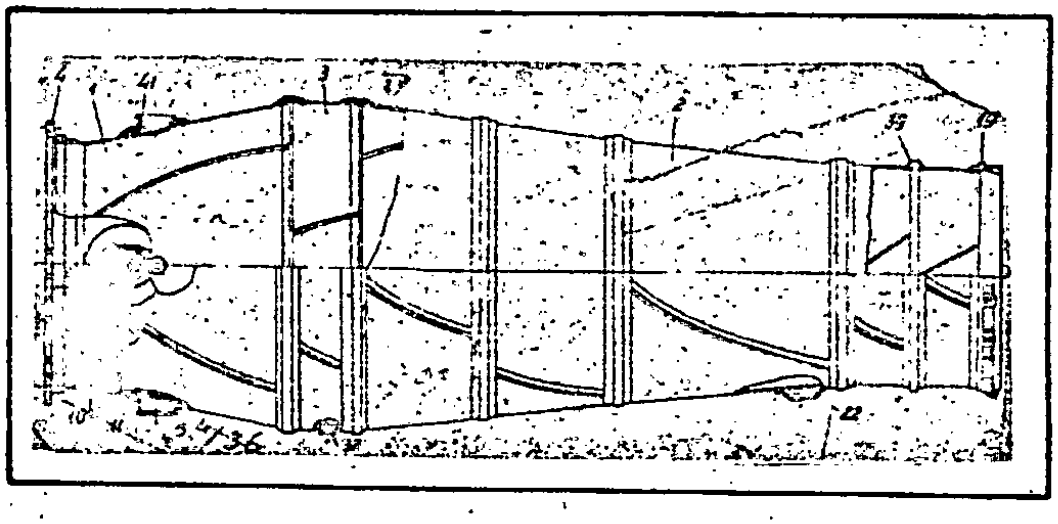


Fig.36. Pipe of the Afterburner.

1-widening part, 2-tapering part, 3-annular cylindrical part, 4-flange, 10-fastening bracket for insulating cover, 11-neck for the thermocouple, 13-flange of the jet nozzle, 22-bracket for mounting of the hydraulic jack, 32-draining neck, 39-support flange, 41-flange for fastening bolts of the inner cone.

On the right side of the insulating cover is a hole for the pipe of fuel collector of the afterburner. Inside the insulating cover there is placed heat insulating insertion "d" made of fabric

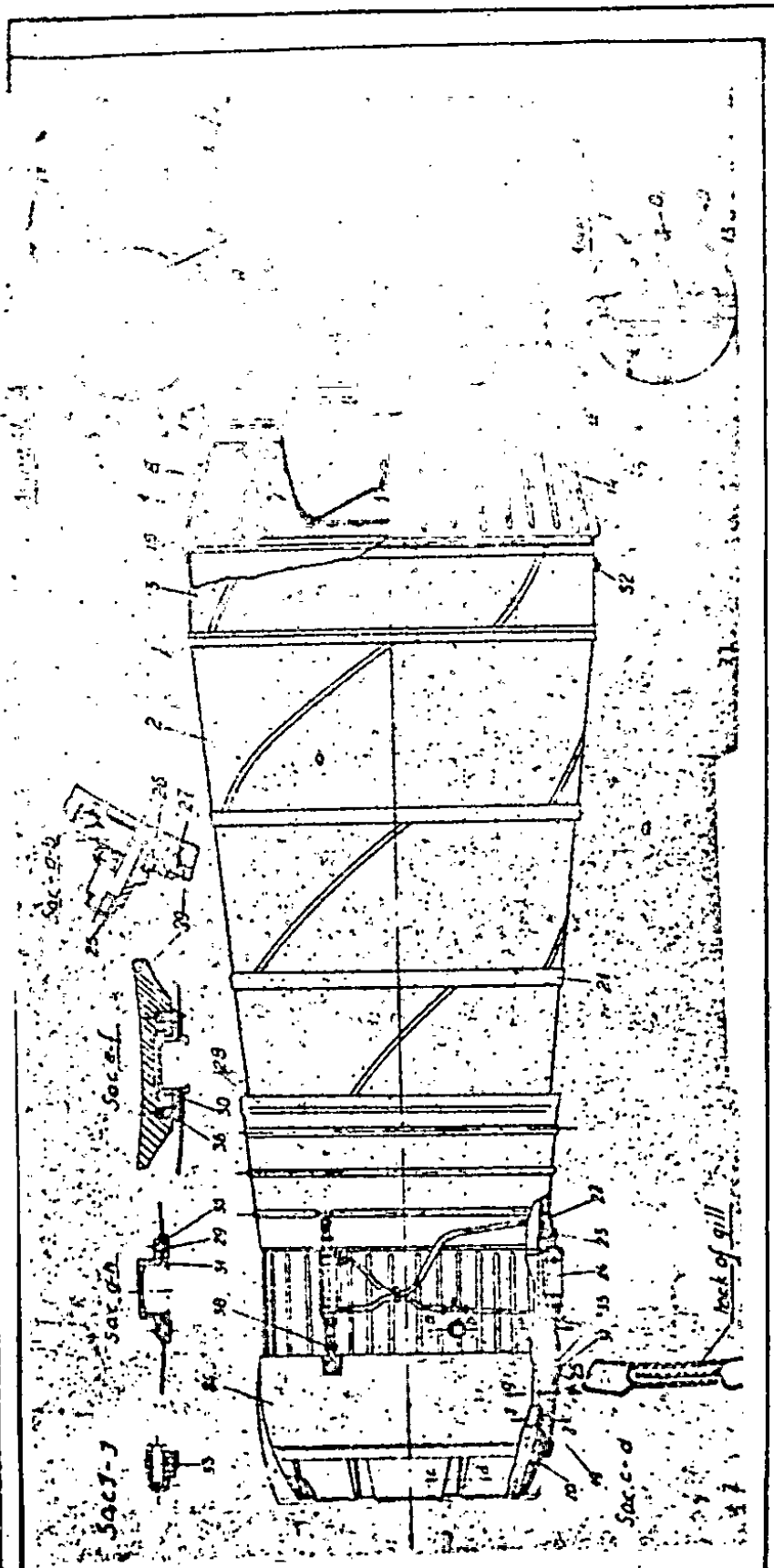


Fig. 37. Afterburner.

1-widening part, 2-tapering part, 3-annular cylindric part, 4-flange, 5-annular deflector, 6-ring, 7-bolt, 8-heat insulating cover, 9-screw, 10-fastening bracket of insulating cover, 11-neck for the thermocouple, 12-flange, 13-pipe for inlet of fuel, 14-neck for electric lead to the ignition plug, 15-inner cone, 16-aerodynamical shield, 17-fastening bolt, 18-annular stabilizer, 19-flange of the jet nozzle, 20-ring, 21-hoop, 22-bracket, 23-bolt, 24-hydraulic jack, 25-support pin, 26-link, 27-fastening bolt of link, 28-vent jacket, 29-fastening screw of jacket, 30-stiffening plate, 31-guide channel of roller of the fairing, 32-draining neck, 33-axle, 34-fairing, 35-roller, 36-peg of the guide channel, 37-fastening axle of roller, 38-fork of hydraulic jack rod, 39-support flange, 40-ball.

AT-7, 2,5 mm thick. The heat insulating cover is fastened by eight Screws 9 on the brackets 10, welded to the afterburner /see fig.37/

From outside on the periphery of the widening part, at a distance of 100 mm from its front flange there are placed four necks, 11 for mounting of the thermocouples and the flange 12 for mounting of the pipe 13, leading fuel into afterburner and the neck 14 for fastening of the high voltage lead of the ignition plug.

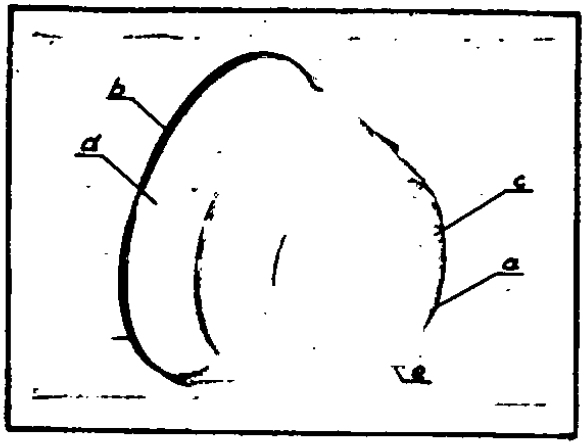


Fig.38. The Heat Insulating Cover /Jacket/.

a - stiffening channel, b-band, c - hole for thermocouple, e - plate of the hole, d-heat insulating fabric.

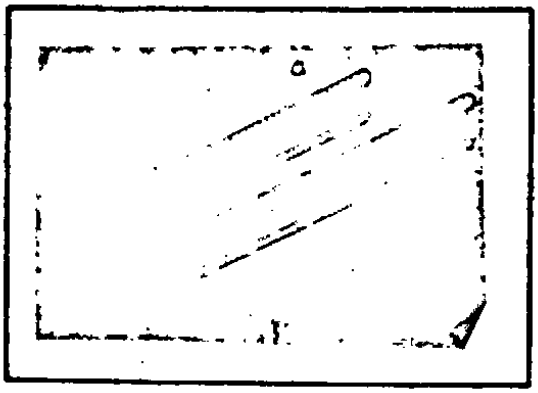


Fig.39. Fastening Bolt

a - vertical
b - horizontal

Inside the widening part of the afterburner are placed: the inner cone 15, four fairings 15 and two fastening bolts 17 with H - cross-section. Two fairings are in horizontal position and two fairings in vertical position. The fastening bolts are shown in fig.39. The vertical fastening bolt is by 22 mm longer than the horizontal fastening.

The widening part and the inner cone form an annular diffusor, where the mean speed of the gas stream is reduced from 330 m/sec. to 100 m/sec. In the annular diffusor of the afterburner is placed the annular stabilizer 18 /fig.37/ serving for stabilization of the combustion.

The stabilizer /see fig.40/ consists of a V-shaped ring "a", in the base of which are made 24 holes for the burners and 4Holes for fastening of the brackets. The ring is made of heat resistant steel FI-435. In order to increase the rigidity of the ring same has a welded edge "b" an inner edge "c", which are turned rings. In the 24 holes of the stabilizer are inserted and welded the jackets for the burners which are ended by welded-on terminals "e". Into the four bosses "f" four brackets "g are screwed in, having a T-shaped cross section, ended by eyes., serving for fastening of the annular stabilizer to the fairings of the fastening bolts. The brackets of the stabilizer are fastened to the ring "a" by nuts "h".

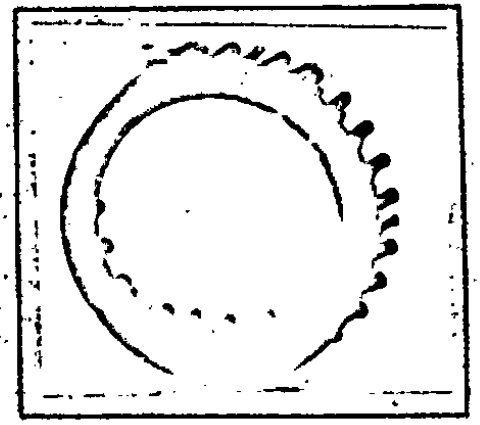


Fig.40. The annular Stabilizer.

a-ring, b-outer edge, c-inner edge, d-jacket, e-terminal, f-boss, g-bracket, h-nut.

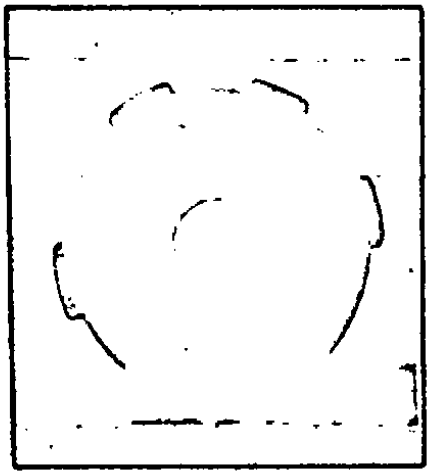


Fig.40a. Shroud /screen/

The inner barrel /see fig.41/ is a cut-off cone made of steel FI-435. The bottom "a" is welded inside the body on the side of larger diameter. For better rigidity of the barrel, a ring "b" and a hoop "c" is welded on it.

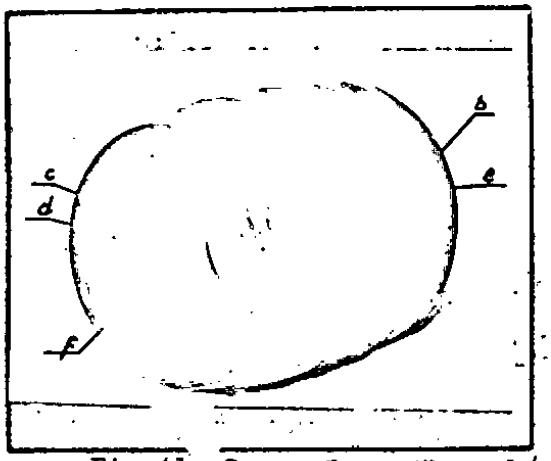


Fig.41. Inner Cone /Barrel/.

a-bottom, b-ring, c-hoop, d-flange, e-hole for fastening bolt, f-bracket, g-hole for the stem.

On the side of the minor diameter is welded the flange "d" of the barrel, serving for stiffening and for fastening of the diaphragm to the barrel. The flange has 20 holes for bolts.

In the barrel there are four holes for fastening bolts. From inside is welded a bracket "f" for insulator of current leading stem and in the barrel is a hole "g" for this stem.

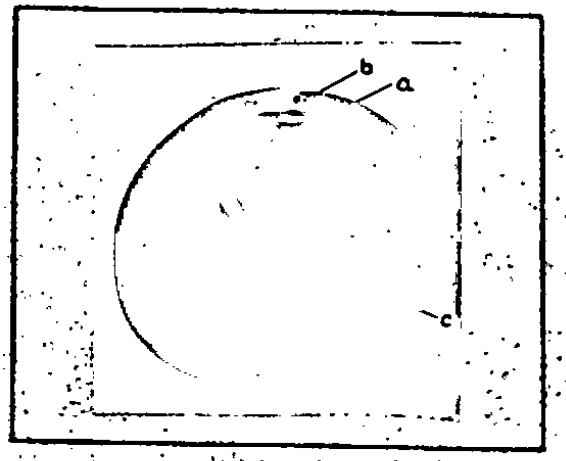


Fig.42. Diaphragm.

a-holes for fastening screws of the diaphragm to the inner barrel, b-lock holes, c-body of ignition plug, d-flange..

The diaphragm /fig.42/ is made of steel EI-435, has a form of a cut-off cone. On the larger diameter there are 20 holes "a" for fastening bolts of the diaphragm and 20 holes "b" for locking of these bolts. In the centre of the minor diameter there is made a hole, into which the body "c" of the ignition plug is inserted with flange "g", welded to the diaphragm. The fairings, shown in fig.43, are made of heat resistant steel sheet OI-435. Inside the fairing is welded a stiffening bush, through which, the fastening bolt is fitted. At the back is welded a loop "a", serving for fastening of the stabilizer with the fuel collector. From upside to the fairing is welded a cover "b", from the other side the bottom "c".

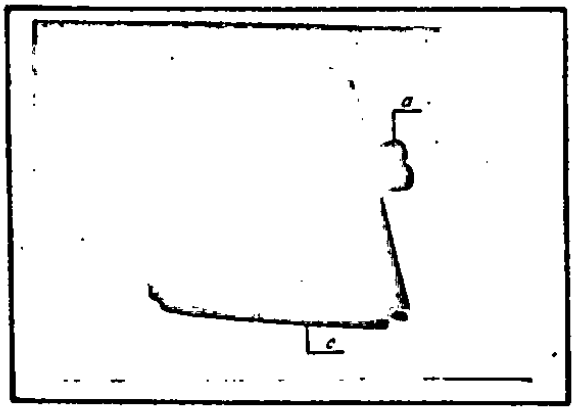


Fig.43. Fairing.

a - loop, c - bottom, b - cover.

Tapering Part of the Afterburner.

In the tapering part of the afterburner the additional fuel is completely burnt and the gas flow speed increases. The tapering part 2 /see fig.36 and 37/ of the afterburner is a cut-off cone, which is welded by its larger diameter to the annular cy-

lindrical part of the afterburner. The tapering part is and d by a cylindrical section with two flanges: the support flange 39 and flange for the jet nozzle 19. The support flange 39 has three grooves for guide channels 31 for rollers of the fairing and two grooves for links 26. The flange of the jet nozzle 19 has three grooves for the guide channels 31 for fairing rollers and on its rear side are welded forks for fastening of the gills of the jet nozzle. In order to improve the strength and rigidity of the tapering part of the afterburner there are used skew welding seams and transversal hoops are applied. /pos.21/ On the end of the tapering part are welded three brackets 22, to which by bolts 23 three power jacks are fastened /24/, by which the extensible jet nozzle is controlled, and further here are two journals for fastening of the afterburner to the framework of the aircraft. The support journal is screwed in into the link 26, which is fastened by two bolts 27 to the support flange 39. Three steel guide channels 31 for rollers of the fairing are fastened in the grooves of the flange of jet nozzle and of the support flange. The axial motion of the guide channels is made impossible by two pegs 36 and the radial motion by projections, meshing with grooves of the flanges. The tapering part of the afterburner has no heat insulation. The air frame is protected against overheating from running engine and the afterburner is cooled by flow of cool air, blowing between the wall of the afterburner and the air frame jacket. During flight this air is delivered by dynamic pressure at intake of the air inlet mouth of the aircraft. The part of air coming from cooling of the chamber, passes between the inner and outer wall of the gills of the controllable jet nozzle, thus cooling same.

On the outlet end of the tapering part of the afterburner is fastened a vent jacket,28, which is designed as allongation of the frame vent jacket. The vent jacket /fig.44/ is made of steel 1Ch18N9T and consists of two parts - the conical "a" and the cylindrical "b". On the conical part for better rigidity there are three annular channels "c" and a rimming ring "d" is welded.

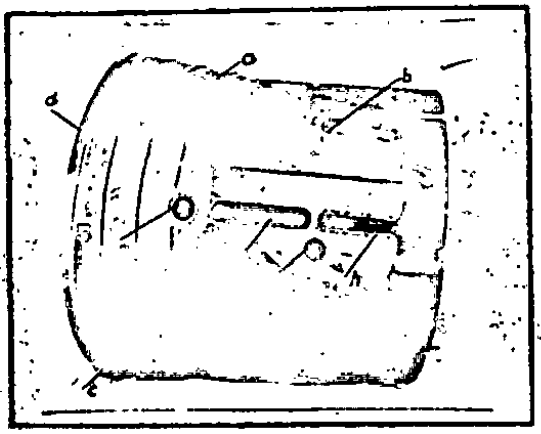


Fig.44. Vent Jacket.
a-conical part, b-cylindrical part, c-annular channel, d-rimming ring, e-hole for bracket, g-dimple for hydraulic cylinder, h-cutout for guide channel of fairing roller, i-hole for the support journal.

Evenly on the periphery there are threee holes "e" for fastening brakets of the hydraulic cylinders /jacks/.

For mounting of hydraulic jacks are made evenly on the periphery three dimples "g", for fastening of the guide channels for fairing rollers are made three cutouts "h" and [illegible] for the support journals. The jacket is fastened by eight screws 29 through plates 30 to each of the three guide channles 31 /see fig.37/.

The Annular Cylindrical Part of the Afterburner.

The cylindrical part serves for connestion of the widening and tapering part of the afterburner. In order to increase strengt and rigidity of the cylindrical part, analogically as in case of the tapering part, skew welding seams are used. For draining of fuel in the bottom of the cylindric part a cock 32 is provided /see fig 36 and 37/.

Controllable Jet Nozzle.

The controllable jet nozzle serves for regulation of clear

cross section in the spot where gases leave the afterburner when engine runs with afterburner „ON" and „OFF". The jet nozzle can be only in two positions: „SHUT" - the minimum cross sectional area and „OPEN" - the maximum cross-sectional area. The controllable jet nozzle of the afterburner /fig.37/ consists of eight gills 20 and of fairing cowl 34 with three rollers 35. The diameter of the controllable jet nozzle is determined by position of the fairing cowl. The controllable jet nozzle allows variation of the exhaust cross-sectional area from ϕ 538 mm to ϕ 630 mm. When the fairing cowl moves forward /along direction of flight/ the ring of the fairing cowl contracts the gills, which form the minimum outlet cross - sectional area in extreme position of the fairing cowl. When the fairing cowl moves rearwards /opposite direction of flight/, the ring of the fairing cowl releases the gills which under action of the discharge gas pressure extend and when the fairing cowl is in extreme front position, the gills form the maximum exhaust cross-sectional area of the controllable jet nozzle.

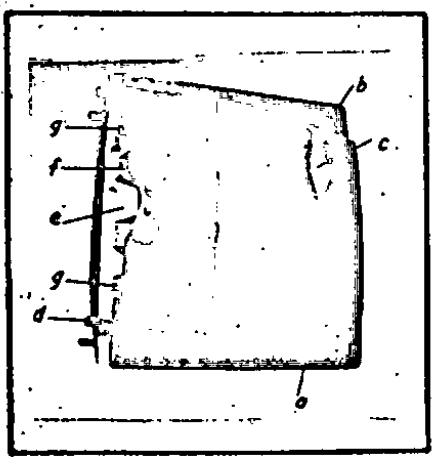


Fig.45. G ill.

a-U-shaped side, b-sheet side, c-outer wall, d-eyelet, e-inner wall, f-longitudinal stiffener, g-stiffening ribs.

The gills /fig.45/ are made of heat resistant steel and are designed as a closed structure for obtaining a better rigidity and for cooling by stream of air. The side walls of the gills form a lap-joint. One of them is made in form of U-section groove, the other is simple sheet. In assembled state the sheet side of one gill enters the groove side of the other gill, by which a sealed connection is provided, preventing gas from breaking through into atmosphere

/see fig.38./ The inner conical wall forms the profile of jet nozzle mouthpiece. The outer wall has a profiled surface in order to secure a close fitting of the gill to the ring of the fairing cowl on the whole surface when the fairing cowl moves and also for obtaining the desired values of cross-sectional area change of orifice of the jet nozzle during linear motion of the fairing cowl.

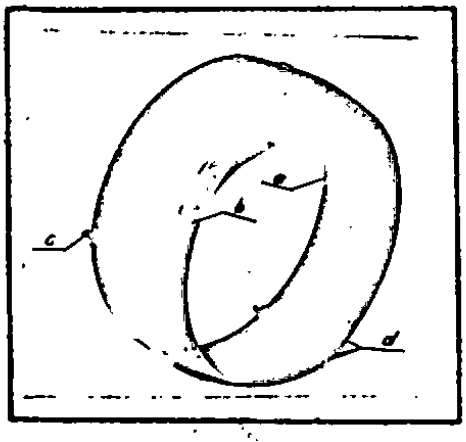


Fig.46. Fairing Cowl.

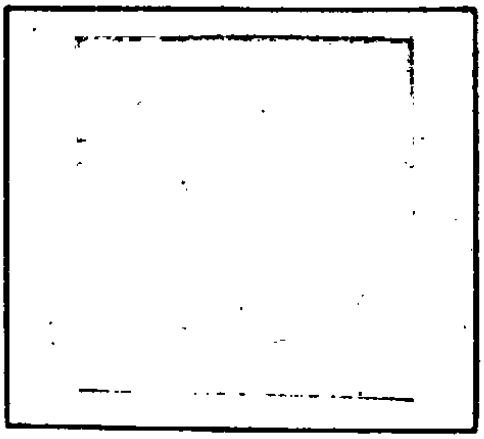


Fig.47. Roller.

a - band, b-ring, c-bracket,
d - copper plate.

For better strength between the inner and outer wall is welded one stiffening rib "f" along the whole gill and per two stiffening ribs "g" on each edge of the gill. The inner wall of the gill and the groove shaped side are made of steel EI-435, the other parts are made of steel 1Ch18N9T.

The friction surface of the gill, in order to prevent seizing, is chromium coated. Each gill is fastened by means of two eyelets and axles 33 in the forks of jet nozzle flange /see fig.37/. The fairing cowl /see fig.46/ is made of steel sheet 1Ch18N9T in form of a cut-off cone with a band "a", ring "b" and with three brakkets "c", evenly placed on the periphery. On the inner surface of the ring "b" are riveted 24 copper plates "d". The inner surface

of the plate "d" and of band "a" has a rough profile and is covered by graphit putty. The chromium coated surface of the outer wall of the jet nozzle gills is in touch with the copper plates of the cowl. Such frictionning couple works readily without additional greasing in high temperature at heavy loads.

Position of the roller 35 /fig.37/ in its guide channel 31 is adjusted by turning the eccentric part of the axle 37 in relation to the roller, owing, to which the roller can move in guide channels without seizing.

The roller, shown in fig.47, is made of cast iron.

To the brackets of the fairing cowl are connected the forks 38 of hydraulic cylinders piston rods /see fig.37/.

The Hydraulic Control System of Controllable Jet Nozzle.

The hydraulic system serves for controlling the controllable jet nozzle in position with or without afterburner ON. The hydraulic control system /fig.48/ consists of 3 hydraulic cylinders 3.

From the aircraft system the hydraulic liquid is brought under pressure approximately 150 atm to the elctrohydraulic valve GA-13. The GA-13 valve has a two-position slide valve, controlled by electromagnet. When the engine operates without afterburner, the hydraulic liquid from the electrohydraulic valve is directed under pressure through the pipeline 3 and connects the hydraulic system of the aircraft with cavity "B" of the hydraulic cylinders. Thus, the hydraulic liquid in the hydraulic cylinders remains under pressure and maintains the cowl in the extreme front position which corresponds to the minimum cross-sectional area of the jet nozzle. The cavities "V" of the hydraulic cylinders are connected with return line and reservoir. When the afterburner is being

turned on, the electromagnet of the electrohydraulic valve 2 shifts the slide valve, connects the cavity "y" of the hydraulic cylinders with the hydraulic system of the aircraft and the cavities "B" with the return line. The hydraulic liquid under pressure is directed into the cavities "y". The pistons of the hydraulic cylinders under pressure of the hydraulic liquid are shifted into extreme rear position together with the fairing cowl, by which the gills are released. This position corresponds to the maximum opening of the controllab-le jet nozzle.

For synchronous action of the power cylinders in the system the jets 4 are mounted. The synchronous action of the hydraulic cylinders and time of motion of the cowl is adjusted by choosing a proper set of jets when the engine is tested on the test bed. The power jack and the jets are marked after test by the same chiffre. The power jack /hydraulic cylinder/ /fig.49/ is made of steel 30ChGSA as a hollow body 1, in the cover of which a hole with three annular grooves is provided, into which three rubber sealing rings 2 are fitted for tightening of the place. Inside the cylinder is a piston 3, the rod of which protrudes through the cover of the cylinder outside from it. The piston divides the cavity of the cylinder into two parts and for preventing of leakage of the liquid from one cavity into another two grooves are provided in the piston, in which rubber sealing rings 4 are inserted. In the cylinder a plug 5 is inserted, on which there are two outer and two inner grooves. In these grooves rubber sealing rings 4 and 6 are inserted, which serve as sealing, preventing the hydraulic liquid from leaking out of the cylinder. The plug is fastened on the cylinder by the nut 7. Into the plug the front fork 8 is screwed in, which limits the travel of the piston and serves for fastening of the cylinder to the bracket of the afterburner.

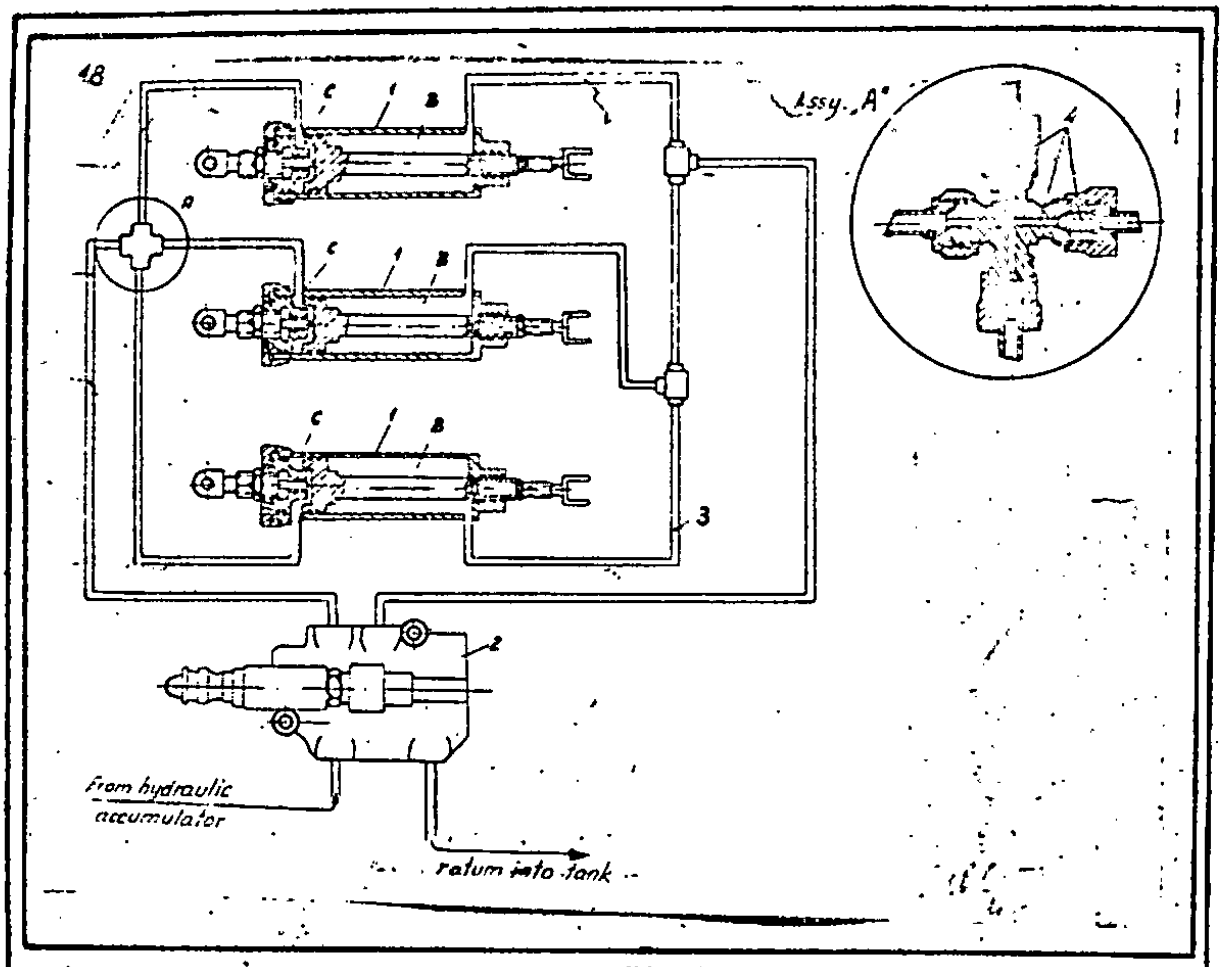


Fig.48.
Diagram of Hydraulic System of the Controllable Jet Nozzle.

1-power jack, 2-electrohydraulic valve GA-13, 3-pipeline, 4-jet.

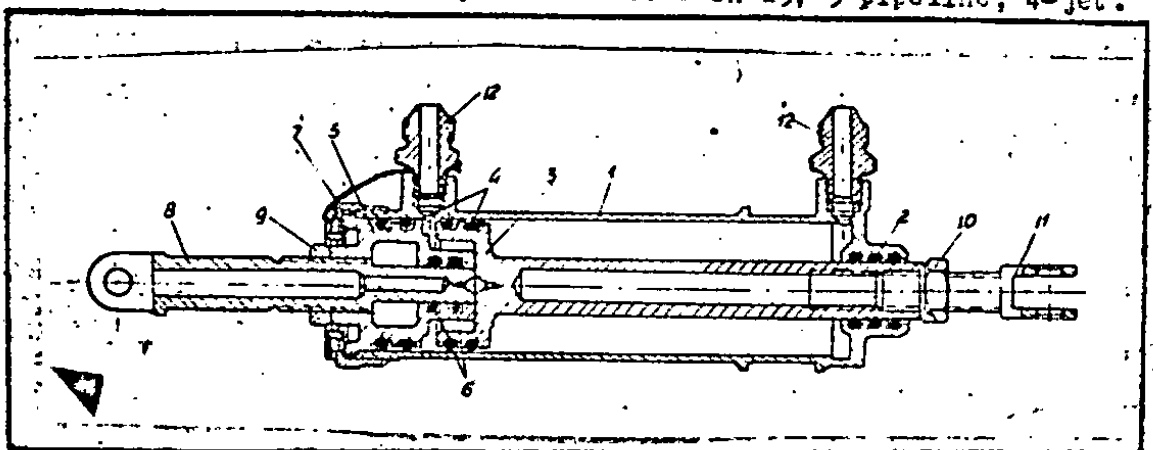


Fig.49. Power Jack. 1-body, 2-rubber sealing of rod, 3-piston with rod, 4-rubber sealing of piston and plug, 5-plug, 6-rubber sealing of front fork, 7-nut, 8-front fork, 9-10 lock nuts, 11-rear fork, 12-necks.

The front fork is locked by a nut 9. Into the rod of the piston 3 is screwed in a rear fork 11, to which is connected the fairing cowl of the controllable jet nozzle. The rear fork is locked by the nut 10. As regulating elements of the clear crose-sectional area of the controllable jet nozzle serve the front and the rear forks.

In order to avoid chamber of the fairing cowl the regulating elements should be turned by the same number of turns on all three power jacks, Both cavities of cylinders divided by the piston are connected with the pipelines. leading the liquid to the hydraulic cylinder by means of the necks 12.

C H A P T E R VII.

ENGINE AUXILIARIES DRIVE BOX.

The engine auxiliaries drive box /fig.50/ with auxiliaries mounted thereon, is placed on the front part of the engine and is fastened by its flange on the stud bolts of front bearing housing. The auxiliaries drive box is calculated for mounting of fuel pumps PN-9MA and PN-14A with gear ratio i - 0,25 and 0,4333 respectively.

The pumps are fastened on the right side of the auxiliaries drive box. The PN-9MA pump is fastened on the upper flange and the PN-14A pump on the lower one. The starter motor drive has a gear ratio i - 2,8. To the lower flange of the auxiliaries drive box on the stud bolts is fastened the oil filter box, separated from the auxiliaries drive box by a special diaphragm. The rotation from the engine rotor is transmitted to the driving cylindrical gear 10 of the drive box through the transmission splined shaft 9 /see diagram fig.51/ The driving gear has the same rotational speed at the engine rotor. In the middle part of the shaft of the driving cylindrical gear on two ball bearings is freely fitted the driven bevel gear of the starter motor 4, which is in mesh with the driving bevel gear 11, which transmits the revolutions from the starter motor, placed on the flange of the auxiliaries drive box on the left side /if you look onto the engine from behid/. The driven bevel gear of the starter motor has inside a rack mechanism which is connected with the shaft of the driving cylindrical gear by splines. The rack mechanism, consisting of three dogs 20 /see fig.50/ with springs 22 serves for starting of engine from the starter-motor and for disconnecting of the latter when the engine accelerates. The dogs of the rack mechanism are fitted on axles

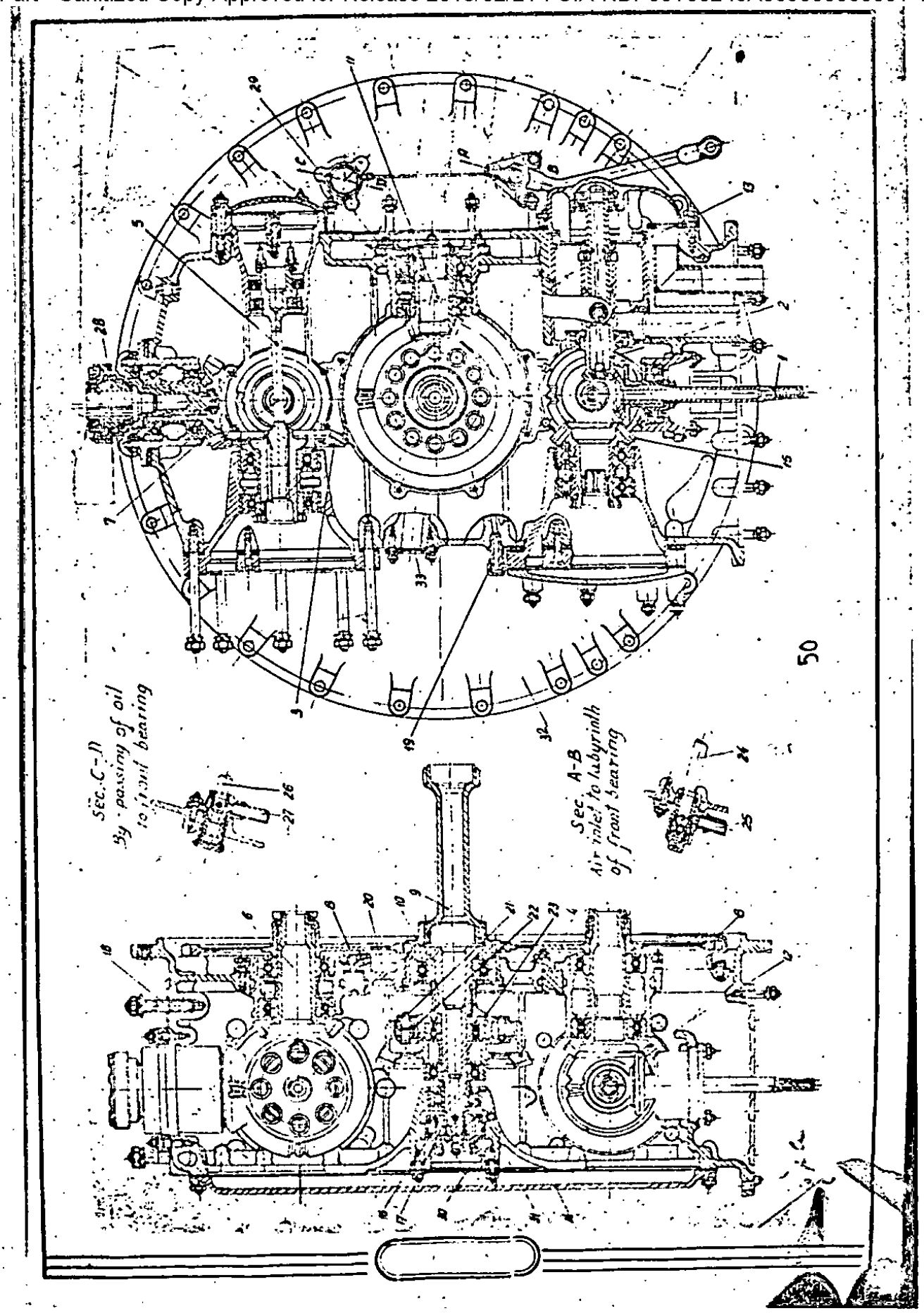


Fig.50. Engine Auxiliaries Drive Box.

1. Gear for driving the oil pump and the separator
2. Gear of the separator
3. Upper bevel gear - driven
4. Driven gear of starter motor
5. Shaft of tacho-dynamo
6. Upper driven bevel gear
7. Gear of spare drive
8. Driven cylindrical gears
9. Shaft of auxiliaries drive box
10. Driving cylindrical gear
11. Gear of starter
12. Lower driving bevel gear
13. Separator
14. Cover of auxiliaries drive box
15. Lower driven bevel gear
16. Body of deaerator
17. Clutch
18. Stud bolt
19. Draining neck of auxiliaries drive box
20. Dog
21. Axle of dog
22. Spring of dog
23. Clutch of starter motor
24. Air pipe of front bearing labyrinth
25. Air pipe
26. Pipe of oil system of front bearing
27. Pipeline
28. Splined bush
29. Bush of starter motor drive
30. Cover of deaerator body
31. Roller bearing
32. Body of the box
33. Mesh of the deaerator

21 in the clutch body 23. The assembly of the clutch is placed in the cavity of the driven conical gear of the starter motor, which has on the inner surface teeth, with which the dogs of the clutch get in mesh. When the engine after having been started by the starter begins to run and its rotational speed overtops the rotational speed of the driven gear of the starter, the dogs, which overwhelm the force of the springs by action of the centrifugal forces, are disenaged from mesh with the driven gear, thus protecting themselves and also the inner teeth of the gear from wear at the engine run.

The position of the driven bevel gear, of bearinge and of the rack machanism of the shaft of the driving cylindrical gear is fixed through spacing bushes and through the regulating washer by a nut, screwed on on the terminal of the shaft.

The driving cylindrical gear 10 is at the same time in mesh with two driven cylindrical gears 8, placed above and under the driving gear. Each of these gears is fitted on a terminal of bevel gears, placed inside the box in seats of its rear wall. The upper bevel gear 6 is in mesh with the driven bevel gear 3, which transmits the revolutions to the upper fuel pump, mounted on a flange of the auxiliaries drive box from the right. With the bevel gear of the upper pump drive is in mesh a bevel gear 7 of the upper spare drive of the drive box. For compensation of lack of alignment of the aircraft auxiliaries drive box splined shaft type D2K, inside the upper spare drive a spherical splined bush 28 is installed /see fig.50/. Into the inner splines of the driven bevel gear of the upper fule pump is fitted a splined shaft 5 driving the tachometer pickup /tachodynamo . The flange for fitting of the tachometer pickup is placed on the left wall of the auxiliaries drive box above the starter motor flange.

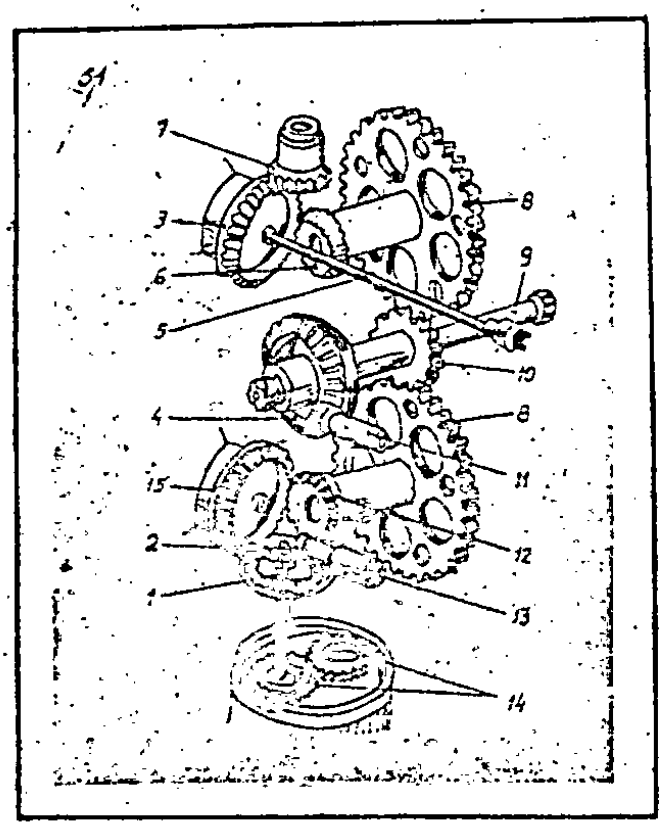


Fig.51. Mechanical Scheme of the Auxiliaries Drive Box.

1-double gear for driving of oil pump /Z-26/ and of the separator /Z-20/, 2-gears of the separator /Z-17/, 3-driven upper bevel gear /Z-32/, 4-driven bevel gear of starter motor /Z-42/, 5-splined shaft of tachometer pickup, 6-upper driving bevel gear /Z-20/, 7-gear of spare drive /Z-20/, 8-driven cylindrical gear Z-45/, 9-splined shaft of auxiliaries drive body, 10-lower driving bevel gear /Z-26/, 13-separator, 14-gears for oil pumps Z-17, Z-21/, 15-lower driven bevel gear /Z-24/.

The lower bevel gear 12 is in mesh with the bevel gear 15 of second fuel pump drive. The pump is mounted also on a flange of the engine auxiliaries drive box on the right side. The bevel gear 15 is in mesh with the lower circle of the double vertical bevel gear 1, the splined terminal of which makes revolve the assembly of oil pumps /the high pressure pump and the scavenging pump/. The upper circle of the double vertical bevel gear 1 is in mesh with pinion 2 of the separator 13, serving for separa-

tion of air from oil. The separator is placed under drive of the starter in a paralell position with it.

The parts of the drives of all auxiliaries and of the separator are assembled as independent assemblies, by which the regulation of clearances is made much easier for assembling the drive box as a whole.

The front support of the auxiliaries drive box central shaft is placed directly in the box body. Deaeration of the box is performed by means of a deaerator, mounted on the central shaft of the box, the deaeration opening being placed in the side wall of the drive box on the right side /in direction of flight/. On the right side of the box, a draining neck 19 is fitted. The cover 14 of the auxiliaries drive box has an oval form. On the upper wall of the box there are 3 bosses for stud bolts 18, serving for fastening of the aircraft auxiliaries drive box.

C H A P T E R VIII.

AIRCRAFT AUXILIARIES DRIVE BOX TYPE D2M

The aircraft auxiliaries drive box type D2M is mounted on the engine M-14P and serves for mounting and driving of the aircraft auxiliaries drive box with the necessary rotational speed. The parts of the drive box are assembled in a housing, cast of aluminium alloy.

On the flanges of the D2M box the following four accessories are mounted :

1. Power generator GSR-6000 or GSR-3000 or GSR-1500 is mounted on the side flange. Direction of shaft revolution is right /for this and also for the other accessories it means, when you look into the corresponding flange on the drive box/. The gear ratio to the engine rotor is 0,768.

2. A.C. generator SGS-7,5 - 3 is mounted on the side flange. Sense of rotation of the drive - right. Transmission ratio to the engine rotor is 0,768.

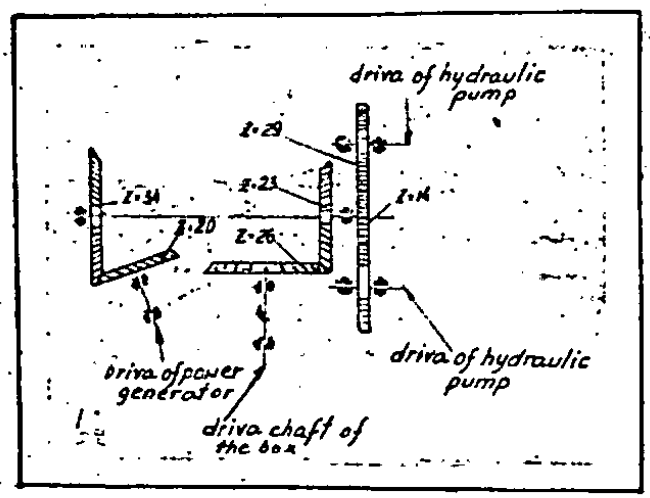


Fig. 52. The kinetic Diagram of the Aircraft Auxiliaries Drive Box D2M.

3. Two hydraulic pumps 623 of NSh-34 or 109A are mounted on the rear flange. Revolution of the drive - to the left. Gear ratio to the engine rotor is 0,213.

The D2M is mounted above the engine auxiliaries drive box on a cast bracket, which is fastened by three stud bolts to the body of engine auxiliaries drive box. The D2M box is fastened by four bolts to the bracket. The revolution from the upper bevel gear of the engine auxiliaries drive box is transmitted on the driving bevel gear of the D2M drive box through a splined shaft, the rotational speed of which is 0,4 of engine rotor rotational speed.

In the upper / spare / drive bush of the engine auxiliaries drive box and in the driving bevel gear of the D2M box spherical splined bushes are fitted, compensating the deflections originated during operation. The revolutions are transmitted to the accessories through a system of gears / see fig.52/. The general viehbf the box is shown in the fig.53.

From the driving bevel gear the revolutions are transmitted to the main shaft through the drivel bevel gear. On one end of the main shaft is fitted by means of a wedge the driving bevel gear, which drives the two bevel gears of the power generators, which are placed symmetricelly in relation to the main shaft and have inner splines, by which the revolutions are transmitted to the driving shafts of the power generators. On the other and of the main shaft is fastened on splines by a bolt the driving cylindrical gear, transmitting the revolutions to two cylindrical driven gears of hydraulic pumps. The two gears have inner splines, by which through splined bushes the revolutions pumps.The driving gear of the drive box, the main shaft and the

two driven bevel gears of the generators are fitted in their busher on ball bearings. The two drivel bevel gears of the hydraulic pumps are fitted each in one ball bearing and one roller bearing. The aircraft auxiliaries drive box has a lubrication system independent from the engine system. For lubrication the transformer type oil or MK-8 oil and also transformer oil with addition of ETI-1 in quantity of 0,009 - 0,01 per cent and AZNII max 0,2 per cent or oil MK-8 with addition of ETI-1 in quantity of 0,009 - 0,01 per cent are used.

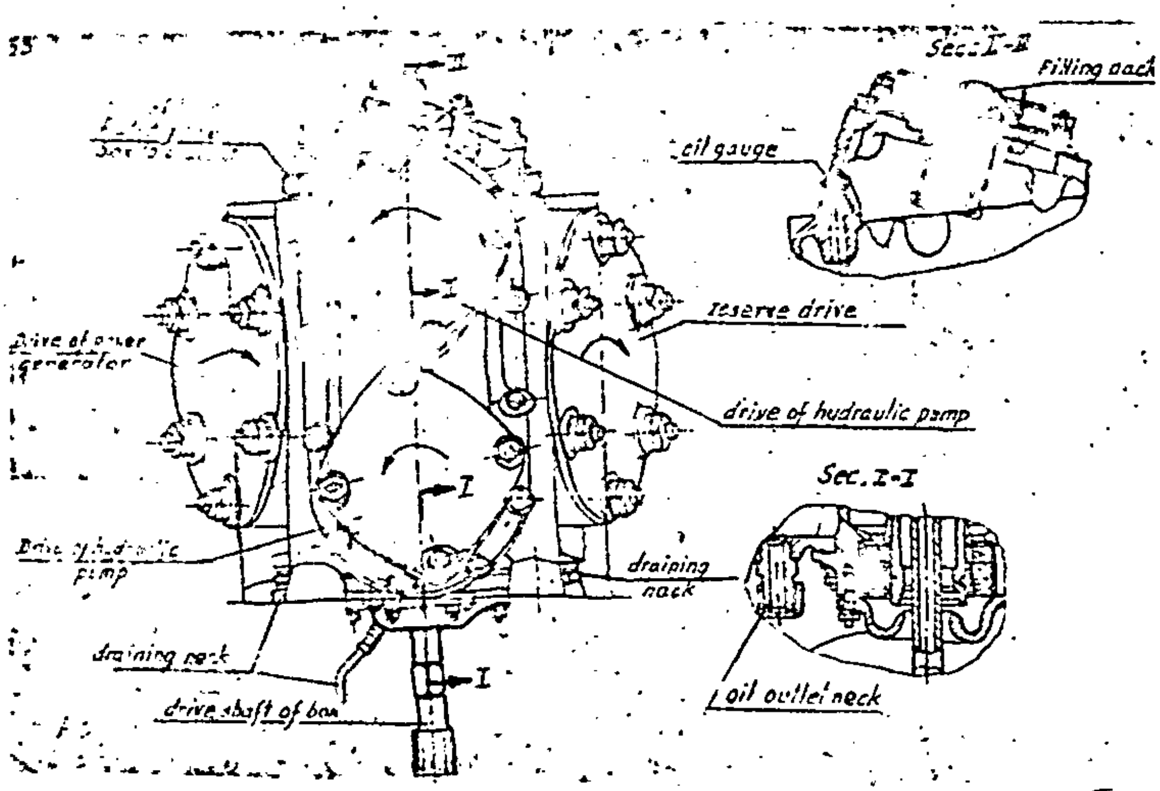


Fig.53. Aircraft Auxiliaries Drive Box Type [illegible] / Rear View.

For lubrication of gears and bearings the splashing system is adopted. Oil is filled into the drive box through filling neck, placed on the top of the box and provided with a filter. In the neck a deaeration device is provided, which connects the inner cavity of the box with the atmosphere. In the cover of the filling neck is fitted a valve /star-type/, preventing oil from leakage into atmosphere when the aircraft flies in inverted position.

Quantity of oil in the box is checked by means of an oil gauge, having two marks with inscriptions "maximum" and "maximum", which correspond to the upper and lower admissible level of oil in the box. Between the extreme marks 6 intermediary marks are cut.

The spherical splined bush and the splines of the shafts are greased by the graphit grease NK-50.

For accessories mounted on the aircraft auxiliaries drive box, no lubricant supply is provided. In order to prevent intruding of oil into generators, sealing glands are fitted in the bushes of driven gears of the generators. Leaking of oil from the drive box down through the ball bearings of the driving bevel gear of the box is prevented by two rubber sealing glands.

Oil leaking through sealing glands of the generators and of the driving bevel gear is led out through draining necks by pipes into the common draining system of aircraft.

Regulation of meshing of the bevel gears is performed by choosing proper dimension of regulating washers. On the lower surface of the box in front the neck for draining of oil from the ox is provided.

C H A P T E R IX.

Lubrication System .

The engine lubrication system / see scheme in fig.54/ is determined for feeding oil under pressure to all friction surfaces of the engine.

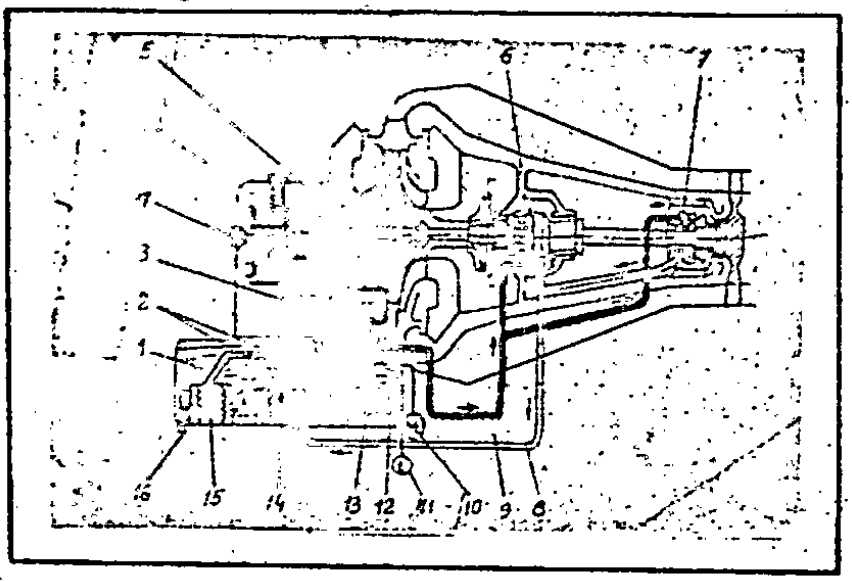


Fig. 54. Engine Lubrication Chart.

1-oil casing, 2-oil pumps, 3-centrifugal deaerator, 4-accessory drive box, 5-front bearing, 6-centre bearing, 7-rear bearing, 8-scavange manifold, 10-pressure gauge, 11-thermometer, 12-relief valve, 13- high pressure filter, 14 and 15 - low pressure filters, 16 - drain cock.

The oil casing 1 serves as oil sump with a capacity of 6 lit. fastened to the bottom flange of the accessory drive box 4. In the oil casing are two oil pumps 2, three filters 13, 14 and 15, and a relief valve 12; on the casing on the left an oil filler neck is fitted on. In the rear end from the side are some flanges for fastening the fuel system components.

The oil passes through a low prerussre filter 15 in from of a bunch of twelve screen discs, into the pressure stage of the oil. pump and through the high pressure filter of similar design into the vertical pressure passage placed in the left section

of the casing.

On the botton of the sump of the high pressure filter is a relief valve 12, which at a higher pressure than determined, bypasses a portion of oil back into the casing.

From the vertical pressure passage the oil passes to the left by an external manifold to jets for lubrication of the centre and rear bearing and of coupling sleeves and upwards into the accessory drive box 4. In the accessory drive box the oil is divided into branches. Through the passage in the inner rib of the rear wall of the accessory drive box oil passes to all bearings, flows down from them and lubricates by splashing all gears of the accessory drive box. The teeth of the spur gears on the external wall of the accessory drive box are lubricated through a hole of a diameter of 0,8 mm from a passage passing through the rib. The second hole discharges into into the rear wall and through a pipe delivers oil to the jet for lubrication of the front bearing. The branches of the rear pipe deliver oil to the bearings of the starter motor drive.

The oil consumption in the accessory drive box is 150 ± 25 lit/h at a pressure of 3,0 atm. and is being limited by a restricted orifice which is in the accessory drive box on the left.

The jets for lubricating the bearings have following oil consumption at a temperature of ± 60°C and a pressure of 3 kg/cm²

for the front bearing ..... 80 - 5 lit/h
for the centre bearing.....125 - 5 lit/h
for the rear bearing .....125 - 5 lit/h

In the left side of the oil casing is a union for the thermometer and a flange for the remote electric pressure gauge transmitter.

From the front bearing the scavenge oil flows [illegible] into the accessory drive box and from here through a [illegible] into the oil casing.

From the centre and the rear bearing through an external manifold through a filter 14, consisting of 12 screen discs located in the centre section of the oil casing, the oil is being scavenged by an oil pump and through a vertical pipe is being transferred into the centrifugal deaerator 3, where the air is being separated from the oil.

The air, separated from the oil, passer through a bore in the centrifugal deaerator shaft into the accessory drive box and through the breather to outside and the oil through a side passage and a pipe flows down into the oil casing.

The oil casing has an overflow cock 16.

C H A P T E R X.

FUEL SYSTEM.

Controlling of WK-1P engine is performed by changing the fuel supply by hand regulation and by automatic regulation. As basic principle of automatic regulation,has been adopted in the main fuel system the principle of centrifugal regulator,maintaining a constant rotational speed of engine at a certain position of throttle cock lever, assembled on the PN-9MA pump. As principle of fuel quantity regulation in the auxiliary fuel system has been adopted the principle of variation of fuel supply in dependance up on the air pressure on the inlet of the engine. Variation of fuel supply is secured by function of the barometrical regulator, assembled in the PN-14A pump.

General.

The fuel system of WK-1P engine consists of two independet systems : the main system, feeding directly the engine and the auxiliary system, supplying the fuel into the afterburner.

Main Fuel System of the Engine.

The main fuel system consistos of the following equipment :

1. High pressure plunger type pump PN-9MA	1	piece
2. Fuel distributing automat ART-8V	1	"
3. Main low pressure strainer / for both the main and auxiliary system /	1	"
4. Fuel manifold / collector /	1	"
5. Operational burners	9	"
6. Priming electric pump PNR-45B	1	"
7. Starting burners	2	"
8. Connecting hoses and pipes	1	set

The Aixiliary Fuel System / System of Afterburner /.

The afterburner fuel system consists of the following equipment :

1. High pressure plunger type fuel pump PN-14A	1 piece
2. Fuel distributor ART-14A	1 "
3. Fuel collector of the afterburner system	1 "
4. Burners of the afterburner system	26 "
5. Connecting hoses and pipes	1 set

The main and the afterburner systems are independent from each other. Controling of the engine, engaging and disengaging of the afterburner is performed by the same lever.

Brief Description of Single Accessories of the Fuel System.

PN-9MA pump is a plunger type pump with centrifugal isodromic[x]/ regulator which - through a servomechanism - controls the rocking ring, which changes the effective stroke of the plungers and consequently the output of the pump.

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[x]/ The isodromic regulation is a system of indirect automatical regulation with elastic back-effect, which secures maintaining of the wanted rating of engine with an insignificant residual error or without it.

The isodromic regulation was adopted originally for maintaining of constant speed of revolution of machines, to which it owes its name.

Owing to favourable qualitites of this system it was adopted also for regulation of pressure, temperature, fuel supply, direction control of ships and for other purposes.

In the PN-9MA pump the isodromic regulator impreves the regulating procedure, i. e. maintains the constant rotational speed as it has been desired through the whole range of automatic regulation with variation of altitude and of air-speed.

ART-6Ж - fuel distributing automat is an instrument, consisting of fuel distributor, shut- off valve and acceleration automat. The ART-6Ж serves for stopping of engine, for distributing of fuel between the main and auxiliary manifolds of the operational burners and for a correct acceleration of the engine on the ground and in any altitude and at any air speed when the throttle cock has been opened abruptly.

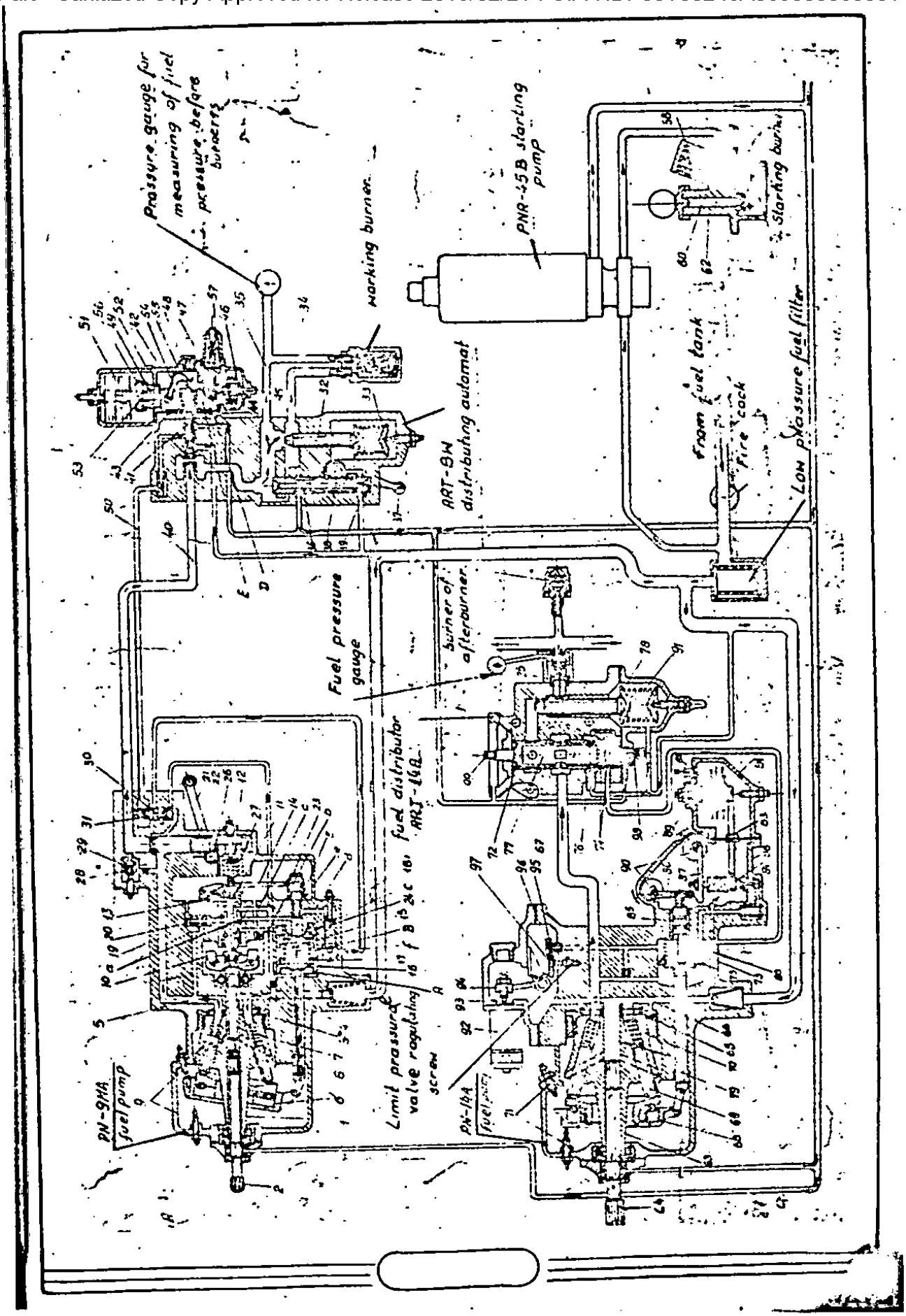
The operational burner - is opened, with centrifugal atomization of fuel, which is performed through two independent channels.

Priming pump PNR-45B and Starting burners - serve for supply of fuel into combustion chambers of the engine during starting. The PNR-45B pump is an eccenter type pump with a reducing valve, which secures the desired pressure on the outlet of the pump.

Starting Burner - is opened, one-channel type with centrifugal atomization of fuel.

PN-14A Plunger Pump is a high pressure plunger type fuel pump of variable output. Output of the pump is controlled by the rocking ring, position of which is given by the servomechanism piston. For regulation of fuel supply with altitude variation in the PN-14A pump a barostat is mounted, which is connected mechanically with the servomechanism of the pump.

ART-14A Fuel Distributor - is a mechanism , provided with a slide valve shutter, altitude valve / dosing needle / and cut-off valve. The ART-14A serves for engaging and disengaging of fuel supply into the afterburner system. Besides that, on the axle of the slide valve shutter of the ART-14A an antomatic switch of the afterburner is mounted, which controls the ignition and hydraulic system of the controllable jet nozzle.



Afterburner System Burner - open, one channel with centrifugal atomization of fuel.

Principal Technical Data of Fuel System.

Fuel	Kerosene T-1. It is allowed to use kerosene T-1 or T-1S with addition of 0,8-1,2 per cent of weight of oil MS-20 or MK-22.
Fuel specific weight	For kerosene T-1 the specific gravity 0,800-0,850, for kerosene TS-1 mimimum 0,775.
Fuel pressure after the fuel filter before the pumps in kg per sq.cm.	1,1 - 1,5
Maximum pressure of fuel after fuel pump of main system PN-9MA in kg p.sq.cm	max.80
Maximum fuel pressure after ART-14A/afterburner system/ in kg per sq.cm.	max.110
Fuel pressure before burners in auxiliary system at n = 2500 ± 100 r.ppm. in kg. per sq. cm.	from 7 to 12
Fuel pressure before burners in afterburner system at n = 11560 r.p.m. /corrected/ in kg per sq.cm.	for kerosene T-1 45 ± 6

Function of the Main Fuel System.

The main fuel system / fig.55./ serves for feeding of engine with fuel. The accessories of the main fuel system secure automatically : stable run of the engine, constant totational speed of the engine, correct acceleration of the engine at pushing of the throttle control cock of PN-9MA pump during 1,5 - 2 seconds in any value of altitude or air speed of the aircraft. From the aircraft tank fuel is boosted by the booster pump through the fire cock to the fuel strainer of engine under pressure of 1,1 - 1, 5 kg per sq. cm. After having passed through the strainer, fuel

Fig. 55 Diagram of the Fuel System .

1- rotor of the pump, 2- splined shaft, 3- disc slide valve, 4- low pressure stage / channel /, 5- high pressure stage/channel/ 6- rocking ring, 7- spring of plungers, 8- plunger, 9- stop screws for limiting of the output of pump, 10- centrifugal weights, 11- slide valve of centrifugal regulator, 12- spring of the centrifugal regulator, 13- sleeve of the centrifugal regulator, 14- back-effect lever, 15- back-effect piston, 16- power piston, 17- spring of the pistons, 18- spring of back - effect piston, 19- constant pressure valve, 20- spring of constant pressure valve, 21- throttle cock lever, 22- needle of the throttle cock, 23- stop of back-effect piston, 24- throttle set, 25- seperating valve, 26- cogged wheel of the throttle cock, 27- cylindric ratchet, 28- seat of low power valve, 29- low power valve, 30- slide valve of the differential valve, 31- spring of the differential valve, 32- needle of the fuel distributor, 33- spring of the needle, 34- channel of main line, 35- channel of low power, 36- slide valve of the shutter, 37- lever of the shut-off valve, 38- cogged wheel of the shut-off valve, 39- holes for return of fuel, 40- channel leading fuel to distributor, 41- slide valve of acceleration automat, 42- spring acting on the membrane , 43- membrane, 44- deaerating hole, 45- air ducting channel from combustion chamber neck, 46- air strainer, 47- take-off needle, 48- air by-passing jet, 49- hole for outlet of air in altitude, 50- outlet channel from spring cavity of differential valve, 51- aneroid, 52- hole with filter, 53- rod of aneroid, 54- lever, 55- membrane loading spring, 56- slides, 57- take-off needle membrane, 58- electromagnet, 59- filter, 60- needle, 61- atomizer, 62- plug, 63- pump rotor, 64- shaft, 65- disc slide valve, 66- low pressure channel, 68- rocking ring, 69- plunger, 70- spring of plunger, 71- pump output limiting stops, 72- shut-off slide valve, 73- cavity of servopistons spring, 74- return channels of slide valve cock, 75- servopiston, 76- jet, 77- cock cavity, 78- distributor needle, 79- rod of the piston, 80- springs of piston, 81- body of aneroid, 82- aneroid, 83- lever, 84- valve, 85-back-effect rod, 86- lever with rollers, 87- back-effect guide lever, 88- spring of valve, 89- sliding support of aneroid, 90- regulating eccenters, 91- spring, 92- electromagnet, 93- rod of electromagnet, 94- lever for emergency disengaging of afterburner, 95- by-passing valve, 96- lever of by-passing valve, 97 - spring of by-pass cock lever, 98- terminal for reducing gear of electric actuator MG-2, 99- terminal for automatic switch of the afterburner.

A- cavity under power piston, B- cavity between power piston and back-effect piston, V-cavity under the piston of back-effect. C- air cavity under the membrane, D- air cavity above the membrane, E- stop.

a- constant pressure valve, b- channel for cavity under back-effect piston, v- channel of the cavity under power piston, g- channel of the inter-piston cavity, d- return channel, d- return channel, e- outlet channel of the inter-piston cavity.

runs into the PN-9MA pump, which serves for delivery of fuel under high pressure to the working burners of the engine. The rotor 1 of the pump is driven through the splined shaft 2. At the base of the rotor is placed a slide valve 3, which has two half-circular openings, which are connected with the low pressure stage 4 and with the high pressure stage 5. On the other side of the rotor of the pump is placed the rocking ring 6, which has freedom of rocking on its journals by a limited angle, from the value of which depends the output of the pump. In the openings of the rotor 1 are placed plungers 8, which are pushed by springs 7 to the surface of the rocking ring. When the angle of slope of the rocking ring increases, the stroke of the plungers increases as well and consequently the pump output rises. For limiting of the maximum and minimum output the pump has limiting screws 9.

When the rotor revolves, each plunger, when passing over the window of the slide valve, connected with the low pressure line, under action of the springs takes fuel into the hole of the rotor. When passing further over the window of the slide valve, connected with the high pressure line, the plunger pushes out the fuel.

In fig. 55 are shown both positions of plungers : the upper one - delivery, and the lower one - suction. The stroke of the plungers is determined by the angle of slope of the rocking ring 6 in relation to the rotor axis. Angle of slope of the ring 6 and consequently the output of the pump are controlled by the servomechanism of the pump, which is controlled by the centrifugal regulator. The centrifugal regulator consists of weights 10, slide valve 11, spring 12, sleeve 13, back-effect lever 14, connected by stop 23 with rod of back-effect piston 15. The servomechanism is a cylindrical chamber, in which is placed the power piston 16 , connected with the rocking ring 6 and the back-

effect piston 15. Thus, the cylindrical chamber of the servo-mechanism is divided by the power piston 16 and by the back-effect piston into three cavities A,B, and V.In the cavity B is placed the spring 17,pushing the power cylinder towards higher performance of the pump and the back-effect piston 15 into its initial position/equilibre position/. From the other side of the back-effect piston 15, in the cavity V, is a spring 18,serving for shifting of the piston 15 and consequently ofall the back-effect system towards the side of the centrifugal weights 10 from the equilibre pasition. In the channel "a" fuel is under constant pressure of 10 kg per sq.cm and is maintained by the valve 19.

When the pressure in the channel "a" drops, the spring 20 shifts the valve 19 down/see diagram/,thus increasing the clear cross-section area for passage of fuel, coming under the valve. When pressure in the channel "a" rises, the valve 19 compresses the spring 20 and diminishes the clear cross-sectional area for fuel, coming to the valve.

The slide-valve 11 of the centrifugal regulator is exposed from one side to the centrifugal forces of the weights 10, from the other side- to the effort of the spring 12. As result of change of the forces, acting on the slide valve 11, it will be shifted either in direction of the cantrifugal weight 10, or in the direction towards the spring 12, which depends from which side the forces will be greater. For reaching a greater rotational speed of the engine it is necessary to compress the spring 12 of the regulator and to increase the clear cross-sectional area on the throttle valve, which is performed by shifting of the lever 21, which simultaneously with change of thrust of the spring 12 changes the position of the needle 22 of the throttle cock. In result of compression of the spring 12 the slide valve

11 travels to the side of the centrifugal weights 10 and thus it connects the cavity A through the channel "v" and through the central channel of the slide valve 11 with the low pressure line. The channel "a", in which the fuel has been under constant pressure of 10 kg per sq.cm. is connected with the channel "b" and through it with the cavity V under the back-effect piston 15, in result of which it is rapidly shifted from its initial position to the side od the rocking ring till to the stop E. The fuel pad of the cavity B acts as a rigid link, in result of which the power piston 16 travels with the same velocity by the same travel as the back-effect piston 15, thus increasing the angle of slope of the ring 6 and consequently also the output of the pump.

When the stop 23 of the back-effect piston 15 leans on the stop E/when pressure is in the channel "b"/, the rod of the back-effect piston 15 connects the channel "a" and overlaps the return channel "d", owing to which the fuel from the channel "a" through the channel "g", through throttling set 24 and through channel "e" slowly/ owing to low by-passing capacity of the throttle set 24/ flows into the cavity B and with the same low velocity the power piston 16 will travel to the side of the sloping ring 6, thus increasing the quantity of fuel delivered into the engine, in result of which the rotational speed of the engine would increase.

When the rotational speed of the engine approaches the desired value, the back-effect system should slowly adjust a correst position of the power piston 16. which, before that, had travelled only very slowly. The back-effect piston 15, when travelling to the stop 23, moves simultaneously through the lever 14 the sleeve 13 of the slide valve 11 towards the rocking ring 6. In result of this the outlet of fuel from the cavity A, connected by channel "v" and by the central channel of the slide valve 11 with the low

pressure cavity, is throttled down and power piston 16, which proceeds slowly to the side of the rocking ring, is still more braked. Owing to increasing fuel supply, caused by the increased angle of sloping of the rocking ring 6, the rotational speed of the engine increases and the slide valve 11 in result of the centrifugal force of the weights 10 will be shifted towards the spring 12. Before the slide valve reaches the balanced position, corresponding to the new desired rotational speed of the engine, the quantity of fuel, passing through the channels "b" and "v" will drop very slowly, i.e. the escaping of fuel from the cavity A, connected by channel "v" and by the slide valve central channel 11 with the low pressure cavity, is throttled down and the power piston 16 will remain motionless / all very *slowl* motions / After the power piston has become motionless, the fuel pad of the cavity B goes on to be filled, by which the back-effect piston 15 is compelled to return into its initial position, at which the sleeve of the slide valve 13 and the slide valve 11 itself become gradually balanced.

For reducing of engine rotational speed it is necessary to reduce the thrust of the spring 12, in result of which all procedures would proceed in opposite succession as compared with the above mentioned procedure. In order to prevent excessive rotational speed when the engine is being accelerated, in the design of the centrifugal regulator is provided the possibility to reset the rocking ring into position, necessary for securing the necessary rating of the engine just before the engine reaches that rating. For this purpose in the regulator under the back-effect piston 15 a spring 18 is mounted, the thrust of which is chosen so that at the ratings, which are not controlled automatically/ up to 9000 r.p.m. ±200 r.p.m./ and in the first moment

of engine acceleration all the back-effect system /piston 15 and through the lever 14 also the sleeve 13/ will be shifted to the side of the centrifugal weights 10. In result of this, when the engine is being accelerated, the main slide valve 11, travelling under action of increasing centrifugal force of the weights, begins to shunt the back-effect sleeve 13 before the engine reaches the desired rating, by which the rocking ring 6 will be deflected towards output drop into a position, which secures the desired rating. In case of altered revolutions of the engine as a result of changed conditions of flight/altitude,speed/, the centrifugal regulator of the pump will be set into action and changes the real dose accordingly with the new conditions of flight and thus the engine rotational speed, needed by the pilot will be automatically restored. The centrifugal regulator works within the range from n = 9000 ± 200 r.p.m. up to the maximum ratotional speed.

At low rotational speed / up to 9000±200 r.p.m./ before the automat of PN-9MA pump is set into action /up to the moment when the centrifugal forces 10 and thrust of the spring 12 of the slide valve 11 are balanced/, the engine is only hand controlled and the rotational speed of the engine depends on the cross-sectional area and overpressure before and after the throttle valve, mounted on the outlet line of fuel from PN-9MA pump. The throttle cock is hand controlled by means of the lever 24, having on the axle a gear 26, which is in mesh with needle 22 and with the cylindrical rathet 27. When the lever turns, the needle is shifted and changes the cross-sectional area in the throttle cock. In the conditions of take-off rotational speed the cock is opened, for low power rating it is necessary to keep it closed. In closed position the cock by-passes through the profile of the needle

quantity of fuel that is not sufficient for run of the engine in low power rotational speed. The missing fuel is delivered in addition through the cutout into the seat 28 of the low power valve 29. In order to secure a constant overpressure before the throttle cock and after it in the range of hand control and for easier operation of the pump / unloading of the rocking ring at low rotational speed from the high pressure /in the design of the pump a differential valve has been included, consisting of the slide valve 30 and spring 31. When the overpressure before and after the throttle cock exceeds 10 kg per sq.cm, the slide valve 30, having overwhelmed the force of the spring 31, travels upwards / according to diagram/, thus connecting the cavity B through the channel "e" with the return line and the cavity A under the power piston 16 with the high pressure on the outlet from the pump. As result the power piston 16, while travelling, changes the angle of slope of the rocking ring and consequently it changes the fuel output of the pump to a valve, securing a normal overpressure.

After the throttle cock of the pump PN-9MA fuel runs into the ART-8W distributor. The distributor has a needle 32 with a profiled end, which under action of the spring 33 closes the main channel 34 and fuel runs only into the low power channel 35. The spring 33 of the distributor needle is adjusted for beginning of operation of the main fuel system at a pressure of 8-10 kg per sq. cm in the auxiliary pipeline. When the pressure after the throttle cock will increase, the needle 32 will be pushed off by the fuel pressure in the auxiliary line and opens the way for the fuel into the main line. The shut-off valve is a slide valve 36 with hand control, which is performed by means of a lever 37, on which is placed a cogged wheel, meshing with the rod of the

slide valve 36. When the slide valve 36 is shifted upwards, it overlaps the channel, over which fuel runs into the distributor, thus stopping fuel supply to the working burners. In this case fuel through the central channel of the slide valve runs into low pressure line to the fuel strainer. The remaining quantity of fuel is drained through hole in the body and through the grooves in the slide valve into the atmosphere.

The shut-off valve must be opened when the engine has to be started and is shut only when the engine has to be stopped. For lessening of fuel delivery during starting of the engine in the slide valve 36 of the shut-off valve are made holes 39, which in the first moment of travel of the slide valve down connect the valve 40 with the fuel strainer through the central channel of the slide valve, thus lessening the fuel delivery to the burners. When the motion of the slide valve 36 down continues till to the full opening of the shut-off valve, the channel 40 is disconnected from the fuel strainer, by which the fuel return is interrupted / fig. 55 /.

The acceleration automat has a slide valve 41, to which by thrust of the spring 42 is pressed a membrane 43, which divides the air cavity of the automat into two chambers G and D. The chamber G is connected by the hole 44 with the atmosphere. Into the chamber D through the channel 45, through mesh filter 46, annular groove in the body round the needle 47 and through its hole air is delivered from the neck of the 6th combustion chamber. Besides that, chamber D is connected with the atmosphere through an outlet jet 48 and at high altitude also by openings 49. When the engine is running, the slide valve 41 is loaded from the side of the membrane by pressure of air in cavity D and by spring 42, from the opposite side the slide valve is loaded by pressure of

fuel on the face of the slide valve. During stable operation and also when acceleration is slow, the rotational speed, acting on the slide valve from the side of the membrane, exceed the forces acting from the side of fuel supply. In this case the acceleration automat does not operate and the slide valve 41 is on the stop and disconnects the channel 50, connected with spring cavity of the differential valve, from the return line. In such position of the slide valve the acceleration automat has no influence on the output of the pump. When the acceleration of the engine is effected, i. e. engine control lever shifted abruptly towards high revolutions, the slide valve 41 under action of rapidly increasing pressure of fuel travels to the right and connects the spring cavity of the differential valve with the return line. The differential valve is shifted upwards. In result of this / see above/ the rocking ring is shifted towards drop of fuel supply as long as the engine reaches the desired rotational speed and the slide valve 41 overlaps the return line 50, which will be caused by increase of pressure after the compressor, the pressure being led to the membrane 43. During the whole procedure of acceleration the acceleration automat governs the fuel supply to the burners in a certain dependance on the pressure after the compressor, securing a tolerable increase of fuel supply as compared with that, normal for a stable operation.

At high altitude flights, owing to changed atmospherical conditions and changed working conditions of the engine, it is essential to secure for engine acceleration a slower addition of fuel to the quantity, due for stable run as compared with the conditions at zero altitude. This involves a necessity of o altitude correction. The altitude correction is secured by aneroid 51. The aneroid chamber is connected by a hole with the filter 52

with the atmosphere. During climb, the air pressure in this chamber will drop, the aneroid 51 will expand, shift the rod 53 and, while acting by a lever 54 on the spring 55, unloads the slide valve 41 from the side of the membrane 43. Simultaneously, the expansion of the aneroids causes a motion of the slides 56, which open additional holes 49 for outlet of air, by which the air pressure in the membrane chamber D will drop. In result of this the slide valve 41, when acceleration is being effected at altitude, controls the PN-9MA pump and holds it for a longer period in lower output run according to flight altitude. The acceleration automat is provided with the take-off needle 47, which, being connected with the membrane 57, at increased pressure of air after the compressor leaves its seat and increases the clear cross-sectional area for air, delivered into the membrane chamber D. Thus an increased fuel pressure is secured before the burners when engine accelerates up to maximum rotational speed.

From the fuel distributor ART-8V through the fuel collector, consisting of a main and an auxiliary lines, fuel runs into working burners of the engine. The working burner /fig. / has two separate fuel channels : the main channel and the auxiliary channel Each channel has on its mouth a centrifugal atomizer and a jet. The jets are concentrical. Fuel from the main and from the auxiliary lines of fuel system collector runs to the main and to the auxiliary channels of the working burners respectively, through the necks 3, springs 2, wire slot filters 4 and connecting lines 6 and 7. Farther the fuel, passing in the main channel through the atomizer 14, is ejected through jets 10 and 12 in form of a conical stream into the combustion chamber, where by means of the whirl shell of the combustion chamber inner tube it is mixed with air. Through the auxiliary channel of the burners the fuel

is delivered at any rating of the engine and through the main line the fuel is delivered only from engaging into operation of the fuel distributor main line. During starting, fuel is delivered from the priming pump PNR-45B and through two starting burners. The accentric starting pump is driven by an electromotor. Inlet pressure of fuel before the pump is 0,7 kg per sq.cm, the outlet pressure after the pump is 2,45 kg per sq. cm. The outlet pressure is limited by a safety reducing valve. From the priming electric pump fuel is delivered through the connecting pipe to the starting burners. The burner consists of an electromagnet 58, filter 59, needle 60 and atomizer 61 with outlet hole / fig.55/. When the engine is being started, the electric starting /priming/ pump PNR-45B, the starting plug 62 and the electromagnet 58 are switched on simultaneously. The electromagnet attracts the needle 60 and opens way for fuel to the atomizer 61.

Through the outlet hole of the atomizer the atomized fuel streams by a conical stream into the combustion chamber and is ignited by the electrodes of the spark plug. Fuel from the starting burners set afire the fuel, delivered by the working burners into the third and eighth combustiom chambers. From these chambers the flame is transmitted through the connecting branches into all remaining combustion chambers. After accomplishing the starting cycle the starting burners and the priming electric pump are switched off automatically.

Operation of the Afterburner Fuel System.

The afterburner fuel system /see fig.55./ serves for supply of fuel into the afterburner fuel system when the afterburner is switched on. From the low pressure fuel strainer of the engine the fuel runs to the pump PN-14A, which serves for delivery of fuel under a high pressure to the burners of the afterburner.

The rotor 63 of the pump is driven by the [illegible] shaft 64. At the base of the rotor a disc slide valve is placed, which has two semi-circular openings, connected with the low pressure channel 66 and with the high pressure channel 67 respectively. On the other side of the rotor of the pump is placed the rocking ring 68, which has freedom of rocking on two journals at an angle, which is characteristic for output of the pump. In the openings of the rotor 63 are plungers 69, which by springs 70 are pushed to the surface of the rocking ring 68. With increasing angle of the rocking ring sloping the travel of the plungers and consequently the output of the pump is changed as well. For limiting the minimum and maximum output of the pump same has limiting stops 71. During revolution of the rotor 63 each plunger, passing above the opening in the slide valve, connected with the low pressure line, under action of the spring draws fuel into hole of the rotor. When passing above the opening of the slide valve, connected with the high pressure line, the plunger delivers the fuel into the high pressure line. Fuel from channel 67 runs to the slide valve 72 of the ART-14A distributor. Spring cavity of the servopiston 73 at disengaged afterburner is connected through return channels 74 of the slide valve of ART-14A distributor with return line and suction line, owing to which the servopiston, and consequently the rocking ring, are kept in position of a minimum output. In this position all fuel, delivered by the pump, returns through the slide valve 72 into the return line and farther into suction line. Quantity of fuel delivered into return line, is determined by the jet 76. When the engine is operating without afterburner, fuel from spring cavity of the servopiston 73 through slide valve of ART-14A cock returns into the suction line and

the pump is set into minimum outout position, necessary for greasing and cooling of frictionning parts of the pump. When the afterburner system is engaged into operation, then by turning the slide valve of ART-14A distibutor from "OFF" position into "ON" position, the cock switches over the fuel delivery from return to the main pump to the delivery through cavity 77 of the cock to the burners of the afterburner. When fuel pressure before the needle of the distributor 78 overtops 10 atm, the needle will travel slowly down and owing to profiled part of the needle the fuel delivery into the collector of afterburner will increase. When the slide valve of ART-14A distributor cock is turned into position "ON", fuel escaping from the piston spring cavity will be interrupted and an overpressure will be built up as result of different areas from the side of the rod of the piston 79 and from the side of the springs 80. Owing to action of this pressure and by thrust of the spring 80 the piston will be shifted into position of increased outout. For correction of fuel output with varying altitude the RN-14A pump is provided with a barometric regulator. With climb the lower pressure in the chamber of the aneroid 81 causes expansion of the aneroid 82, i. e. increase of pressure on the arm of the lever 83, which causes again a drop of load on the by-passing valve 84. With drop of the load the valve 84 will open and consequently also by-passing of fuel from the spring chamber of the servopiston will increase. Pressure in the spring chamber drops and the servopiston 75 parts to the side of the springs 80, thus lessening the angle of sloping of the rocking ring, the plungers stroke and output of fuel. During its motion the servopiston 75 by intermediary of rod 85, lever 86 and guide 87 increases the thrust of the spring 88, throttles down the bypassing of fuel through valve and gets into balanced state.To

each pressure valve in the aneroid chamber corresponds a certain position of the servopiston 75 and a definite quantity of fuel. As the pressure in the aneroid box depends on altitude and air speed, the barostat controls the fuel dose of the fuel pump with respect to conditions of flight. At high air speed in low altitudes the aneroid may be compressed to stop and to prevent it from falling out of its holders, the holder 89 on the regulating screw has a spring. At high pressure values this holder slides on the regulating screw and thus prevents the aneroid from falling out.

The necessary regularity of fuel supply is secured by the characteristic of the aneroid 82 by profile of the guide and by choosing an appropriate mutual position of guide 87 and lever 86 which is performed by means of eccenters 90, by turning of which is changed the position of profiled part of the guide in relation to the roller, sliding on it. As in high altitudes the fuel supply quantities are low and the pressure before the burners of the afterburner drops as much as the pressure in the cavity of servopiston is no more able to shift it for lessening of pump output / i. e. overthelming the thrust of the spring /, in ART-14A distributor a needle 78 is fitted, which increases the fuel pressure on outlet from the pump in dependance on thrust of spring 91.

For emergency disengaging of afterburner in the PN-14A pump an emergency electromagnetic valve is provided, which is an electromagnet, /92/, acting through the rod 93 and lever 94 on the valve 95. When the electromagnet is switched on / feeding of electromagnet with d.c. /, the rod 93 is shifted to the right and through the levers 94 and 96 opens the valve 95. The cavity of the springs of the servopiston is now connected with the low pressure channel 66 and the servopiston, shifting to the right, sets

the rocking ring into position of minimum output. The minimum output volume is regulated by stop 71 and is chosen so as to secure the operation of the pump without overheating. Pressure before the needle 78 of the distributor ART-14A drops, the needle travels towards the eye and reduces the fuel delivery to the burners to 300 - 400 litres per hour.

The valve serves also as limiter of maximum possible pressure of fuel in the afterburner fuel system. Regulation of the maximum possible pressure in the system is perfomed by change of thrust of the spring 97, placed under the lever 96. When the pressure exceeds the permissible value, the valve 95 opens.connects the spring cavity of the servopiston with low pressure channel 66 and the servopiston, travelling to the right, shifts the rocking ring for lower supply. When the pressure in the system drops to a value corresponding to regulation of the valve 95, the valve closes.

After the PN-14A pump the fuel flow to the slide valve shutter 72 of the fuel distributor ART-14A. The slide valve shutter is connected on one side by terminal 98 with the reducing gear of the electric actuator MG-2, securing opening and closing of the shutter when the afterburner is turned on or off. On the other side the slide valve shutter has a terminal 99, on which is assembled the afterburner circuit breaker, which engages and disengages the ignition and the electrohydraulic valve controlling the jet nozzle. When the slide valve shutter is turned, fuel from the PN-14A pump through the slide valve shutter 72 flows to the needle 78, which secures the necessary pressure after the pump in altitudes and consequently also the necessary fuel pressure before burners of the afterburner. When the slide valve shutter is turned, the ignition of the afterburner, which secu-

res ignition of fuel delivered by burners of afterburner, is turned on, Simultaneously with turn of the slide valve shutter is engaged also the electrohydraulic valve controlling the gills af the jet nozzle and increases the clear cross-sectional area of the jet nozzle. At disenaged afterburner i.e. at closed slide valve shatter 72, for separating of fuel, leaking through clearances between the needle and its bush, on the outlet from the ART-14A distributor the separating valve 25 is mounted. When the afterburner is being turned on, fuel from ART-14A runs to the annular collector of the afterburner system, on the pipes if which 24 burners are fastened and placed evenly on periphery of the ring, and shooting the fuel opposite the gas flow, and two burners, placed diametrically opposite each other, spraying fuel towards the centre with angle of spray cone to the pipe axis 45°. These two burners serve as starting burners, delivering fuel in--to the zone where the ignition plug is placed. The burners are calculated for giving a sufficient dispersion at both high and low pressure and fuel consumption and secure operation of the afterburner system at all altitudes and air speeds. All accessories of the fuel system are interconnected / see diagram 55/ by metal pipes and hoses, through which fuel is delivered. Layout of all accessories on the engine is shown in fig. 66.

Design of the Accessories.

Fuel Filter / fig.56./

The assemblies and parts of the fuel filter are placed in housing 1 and cup 2. The housing 1 has a flange with four holes for fastening of the filter to the oil pumps box the engine. On the body is fastened a pipe neck 4 for supply of fuel and two pipe branches 3 for outlet of fuel from filter. On the body of the filter the cup 2 is fastened by bolt 5. The fastening bolt 5

is screwed in into the centering stem 12. Between the cup and the filter body is inserted a sealing ring 6. As filtering element a set 7 of mesh rings with sealing rings on the faces is used. For measuring of fuel pressure on the outlet of the filter, there is a neck 9 screwed in into the body, which serves for fastening of fuel pressure switch SD-3 and for fastening of hose, leading fuel to the starting electric pump PSH-45B. The neck 10 serves for fastening of fuel return hoses from the fuel distributors ART-8W and ART-14A. In order to prevent leakage of fuel on the fastening screw into the groove of the cup 2 a sealing ring 11 is inserted.

P u m p PN - 9 MA

/ fig. 57./

Pump PN-9MA - plunger type pump, consisting of the following main assemlies and parts : body of pump, rotor, slide valve, plungers, rocking ring with bearing, centrifugal regulator, servomechanism and throttle assembly. The body of the throttle cock is cast as one piece with the body of the pump. The body of the pump 1 is cast of aluminium alloy. On the body is a flange 2 with eight holes 3 for fastening of pump to the engine auxiliaries drive box. On the inlet of the pump is placed the mesh filter 35. The inlet pipe branch 36 is fastened to the flange of pump body by four stud bolts. The rotor 4 of the pump revolves in two roller bearings 5 and 6. The rotor of the pump is driven from the engine through the splined shaft 7. The rotor has nine plungers 8 with springs 9, placed evenly on the periphery of the rotor and inclined towards its axle / towards the face /. The rotor 4 leans on a steel slide valve 10. which has two half round windows, one of which is connected with the intake line, the other with the high pressure line the fuel system.

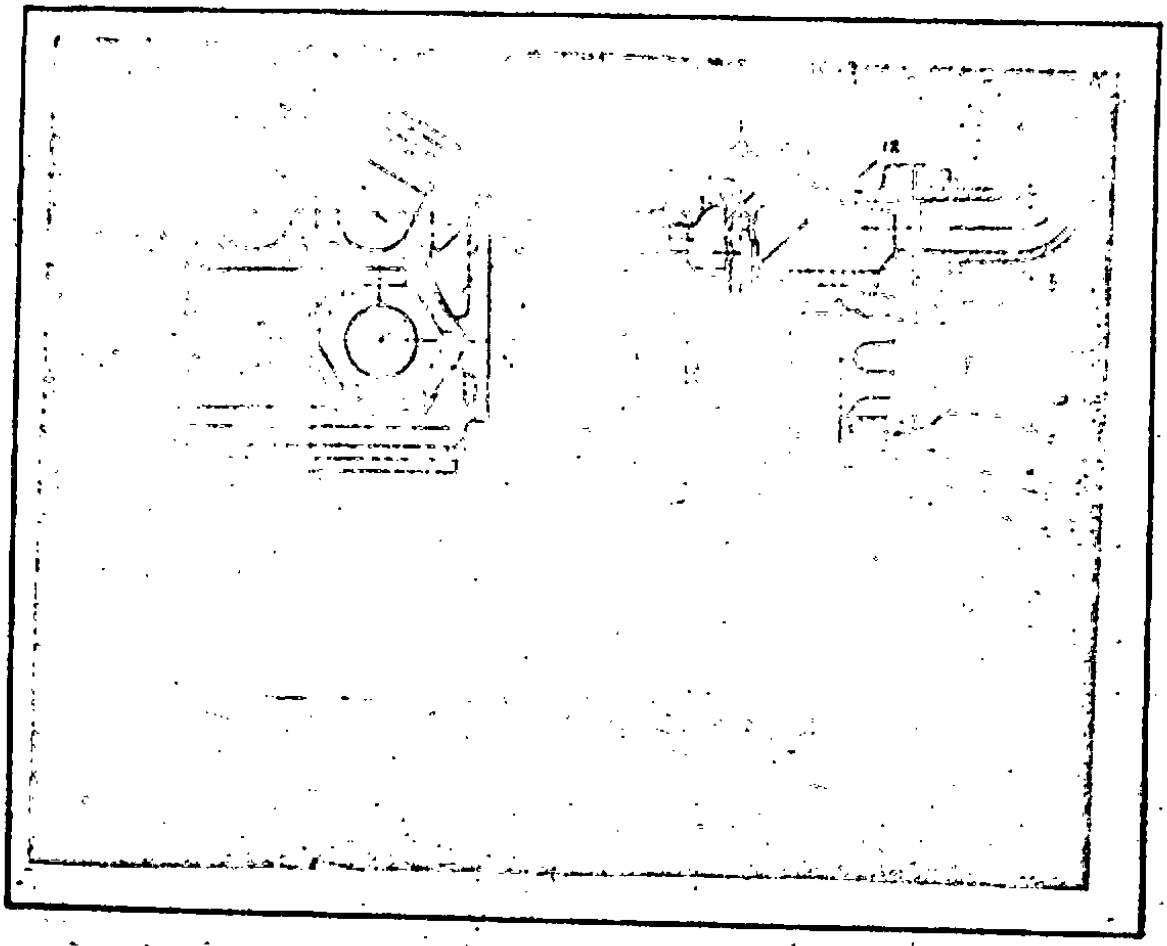


Fig. 56 Fuel Filter of the Engine.

1- body, 2- cup, 3-fuel outlet neck, 4- fuel inlet neck, 5-fastening screw, 6- sealing, 7-set of mesh discs, 8- face sealing, 9- neck for mounting of low pressure switch and a hose, leading fuel to the starting electric pump PNR-45B, 10- neck for fastening of hoses for return of fuel from distributors ART-67 and ART-14A, 11- sealing ring, 12- centre stem.

Body 11 of the bearing of the rocking ring has two holes for journals 12 and an eye for connection with rod of the power servopiston 13. The centrifugal regulator consists of 8 weights 14, slide valve 15, springs 16, sleeve 17, connected with back-effect lever 18, which through the stop 19 and rod 20 is connected with the back-effect piston 21. The servomechanism is a cylindric chamber, in which are placed : the power piston 22, connected by rod 13 and link 23 with body of the bearing 11 and pi-

Fig. 57. Plunger Type Fuel Pump PN-9MA.

1- body of the pump, 2- flange for fastening of the pump to the engine auxiliaries drive box, 3- hole for stud bolt in flange for fastening of the pump to the engine auxiliaries

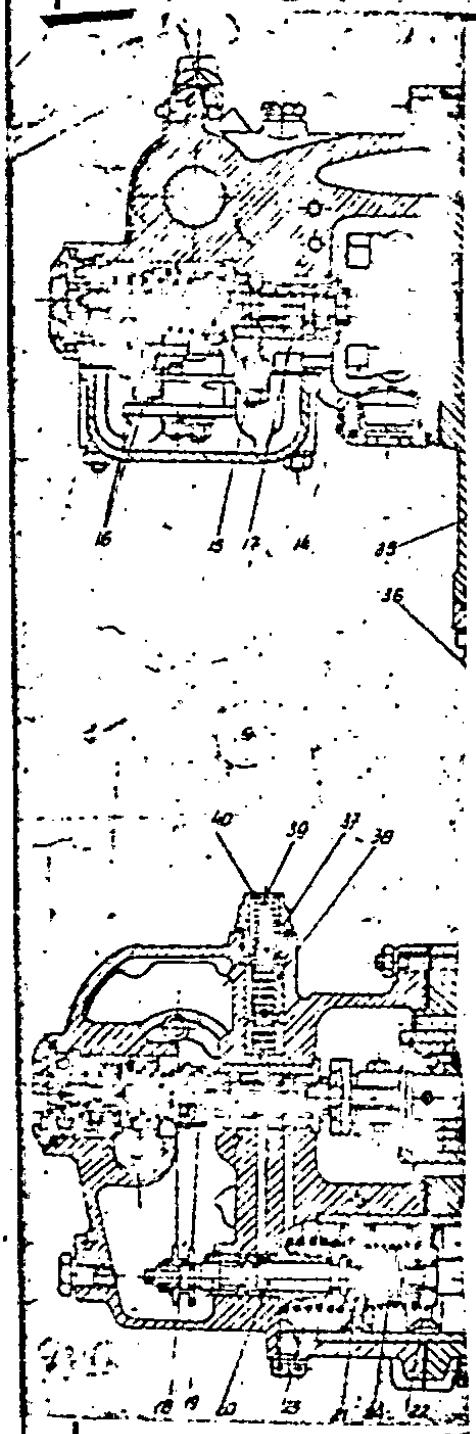


Fig. 57. Plunger Type Fuel Pump PI-9MA.

1- body of the pump, 2- flange for fastening of the pump to the engine auxiliaries drive box, 3- hole for stud bolt in flange for fastening of the pump to the engine auxiliaries

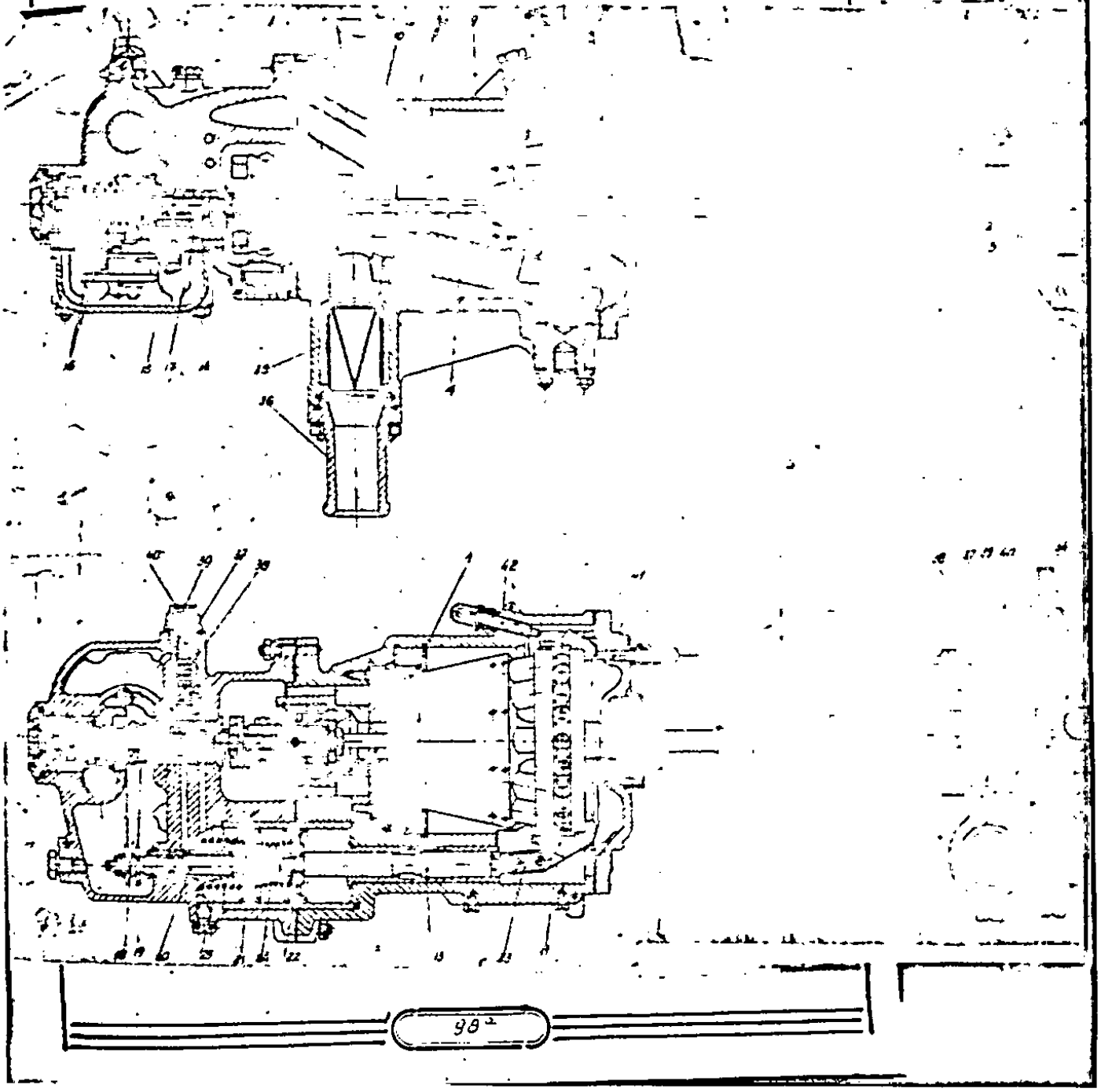
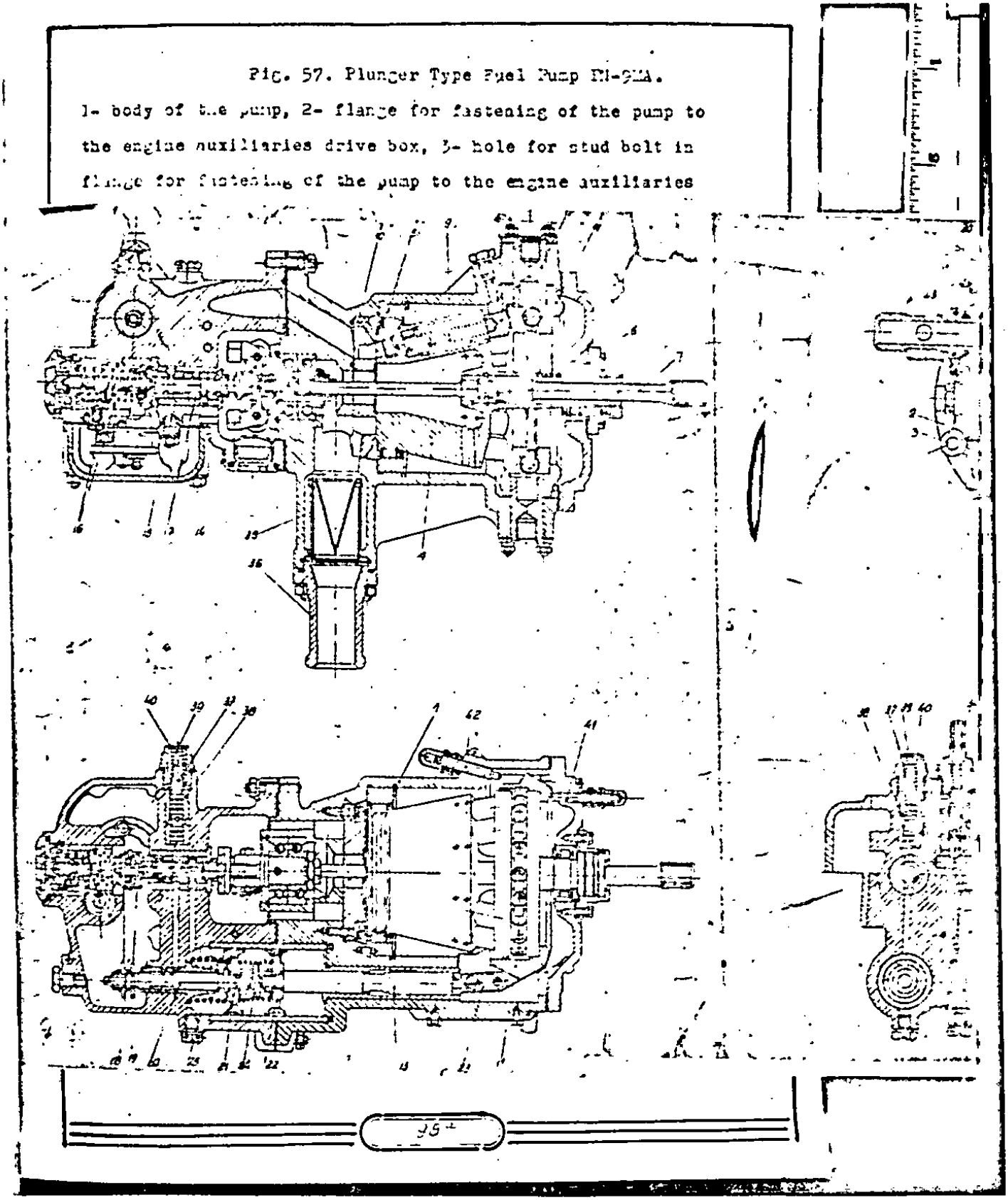


Fig. 57. Plunger Type Fuel Pump PI-9MA.

1- body of the pump, 2- flange for fastening of the pump to the engine auxiliaries drive box, 3- hole for stud bolt in flange for fastening of the pump to the engine auxiliaries

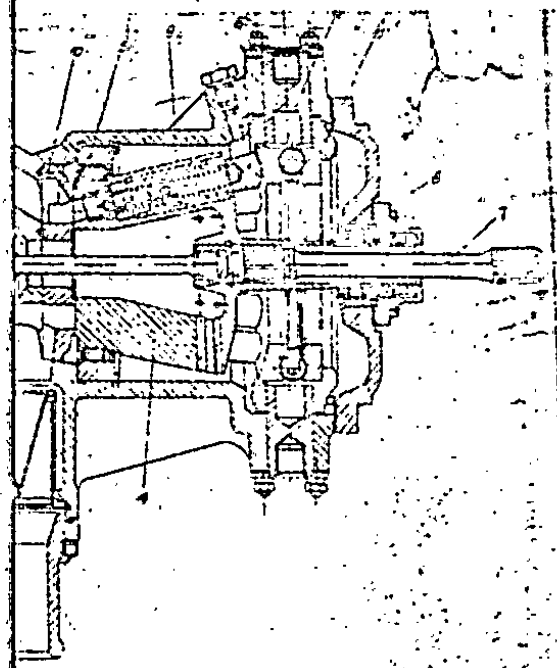


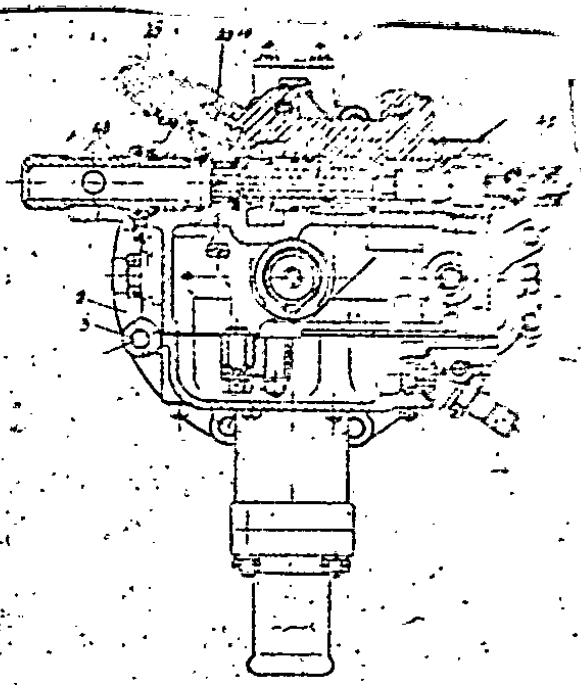
Plunger Type Fuel Pump PI-9UA.

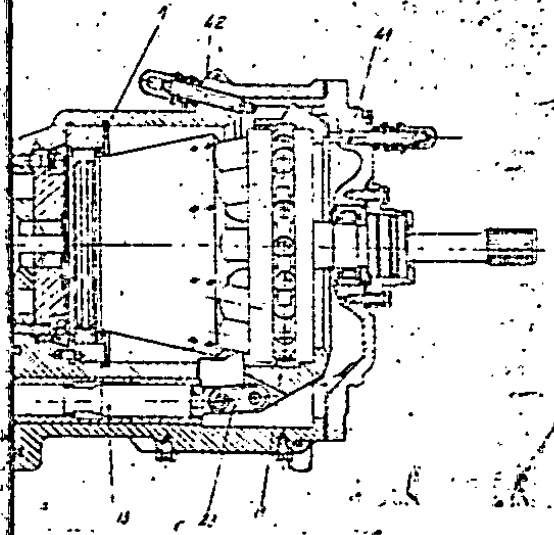
lange for fastening of the pump to

ive box, 3- hole for stud bolt in

he pump to the engine auxiliaries







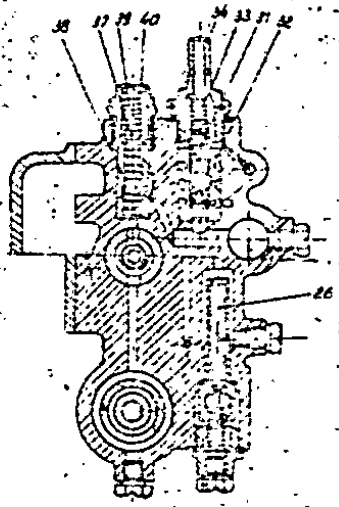


Fig. 57. Plunger Type Fuel Pump PI-9MA.

1- body of the pump, 2- flange for fastening of the pump to the engine auxiliaries drive box, 3- hole for stud bolt in flange for fastening of the pump to the engine auxiliaries drive box, 4- rotor of pump, 5- front roller bearing, 6- rear roller bearing, 7- splined shaft, 8- plunger, 9- spring of plunger, 10- slide valve, 11- body of bearing of the rocking ring, 12- journals, 13- rod of power servopiston, 14- weights, 15- slide valve of centrifugal regulator, 16- springs of centrifugal regulator, 17- sleeve, 18- back - effect lever, 19- stop, 20 - rod, 21- back- effect piston, 22- power piston, 23- link, 24- spring, 25- spring of back-effect piston, 26- throttle assembly, 27-needle, 28- valve, 29- valve seat, 30 - valve screw, 31- differential slide valve, 32- sleeve of differential valve, 33- spring of differential slide valve, 34- fastening neck of hose leading fuel from differential valve, 35 - mesh filter, 36- inlet branch, 37- slide valve of constant pressure valve, 38- sleeve of constant pressure valve, 39- spring of constant pressure valve, 40- plug of constant pressure valve, 41- regulating screw of minimum output, 42- regulating screw of maximum output, 43- neck for fastening of hose leading the fuel from the pump, 44- neck for fastening of draining hose, 45- neck for fastening of hose serving for measuring the fuel pressure after the throttle cock.

stem of the back-effect 21. Between the back-effect piston 21 and power piston 22 is a spring 24, which throws the power piston in the direction of maximum output of pump, and the back-effect piston into its initial position. From the other side of the back-effect piston is a spring 25, serving for shifting of the back-effect piston to the side of the centrifugal weights. For a more complete filling with fuel of the space between both the back effect piston and the power piston, a throttle assembly 26 is inserted into the fuel channel. On the way of fuel, streaming out under high pressure from the RN-9MA pump is mounted the throttle cock. From regulation of the clear cross-sectional area in the throttle cock is a needle 27, which is in mesh with the lever of the throttle cock. From regulation of fuel consumption at low power rating in the throttle cock a low power valve is mounted, consisting of a valve 28, seat 29 and screw 30. For securing of the desired overpressure before and after the throttle cock in the range of hand regulation and for relieving of the rocking ring at low rotational speed from higher pressure, into the design of the pump a differential valve has been included, consisting of a slide valve 31, sleeve 32 and spring 33, placed inside the neck 34 for fastening of the fuel outlet hose from the differential valve to the distributor ART-6M.

In the body of the pump is mounted the constant pressure valve consisting of slide valve 37, sleeve 38, spring 39 and plug 40. For limiting of the minimum and maximum output there are mounted regulating screws 41 and 42. For connection with the fuel lines in the body of RN-9MA pump are screwed in the neck 43 for fastening of hose, leading fuel from the pump to the ART-6M distributor, the neck 44 for fastening of the drain hose and neck 45 for measuring of fuel pressure after the throttle cock when engine is being tested on test bed.

Fuel Distributor ART-8W.

The ART-8W fuel distributor /fig.58/ consists of the following assemblies: the distributor with the shut-off valve and the acceleration automat. The distributer body 1 has a flange 2 with four holes for fastening of the fuel distributor to the oil pumps box of the engine. The dosing needle 4 leans on the spring 4, which pushes the former for closing the main line of the working burners. The spring 4 is placed in the cover 5 of the distributor body. The cover 5 is fastened to the body by stud bolts. In the cover 5 a regulating screw 6 is fitted. The shut-off valve consists of a cylindrical slide-valve couple - slide-valve 7 and sleeve 8. On the slide valve 7 are cut teeth, which are in mesh with the gear 9, connected with the shaft of the lever 10. In order to prevent disturbing of meshing of the slide valve with the gear a fixating screw 11 is screwed in into the body, terminal of the screw enters the groove of the slide valve. The acceleration automat is fastened on the upper flange of the fuel distributor body by four stud bolts. The acceleration automat body consists of three parts slide valve body 12, membrane chamber body 13 and aneroid body 14.

Between the body of the slide valve and the body of membrane chamber is fastened an armoured membrane 33. In the body 12 is pressed a bush 15, in which is fastened a slide valve 16. In order to prevent the foreign matters from intruding into the slide valve couple in the body two filters are mounted: the microporous filter 17 and the mesh filter 18. Into the body of the membrane chamber 13 is screwed in the body of the jet 19 with a jet 20, serwing four outlet of air. To the flange of the body 13 is fastened by three screws the cover 21 of spring 22 of take-off needle 23, fastened on the membrane 24.

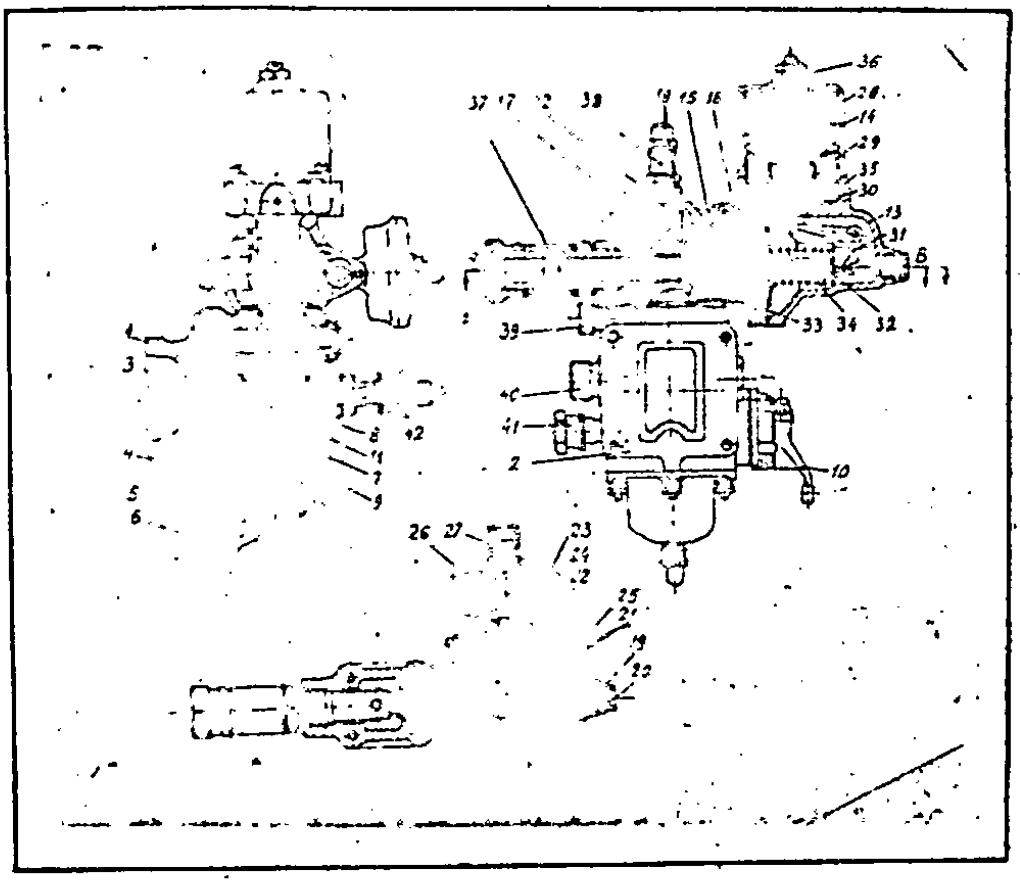


Fig.58. Fuel Distributor ART-8V.

1-body of distributor, 2-flange for fastening of the distributor to the oil pump box, 3-dosing needle, 4-spring, 5-cover of distributor body, 6-regulating screw, 7-slide valve of the shut-off valve, 8-sleeve bush of the shut-off valve, 9-gear, 10-lever, 11-fixating screw, 12-body of slide valve, 13-body of membrane chamber, 14-body of aneroid, 15-bush, 16-slide valve, 17-microporous filter, 18-mesh filter, 19-body of jet, 20-air outlet jet, 21-cover, 22-spring of take-off needle, 23-take-off needle, 24-membrane of the take-off needle, 25-regulating screw of the spring, 26-air filter, 27-neck of air inlet pipe, 28-aneroid, 29-slides, 30-rod, 31- two-arm lever, 32-small spring acting on membrane, 35-membrane, 34-large spring acting on membrane, 35-mesh filter of aneroid chamber, 36-regulating screw of the aneroid, 37-neck for fastening the hose, leading fuel from TN-3MA pump, 38-neck for fastening of the hose, leading from the differential valve of TN-14A pump, 39-neck for fastening of hose, leading fuel to the collector of low power line, 40-neck for fastening of the hose, leading fuel to the main system collector, 41-neck for fastening of hose, returning waste fuel into suction stage, 42-neck for fastening of drain hoses.

Thrust is regulated by regulating screw 25, screwed in into the cover 21. Air into the membrane chamber is led through an air filter 26, fastened by neck 27 to the body of the membrane chamber. On the body of the membrane chamber 13 is mounted the aneroid body 14, inside of which is fastened the aneroid 28 with slides 29. The aneroid 28 through rod 30, through two-armed lever 31 and spring 32 acts on the membrane 33. In the body of the membrane chamber 13 is a spring 34, which presses the membrane 33 to the slide valve 16. The aneroid chamber through the mesh filter 35 is connected with the atmosphere. The thrust of the aneroid is adjusted by regulating screw 36, screwed in into the aneroid body 14. For connection with the fuel pipelines in the body of ART-8W distributor are screwed in the following necks: neck 37 for fastening of hose, leading fuel from PN-9MA pump, neck 38 for fastening of hose, leading from differential valve of the PN-9MA pump, neck 39, for fastening of hose, leading fuel to low power fuel line, neck 40 for fastening of hose leading fuel to main system collector, neck 41 for fastening of hose for returning of fuel into suction stage and neck 42 for fastening of drain hoses.

The Working Burner
/fig.59/

The burner has the following parts: flange 1, by which it is fastened to the intake branch of the combustion chamber, the body in which are placed the atomizing elements and two pipelines, connecting the body with the flange. In the flange two separate channels are made: the main channel and the low power channel. In each channel there are wire-wound slot filters 4. The filters are clamped by springs 2. For connection of the hoses from the fuel

collector; necks 3 are mounted in the flange. The connecting pipes of low power 6 and of the main channel 7 are soldered by their one end into the flange, by the other end into the inner body of the burner 16; between these pipelines, for securing a proper rigidity, four clamps 5 are inserted. In the outer body are made twelve holes 9 for passing of air. In the bush 17 are placed the atomizing parts of low power line: low power whirl cone 14 with a spring 15, seat of the whirl cone 13 and the jet of low power 12 and further the parts of the main line: whirling ring 11 and jet 10. The mentioned parts together with the bush are clamped by the outer body 8 to the face of the inner body by a thread coupling, which is locked by a lock nut 18 and by lock washer 19.

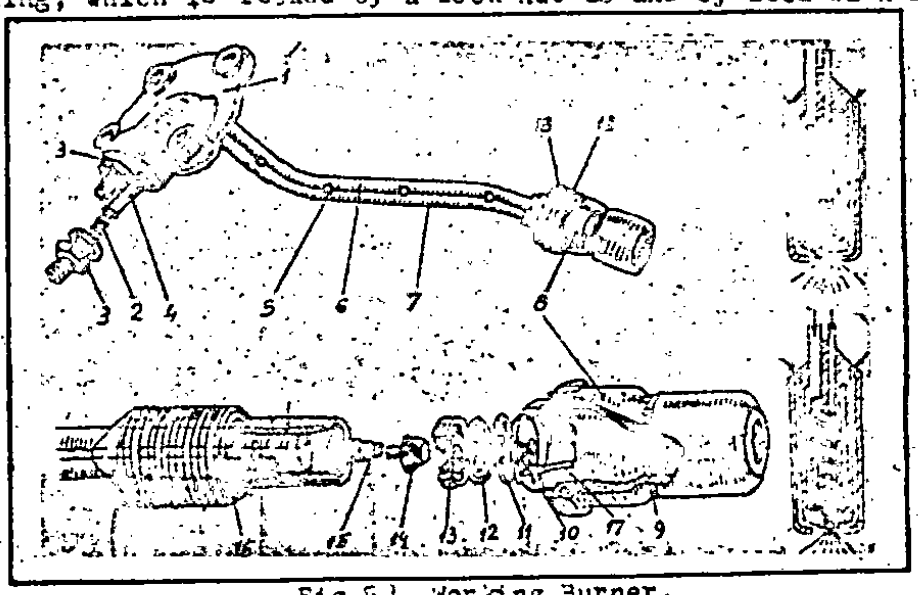


Fig.59. Working Burner.

1-fastening flange of the burner, 2-spring, 3-necks for fastening of hose leading fuel from the fuel collector, 4-wirewound slot filter, 5-clamp, 6-connecting pipe of low power, 7-connecting pipe of main line, 8-outer body of the burner, 9-holes for passage of air, 10-jet of the main line, 11-whirl ring, 12-jet of low power, 13-seat of the whirl cone, 14-whirl cone, 15-spring of whirl cone, 16-inner body of the burner, 17-bush, 18-lock nut, 19-lock washer.

Fuel in the low power channel proceeds into the whirl cone 14 and, after having got into right-hand spiral, is ejected in atomized state through jet 12 into the combustion chamber. Fuel in the main channel runs to the whirl ring 11, where it gets into right-hand spiral and through the annular clearance between the concentrically set jets 10 and 12 it is dispersed into the combustion chamber. When both channels are in operation, the fuel on the outlet from the burner is formed into one united atomized stream. The jets are divided according to their output capacity into three groups as follows:

Group O from 377 to 387 litres per hour

Group A from 392 to 400 litres per hour

Group B from 410 to 418 litres per hour

Change of output of the jet is adjusted by choosing a proper thickness of the atomizing ring. The hydraulic resistance of the fuel collector channels is practically insignificant and therefore output of the burner does not depend on where the burner is placed on the fuel collector and the burners are interchangeable within the same group.

Fuel Collector /see fig.56/.

The fuel collector consists of the main and auxiliary lines, having nine branches each, leading to the corresponding hoses, which deliver fuel into channels of working burners. The fuel collector is made of pipes, forming four half-circles, two of which form the main fuel system and the other two - the auciliary one. The pipes are connected by union nuts to the necks of the fuel collector bracket. The fuel collector bracket has a neck for connection of the hose of the pickup, by which the fuel pressure before the burners is measured, and two necks for connection of hoses, leading

fuel to the collector from the fuel distributing automat ART-2V The fuel collector is placed round the rear sieve of the compressor air intake and is fastened by means of brackets on the stud bolts of the compressor housing. In these brackets is also fastened the connecting pipe of engine starting burners.

Starting /priming/ Pump.

The starting pump PNR-45B /fig.60/ consists of three parts: pump, reducing gear, and electromotor I. The pump is an eccenter type mechanism. The four blades 2 of the pump, driven by the rotor 3 are leaning by one their side on the central pin 4 and by the other side - on the inner cylindrical surface of the bush. The bush is pressed into the body 6 with eccentric position in relation to the pins.

The desired pression in the pump is maintained by by-passing of the excess fuel through the reducing valve 7, which is actuated by the spring 8 with a regulating screw 9. The reducing gear lowers the rotational speed of the pump in relation to rotational speed of the rotor in relation 1:4. It consists of a body 10 and two parts of cylindrical gears 11 /description of the electromotor D-150 see in Chapter XI/. On the body of the pump are assembled three necks: the neck 12 for fastening of the drain hoses, neck 13 for fastening of hose, leading fuel to pump PNR-45B from low pressure fuel filter, neck 14 for fastening of hose leading fule from the pump.

Starting Burners.

The design of the starting burner /see fig.61/ comprises the following main assemblies and parts: body 1, atomizer 2, filter 3 and electromagnet with a needle.

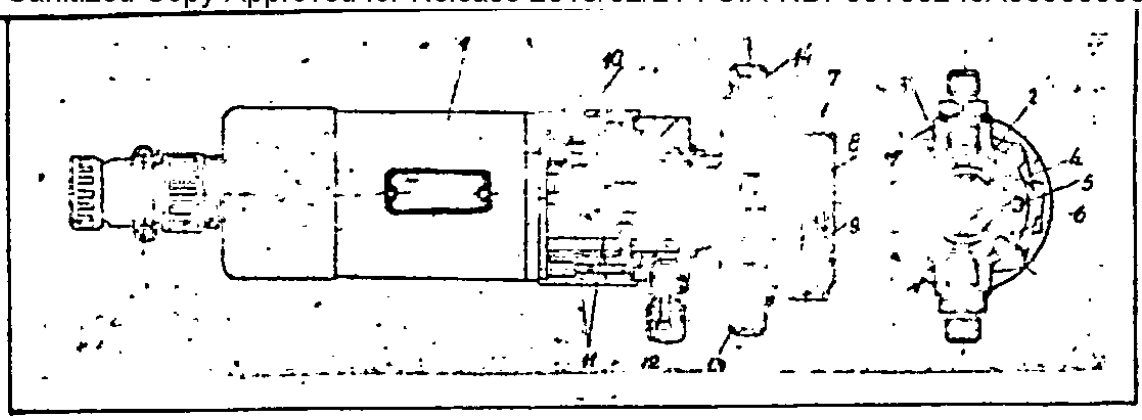


Fig.60. Starting Pump PNR-45B.

1-electromotor, 2-blades, 3-rotor, 4-central pin, 5-bush, 6-body, 7-reducing valve, 8-spring, 9-regulating screw of fuel pressure, 10-body of reducing gear, 11-cylindrical gears, 12-neck for fastening of drain hose, 13-neck for fastening of fuel supply hose, 14-neck for fastening of fuel outlet hose.

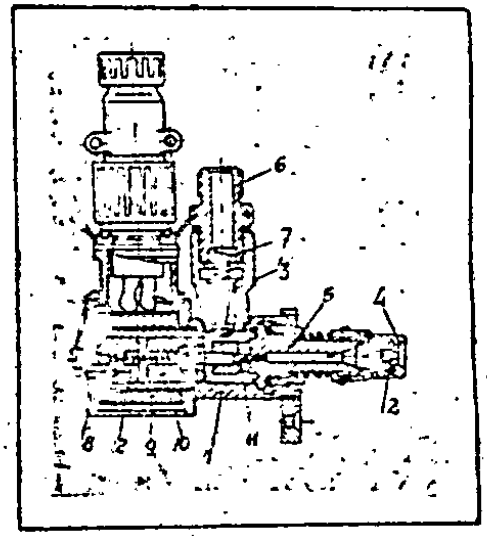


Fig.61. Starting Burner.

1-body, 2-atomizer, 3-wirewound slot filter, 4-nut, 5-atomizer bush, 6-neck, 7-spring, 8-jacket 9-winding, 10-armature, 11-needle 12-spring.

The starting burner is fastened to the body 1 by three stud bolts. The atomizer 2 has two tangetially placed inlet openings and one central outlet opening. The atomizer 2 is fastened by the nut 4 in the bush of atomizer 5. In body 1 is inserted the wire wound slot filter 3 and fitted the neck 6. Between the neck and the filter is fitted the spring 7. The electromagnet consists

of a jacket 8, winding 9, armature 10, to which a needle 11 is fastened, and the spring 12, pishing the needle to the atomizer bush seat.

The Fuel Pump PN-14A.

The plunger type fuel pump PN-14A /fig.62/ consists of the following main assemblies: body of pump, rotor, slide valve, plungers, rocking ring with bearing, servomechanism, barometrical regulator, emergency electromagnetic valve and limit pressure valve. The body of the pump and barometrical regulator is cast of aluminium alloy. On the body 1 of the pump is a flange 3 with eight holes 4 for fastening of the pump to the engine ausiliaries drive box. On inlet of the pump is fitted a mesh filter, which is pushed by a spring to the inlet pipe branch 5. The inlet pipe branch 5 is fastened to the flange of pump body by four stud bolts. The rotor 6 has seven plungers 7 with springs 8, placed evenly on the periphery of the rotor and inclined to its axis /towards its face/. The rotor revolves in two bearings, of which one bearing is roller type /9/ and the other one - sliding 10. The rotor is driven from the engine through the splined shaft 11. By its face the rotor leans on the steel slide valve 12, which has two half-round opening, one of which is connected with the suction line, the other with high pressure line of the fuel system.In order to prevent leaking of fuel from the pump into the engine auxiliaries drive box, in the cover three sealing glands 13 are mounted. Body 14 of the bearing has freedom of revolution on two half-axles, covered by covers.In the cavity of the body is pressed in the immobile ring 15 of the ball bearing. The plungers 7 are pushed by springs 8 to the conical surface of the rotating ring 16 of the ball bearing. Body 14 of the bearing

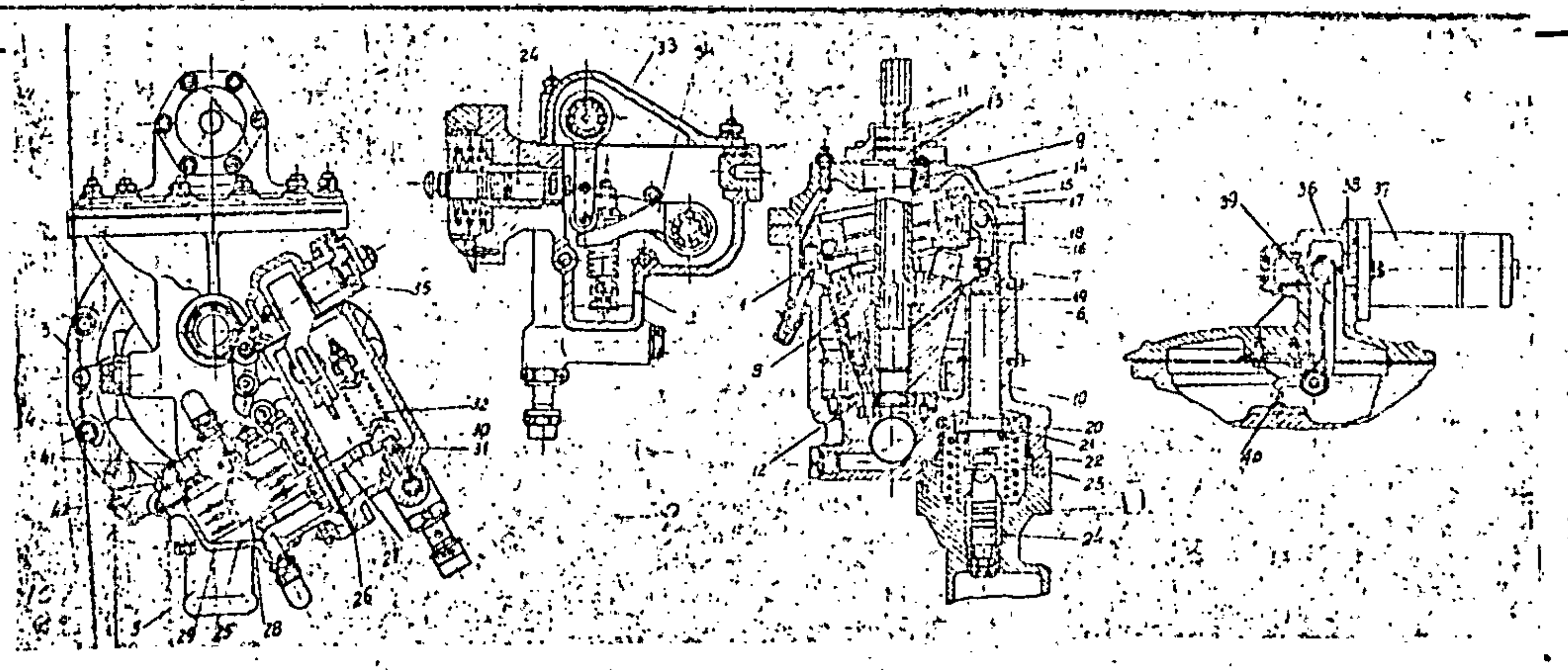


Fig.62. The PN-14A Fuel Pump.

1-body of pump, 2-body of barometric regulator valve, 3-flange, 4-holes for fastening of pump to the engine auxiliaries drive box, 5-inlet pipe branch, 6-rotor, 7-plunger, 8-spring of plunger, 9-roller bearing, 10-sliding bearing, 11-splined shaft, 12-disc slide valve, 13-sealing gland, 14-bearing body, 15-immobile ring, 16-mobile ring, 17-eye of bearing body, 18-link, 19-rod of servomechanism piston, 20-piston of servomechanism, 21-sealing gland, 22 and 23-springs of servomechanism piston, 24-back-effect rod, 25-aneroid housing, 26-diaphragm, 27 - two-armed lever, 28-aneroid, 29-sliding support, 30-by-pass valve, 31-seat of by-pass valve, 32-spring of by-pass valve, 33-lever with rollers, 34-guide fork of back-effect system, 35-eccenter, 36-pump cover, 37-body of electromagnetic valve, 38-armature, 39-lever for emergency disengaging of afterburner, 40-lever of limit pressure valve, 41-neck of aneroid chamber, 42-filter of aneroid chamber.

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17 is connected through link 18 with rod 19 of the power piston 20 of the servomechanism.

The servomechanism is a cylindrical chamber, in which is the power piston 20, dividing the chamber into two cavities. In order to prevent leaking of fuel from one chamber to another, on the piston 20 a sealing gland 21 is fitted. From the opposite side of the piston rod are placed two springs 22 and 23 and the piston 20 is connected with the back-effect rod 24 of the barometric regulator. The barometric regulator is assembled in the body with the pump and consists of two housings: the housing of valve 2 and housing of aneroid 25. Between the housings an armoured diaphragm 26 with a two-armed lever 27 is fitted. In the aneroid housing 25 is placed the aneroid 28, which by one end leans on the lever by the other end on the sliding support 29.

In the body of valve 2 is mounted the valve 30 with seat 31 and spring 32. The back-effect rod 24 leans on the lever with rollers 33, which slides in the profiled surface of the guide fork of back-effect 34. The back-effect guide fork and the lever with rollers 33 are assembled in regulating eccenters 35. On the upper cover 36 of the pump is mounted an emergency electromagnetic valve for disengaging of the afterburner. The electromagnetic valve consists of a body 37, inside of which a coil /electromagnet/ is placed. Inside the coil is inserted an armature 38, acting on the emergency disengaging lever 39, which again acts on the lever 40 of the limit pressure valve /when the electromagnetic valve is off/. The limit pressure valve consists of a valve lever, spring and of valve with seat. In aneroid chamber is connected with atmosphere through neck 41 with filter 42.

The AR-11A fuel distributor.

The fuel distributor /fig.63/ consists of the following main assemblies: distributor body 1 with cover 2, slide valve shutter

3, dosing needle 4 with spring 5 and separating valve 6. The body of the distributor has three holes 7 for fastening of same on the oil pumps box of the engine and also two flunges 8 and 9, each of the with three stud bolts, on which the afterburner actuator and reducing gear of the electromechanism MG-2 respectively, are fastened. For connection with the fuel lines in the distributor body the following necks are screwed in: neck 10 for fastening of hose, leading fuel from pump PN-14A, neck 11 for fastening of hose, leading from the servopiston of PN-14A pump, neck 12 for fastening of hose, by-passing fuel to the low pressure filter, neck 13 for fastening of the drain hose, neck 14 for fastening of pipe of the pickup, serving for measuring of fuel pressure at afterburner running, neck 15 for fastening of pipe, leading fuel to collector of the afterburner. In the neck 15 is placed the separating valve 6 of plate-type /poppet/, which leans on seat 16, pushed by spring 17. The dosing needle 4 leans on spring 5, which forces the needle for closing of the channel containing fuel. The spring 5 is placed in cover 2 of distributor body. Cover 2 is fastened on the body 1 by six stud bolts. Into the cover 2 is screwed in the regulating screw 18. The slide valve shutter 3 has two terminals 19 and 20, which are connected with afterburner switch and with reducing gear of electromechanism MG-2. The slide valve shutter revolves in its bush 21 by an angle of 90° and thus it delivers fuel from pump PN-14A to the collector of afterburner.

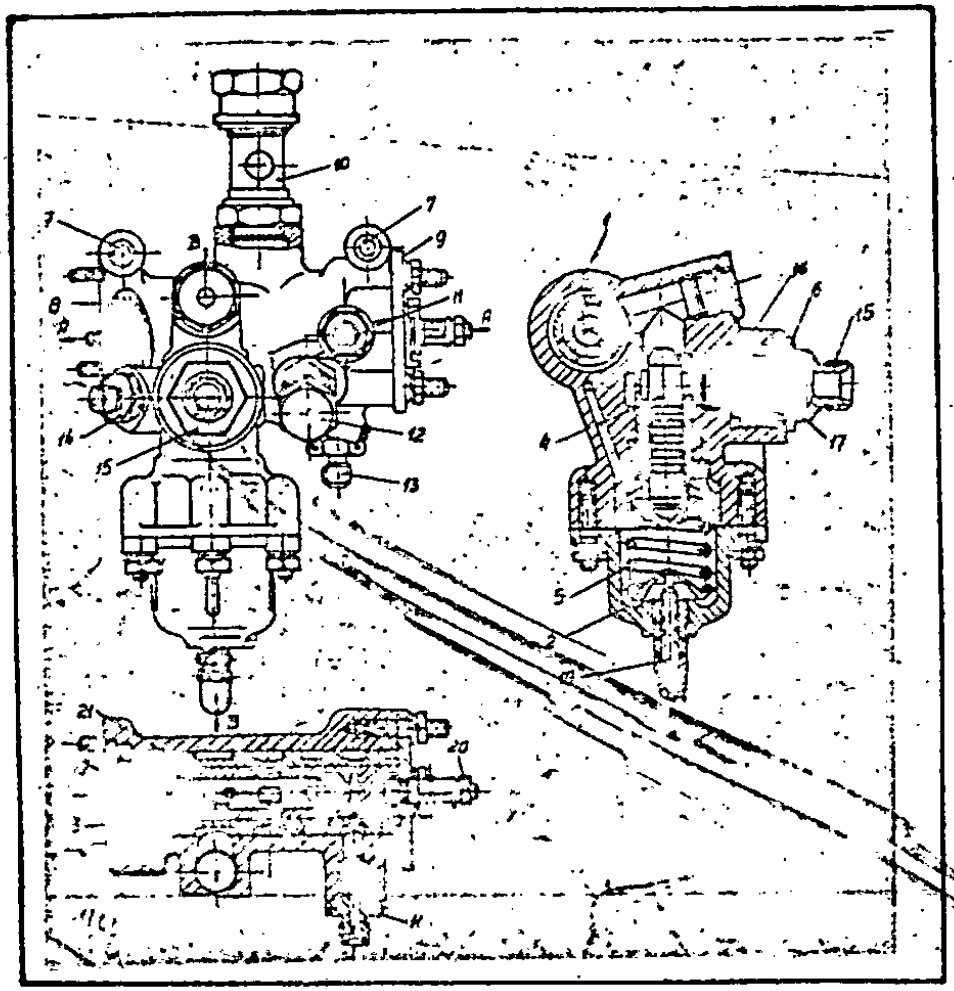


Fig.63. Fuel Distributor ART-14A.

1-distributor body; 2-cover, 3-slide valve shutter, 4-dosing needle, 5-spring of dosing needle, 6-separating valve, 7-holes for fastening of distributor on engine, 8-flange for mounting of afterburner switch, 9-flange for fastening of reducing gear of the MG-2 electromechanism, 10-neck for fastening hose, leading fuel from servopiston of PN-14A pump, 12-neck for fastening of hose by-passing the fuel to the low pressure filter, 13-neck for fastening od drain hose, 14-neck for fastening of pipe of pressure pickup, measuring fuel pressure at afterburner running, 15-neck for fastening of pipe, leading fuel to afterburner collector, 16-seat of the separating valve, 17-spring, 18-regulating screw, 19-terminal of slide valve shutterm serving for connection with afterburner switch, 20-terminal of slide valve shutter, serving for connection with reducing gear of the electromechanism MG-2, 21-bush for the slide valve shutter.

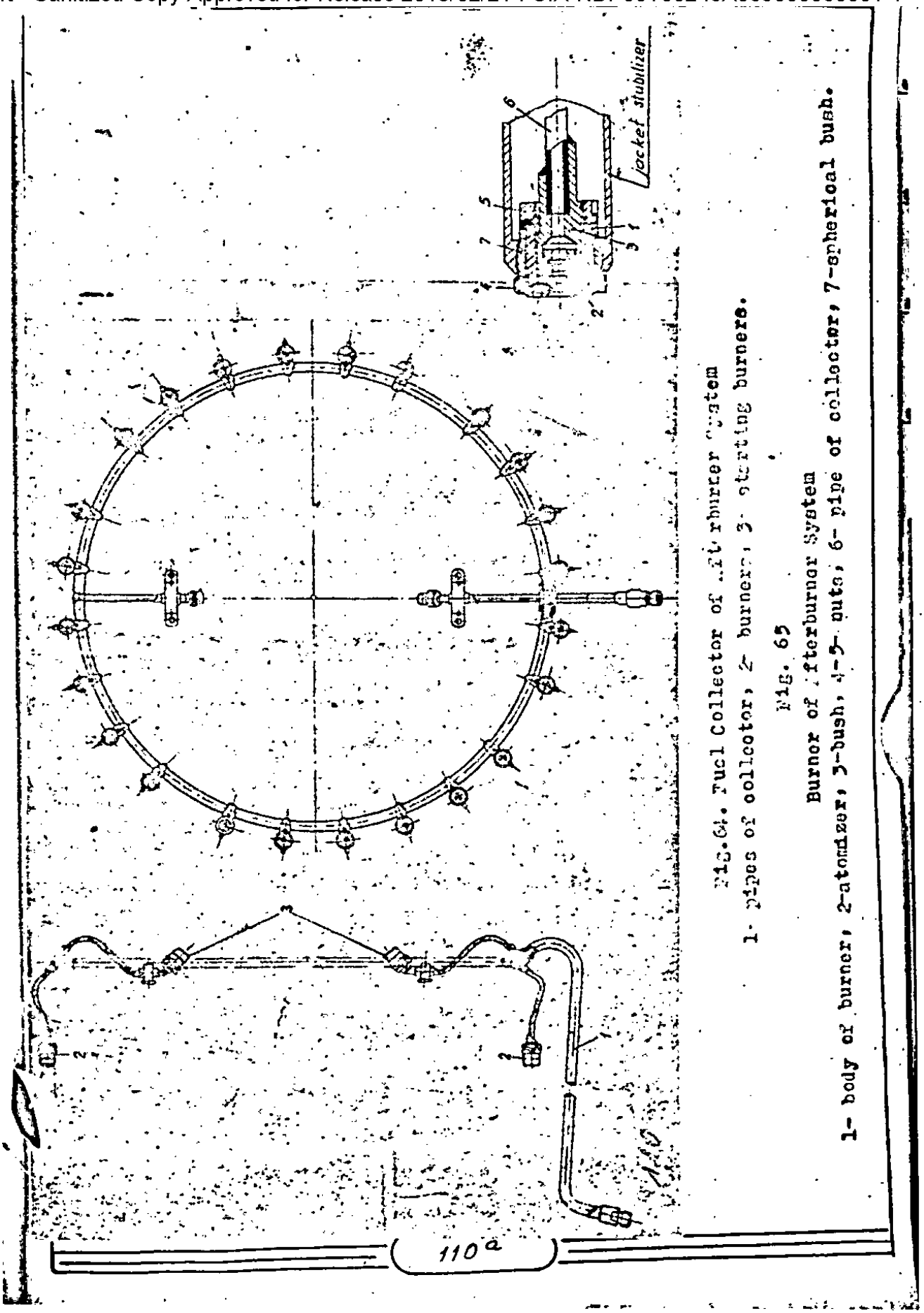


Fig.64. Fuel Collector of Afterburner System
1- pipes of collector, 2- burners, 3- starting burners.

Fig. 65
Burner of Afterburner System
1- body of burner, 2-atomizer, 3-bush, 4-5- nuts, 6- pipe of collector, 7-spherical bush.

Fuel Collector of Afterburner System.
/see fig.64/.

The collector has a ring form and has fuel intake from one side only. To pipes of the collector are fastened twenty four burners 2, placed evenly round the periphery of the circle, delivering fuel against the gas stream, and two burners 3, placed diametrally opposite each other, which deliver fuel towards the centre, with inclination of fuel stream axis at an angle of 45° to the pipe axis. These burners serve as starting means, as they deliver fuel into the zones of the ignition plug of the afterburner.

The collector is placed in the annular stabillizer, placed in the widening part of the afterburner.

The burners are of centrifugal type and consist of a body 1, atomizer 2 and bush 3, clamped from both sides by nuts 4 and 5 /see fig.65/. For avoiding of deformations of the collector pipelines /as result of differing thermal dilatation of the collector, stabilizer an pipe of afterburner/, the burners are set in the stabilizer on ball seats 7, and the fuel delivery pipe for the collector has also a spherical connection with same /see fig.37 and 65/.

Layout of accessories of fuel system on the engine is shown in fig.66.

Fuel Hoses.

The fuel hose is a rubber hose armoured by steel sheath, ends of the hose being provided with special terminals with union nuts or rotary necks according to the place, where the hose is fastened on the accessories. Dimensions of the hoses are the following: 8x15, 8x18, 10x20, and 16x30 mm. The hoses 16x30 mm

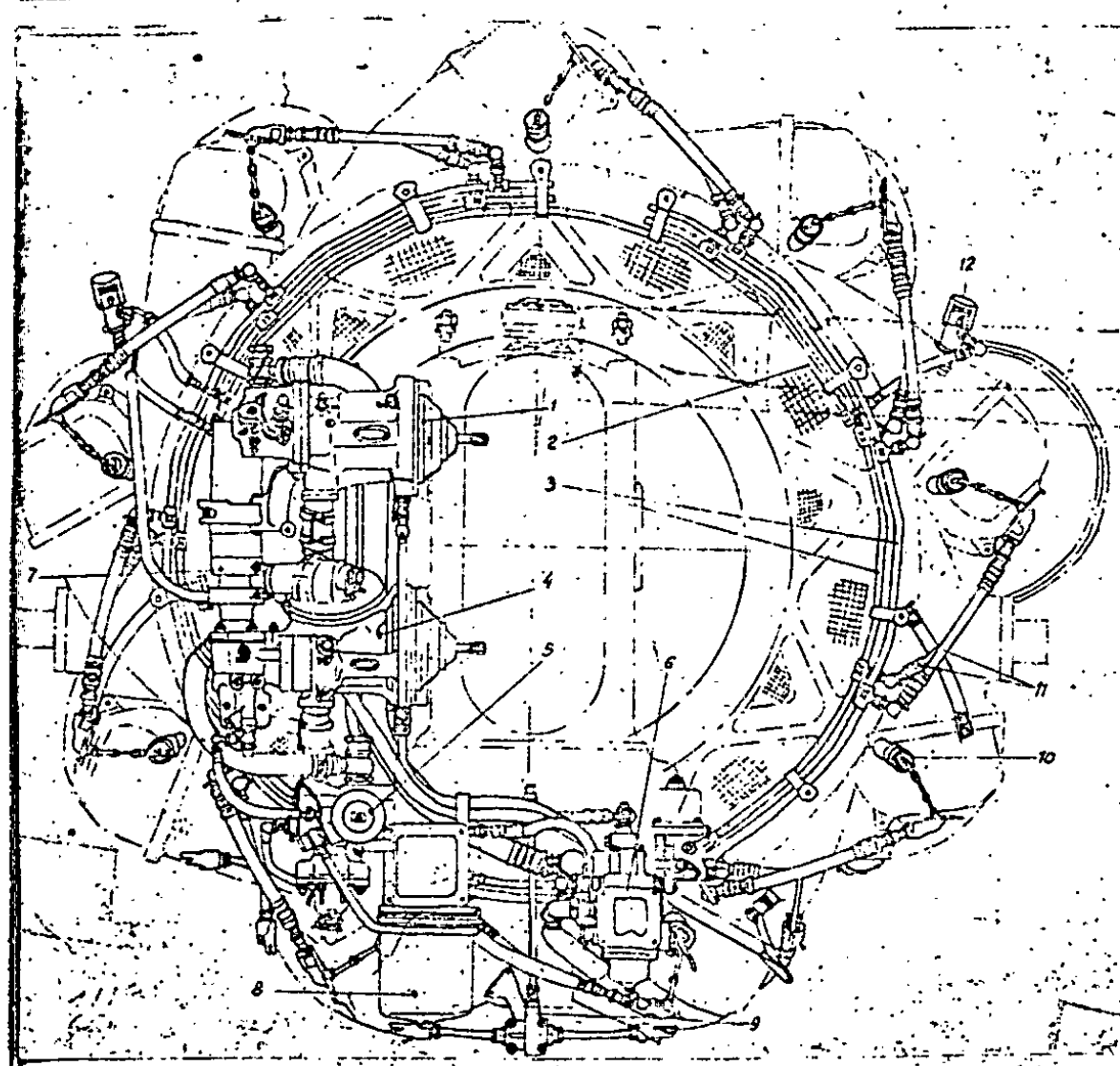


Fig.66. Layout of Fuel System Accessories on Engine.

1 - PN-10A fuel pump, 2-pipeline, loading fuel to starting burners, 3-fuel collector, 4 - PN-14A fuel pump, 5-fuel distributor ART-14A, 6-fuel distributor ART-8V, 7-starting electric pump PNR-45B, 8-fuel filter for low pressure line, 9-drain valve, 10-working burner, 11-hoses to working burner, 12-starting burner.

are armoured by two steel sheaths, enclosed between the inner and outer rubber chambers. The hoses of remaining cross-sections have one steel sheath. The rubber the hose is made of, is frost-proof.

Fuel Draining System /Fig.67/.

The fuel *draining* system serves for leading out into the atmosphere the fuel, deposited in the combustion chambers and in the afterburner or leaking through sealing of the fuel accessories and remaining in the collectors after stopping of engine. From the combustion chambers the fuel rest is drained by the draining valve, from the fuel accessories and fuel collector - through hoses, through T-joint on the ART-8W fuel distributor, form the afterburner - through draining hole, placed in the bottom of the annular /cylindrical/ part. Fuel, leaking through the telescopic connection of the afterburner, is deflected by two fuel deflectors and flows into fuel sump, through the neck of which it is drained into atmosphere.

The draining valve /fig.68/ consists of body 2, cover 4 and elastic plate with valve 5, the plate being clamped between the cover and body. The drained fuel is delivered to the body of the valve through pipes. When the engine runs, the valve is closed by pressure of gases. To the outlet channel and to the cover of the valve body a pipe is installed, through which oil from the body of engine centre bearing is drained.

The draining valve is fastened by the bracket 3 to the fifth combustion chamber. The fuel deflector is fastened by its flange on the outer side of the flange, by which the afterburner is fastened to the engine turbine body /fig.67/. The flange of the fuel deflector as to its form corresponds to flanges of turbine body and of afterburner /fig.69/.

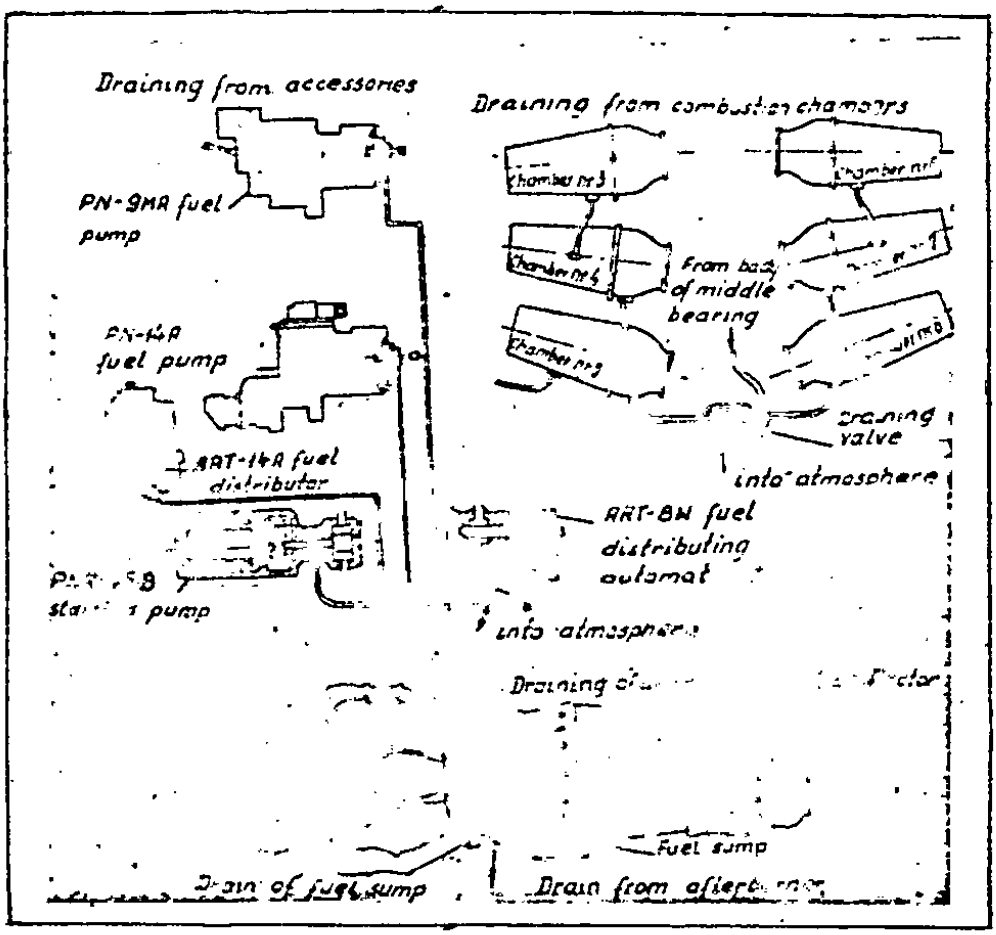


Fig.67. Diagram of Fuel Draining.

The fuel deflectors are installed both on the right and the left sides of the engine and are fastened by 19 b-olts each, beginning from the seventh bolt, the bottom bolt being taken as No.1 The fuel sump /fig.69/ covers the bottom part between the fuel deflectors; it is a channel with two welded-on eyes for fastening of the fuel sump to the body of the turbine. The fuel sump is fastened by the eyes on two bolts No.8., the bottom bolt being taken as No.1.

In the bottom of the fuel sump is welded-on a draining neck to which the draining pipe of the aircraft is screwed on.

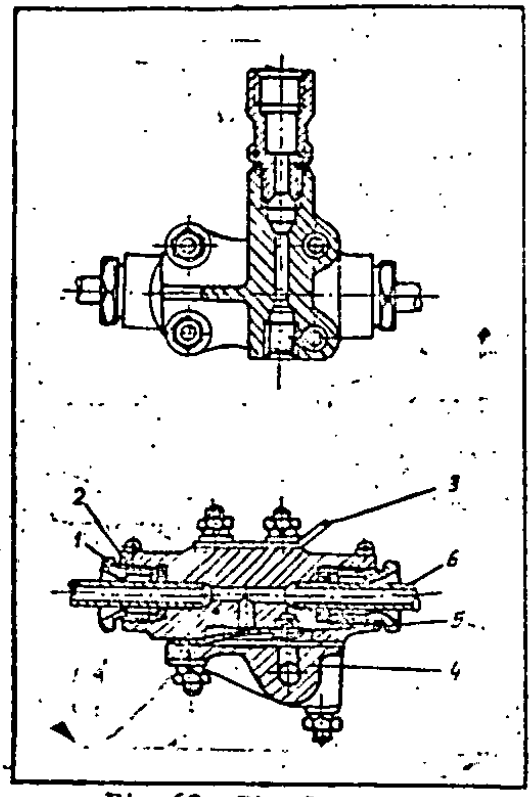


Fig.68. The Draining Valve.

1 - thrust nut, 2-body of valve, 3- bracket, 4-cover, 5-plate with valve, 6-pipes.

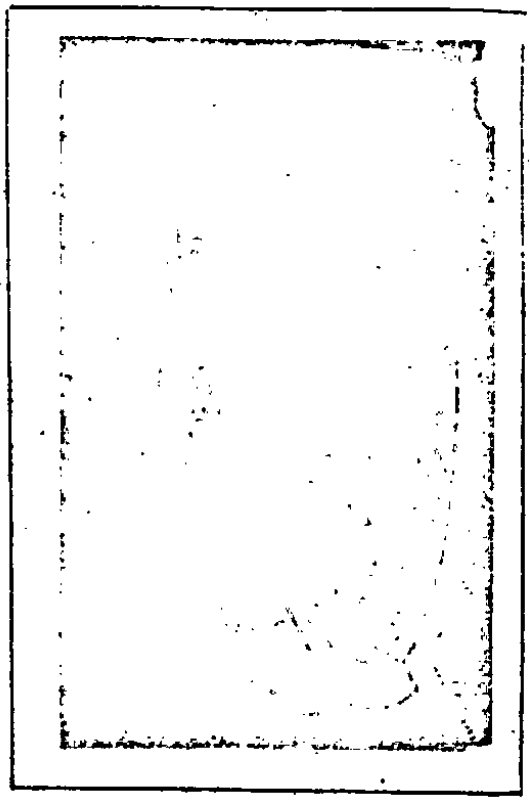


Fig.69. Fuel Sump with Deflectors.

1-fuel sump, 2-fuel deflectors.

The Regulating Elements.

The accessories of the fuel system have the following regulating elements:

Fuel Pump PN-1MA /see fig.70/:

1. Stop of maximum revolutions
2. Stop of minimum revolutions /low power/
3. Screw of low power valve
4. Stop of maximum output of pump
5. Stop of minimum output of pump

6. Screw for regulation of beginning of action of the all range regulator, shown in fig.57 left from spring 16/.

Fuel Pump PN-14A /fig.71/.

1. Stop of maximum output of pump
2. Stop of minimum output of pump
3. Screw for regulation of the limit pressure valve spring /fig.55/
4. Screw for regulation of afterburner emergency disengaging /shown in fig.62, screwed in into lever 39/
5. Screw for regulation of aneroid
6. Stop screw of barometric regulator lever
7. Screw of barometric regulator spring /shown in fig. 62 above the spring 32/.
8. Levers of regulating eccenters of back-effect guide fork and of lever with rollers.

Fuel Distributor ART-3V /fig.72/:

1. Screw of distributor needle spring
2. Screw of take-off needle spring
3. Jet for outlet of air
4. Screw of aneroid.

Fuel Distributor ART-14A.
/fig.73/

1. Screw of distributing valve spring.

Starting Electro-pump PNR-45B.
/fig.60/

1. Screw for regulation of output pressure.

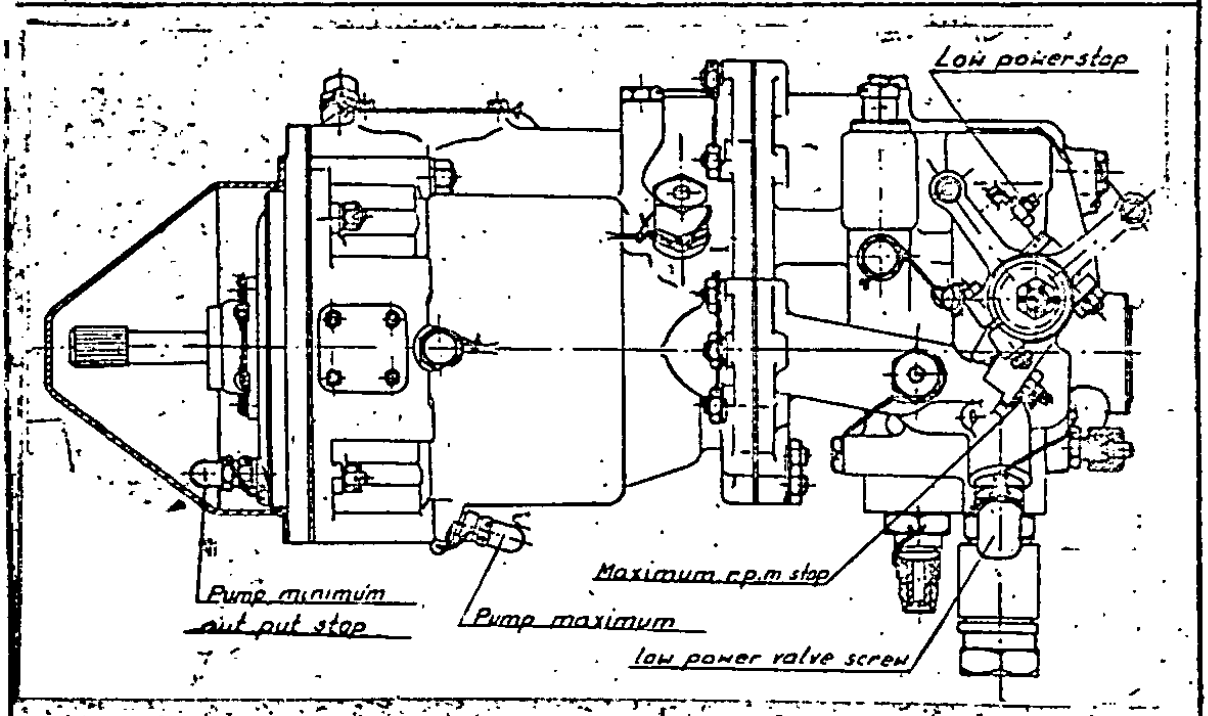


Fig.70.

Regulating Elements of PW - 3MA Fuel Pump.

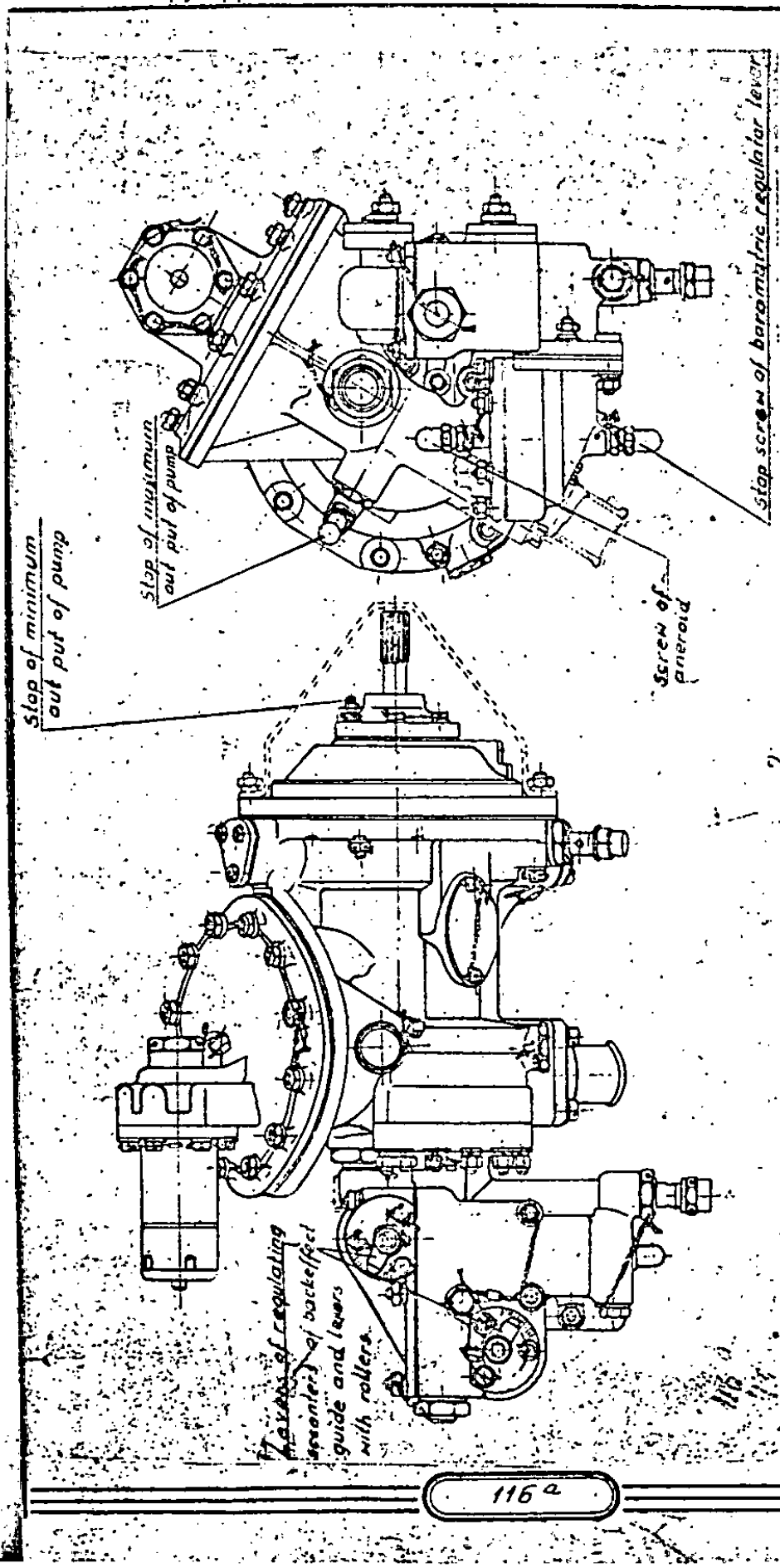


Fig.71.
Regulating Elements of PM-14A Fuel Pump.

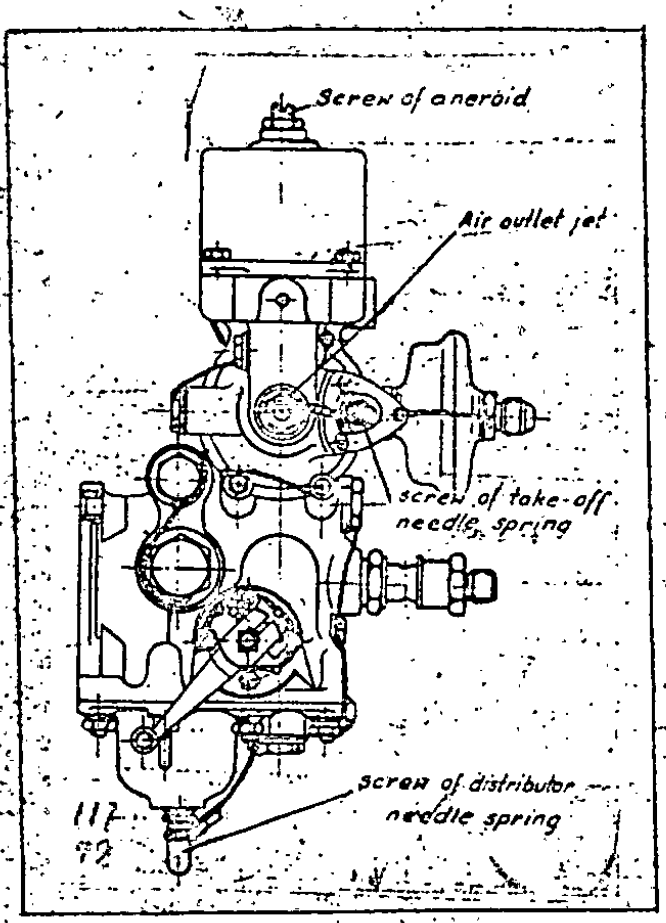


Fig.72. Regulating Elements of ART-6A Distributor.

Purpose and Funtion of the Regulating Elements Fuel Pump PR-3MA.

1. Stop of maximum rotational speed serves for limiting of position of throttle cock in maximum rating.

2. Stop of minimum rotaticanal speed serves for limiting of position of throttle cock needle in low power rating.

3. Screw of low power valve serves for regulation of low power rating: By screwing down the screw the fuel consumption will drop, by unscrewing - fuel consumption will be increased.

4. Stop of maximum output of the pump serves for limiting of maximum output of the pump.

5. Stop of the minimum output of the pump serves for limiting of the minimum output of the pump.

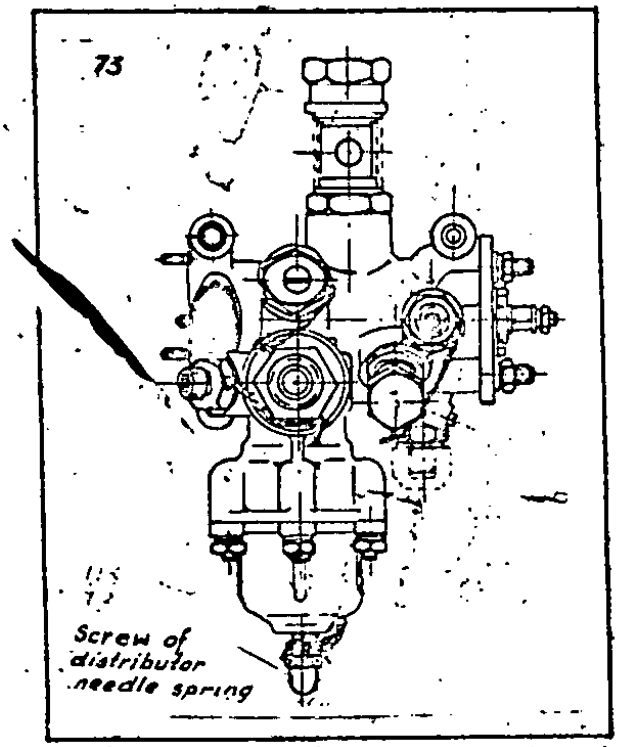


Fig.73. Regulating Elements of the ART-14A Distributing Valve.

Fuel Pump PN-14A.

1. Stop of maximum output of pump serves for limiting of the maximum output of the pump.

2. Stop of minimum output of the pump serves for limiting of the minimum output of the pump.

3. Screw for regulation of limit pressure valve spring serves for limiting of the maximum pressure before burners of the after burner.

4. Regulating screw of emergency disengaging of afterburner serves for adjusting of the pump for the minimum desired output.

5. Screw for regulation of the aneroid serves for adjusting of thrust of the aneroid. By this screw it is possible to regulate partially the fuel pressure after the pump.

6. Stop screw of barometric regulator lever determines the position of the lever and valve when the regulator is being regulated for maximum altitude.

7. Screw of barometric regulator spring by its position determines the thrust of the valve spring. The more thrust of the spring, the higher pressure of fuel after pump.

Levers of regulating eccenters of the back-effect guide and of lever with rollers serve for adjusting of the desired order of supply of fuel with varying altitude.

Fuel Distributing Automat ART-3V.

1. By the screw of distributor needle spring is regulated the thrust of the spring. By tightening of the screw the pressure is increased, at which the main system of engine burners get into operation. The screw serves also for regulation of acceleration within 2500-6000 r.p.m.

2. Screw of take-off needle spring serves for regulation of acceleration within 10600-11560 r.p.m.

3. Air outlet jet serves for regulation of acceleration within 6000-11560 r.p.m.

4. Screw of the aneroid serves for adjustment of thrust of the aneroid. By this screw is regulated the acceleration of engine for varying altitudes.

Fuel Distributor ART-14A.

1. By the screw of distributor dosing needle spring the thrust

of thes ring is regulated. By tightening of screw the fuel pressure between burners of afterburner is lowered with altitude.

The Starting Electric Pump PNR-45B.

1. The screw for regulation of fuel pressure serves for securing of the necessary pressure at outlet of the pump.

C H A P T E R XI.

ELECTRIC EQUIPMENT OF THE ENGINE.

The electric equipment of the engine consists of four systems:

1. Starting system
2. Electric system of afterburner
3. System of feeding of the aircraft network
4. System of electric instruments, controlling the operation of engine.

The systems are on principle independent form each other, but all leads to accessories and instruments are collected in one screened collector.

The systems of engine electric equipment serve for:

1. Running-in of engine rotor to the desired rotational speed and ignition of the fuel-air mixture in combustion chambers,

2. Automatic controlling of afterburner system /opening and closing of slide valve shutter of ART-1MA for fuel supply, ignition of fuel in the afterburner and controlling of jet nozzle gills/.

3. Automatic engaging of the power generator into the network of the aircraft and recharging of accumulator battery.

4. Controlling of main parametres of engine: rotational speed, temperature of gases after [illegible], temperature and pressure of oil, fuel pressure in the [illegible] system of engine and in the afterburner fuel system.

In fig.74 is shown the principle diagram of all systems. At the top of the diagram, above the electric connectors 19 and 20 are given the following accessories and instruments, mounted in

the aircraft on the engine: 1-electric starter-motor [illegible], 4-motor of PIM-4 B starting pump, 5-fuel pressure signal[illegible]ter SD-3, 6-double ignition coil KM-1, 6-ignition plugs SD-[illegible], 7-elbow piece UB-09-2, 9-electromagnet of emergency valve of PN-14A fuel pump, 8-electromagnets of starting burners, 2-pickup of TE-15 tachometer, 10-pickup PE-100 of pressure gauge for measuring of fuel pressure in the engine main system, 11-pickup P-1 of oil thermometer, 12-pickup P-10 of oil pressure gauge, 13-pickup EM-100 of fuel pressure gauge of afterburner, 14-motor of the MP-2 electromechanism, 15-afterburner switch, 17-ignition plug of afterburner SB-92, 18-thermocouples for measuring of gas temperature after the turbine; the starting coil MPM-1A /see pos.16/ is mounted on the air frame.

In the middle part of the diagram are shown the commutating devices of the electric equipment, placed on the switchboard of the engine control in the cockpit and also the ground feeding connector 42 with switch of storage battery 46, used as starting of the engine with use of ground source of electric current. This system comprises the following warning lights: 35a-warning light of fuel pressure switch, 35b-lamp of electromagnet of fuel pump PN-14A emergency valve and 35c-lamp of ignition system of the engine. Switches: 33-main switch, 32-blocking button, 31-starting overswitch, 44-automatic circuit breaker and emergency valve switch AZS-5, 38-jet nozzle control switch, 39-AZS-1C automatic circuit breaker, 40-AZS-3C automatic circuit breaker of supply pump, 27-RT-40 blocking relay, 28-IP-19 inertial circuit breaker and 34-starting button.

In the lower part of the diagram are given the accessories, forming the engine starting system, mounted on the framework of aircraft. There are the following accessories :

45-starting panel PS-27, 47-storage battery 12[illegible]-25 and 52-aircraft power generator with output 3000-6000 W, mounted on the

aircraft auxiliaries drive box on the engine with its set of regulating instruments, consisting of 48-voltage governor R-25, 49-stabilising choke, 50-differential minimum relay DMR-400, 51-generator switch. In the right lower part of the diagram are given the accessories of afterburner control system, mounted on the aircraft.

There are following accessories: 16-ignition coil RPA-1i, 36-relay MR-2 for reversing of MG-2 electromechanism, 37-electromagnet of the electrohydraulic valve GA-15M/3, 41-microswitch of afterburner KF-6A and 43-blocking microswitch KF-6, 60- RM-40 relay, 61 - RP-2 relay, 62- SDU-10A-60 pressure signalizator, 63- automatic ignition release on the ground. Besides that, the following accessories are shown in the diagram: 29- relay R-30, shunting the series winding of the starter motor, 30- relay RM-40, 55- RP-3 relay, 57,58- RPA-200A relay, 59- RM-9Z blocking relay, 56- IP-50 inertial curcuit breaker, 53- engine control lever and indicators of the instruments 21, 22, 23, 24, 25 and 26.

ENGINE STARTING SYSTEM

The engine starting system comprises the following accessories, description of which is given below.

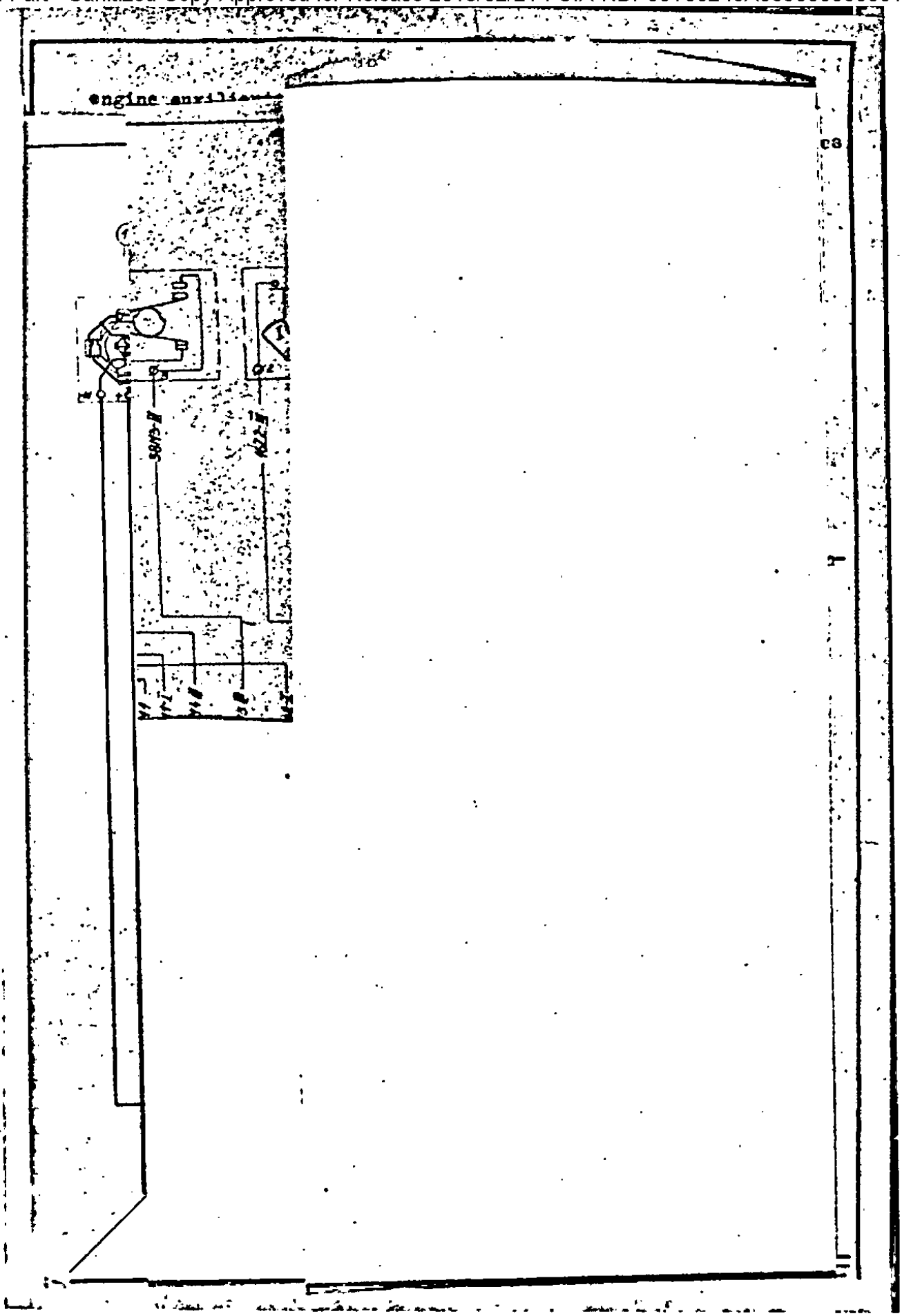
1. The starter motor ST-2-48M

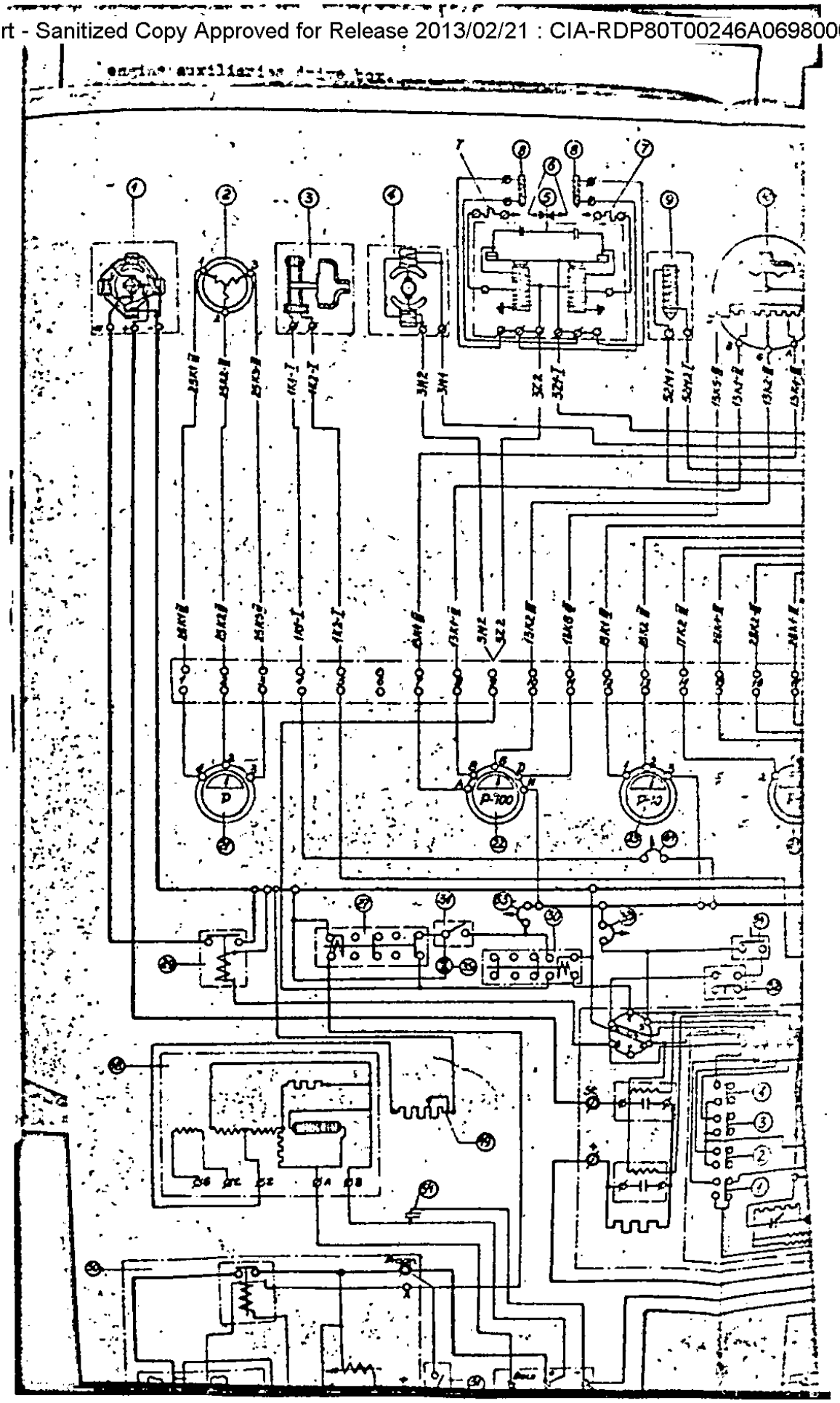
The starter motor is an electric motor for direct current feeding, with compound excitation and serves for driving the engine rotor till the necessary rotational speed is reached.

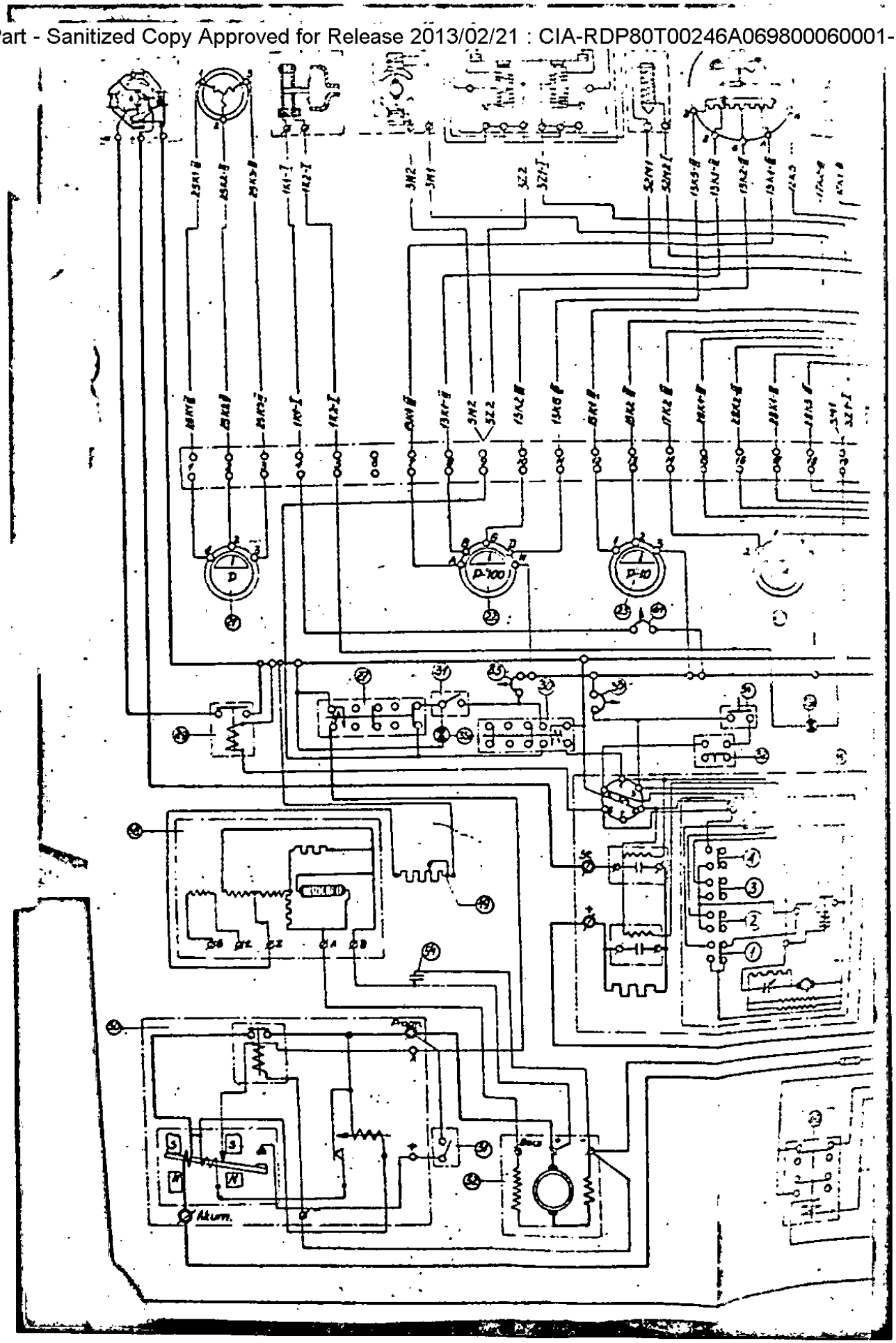
The principle diagram of the starter motor is shown in fig.75.

The starter motor is designed in there main assemblies: the body, two faces and rotor /see fig.76/.

The body of the starter 4 is cast of aluminium alloy inside of which is pressed in a steel sleeve, serving as conductor of magnetism. In the front part of the body are made four holes /overlapped by strip 3/ for checking the brush-holder assembly in the assembled starter. On the opposite side the body is ended by a flange with eight holes for fastening of the starter on the







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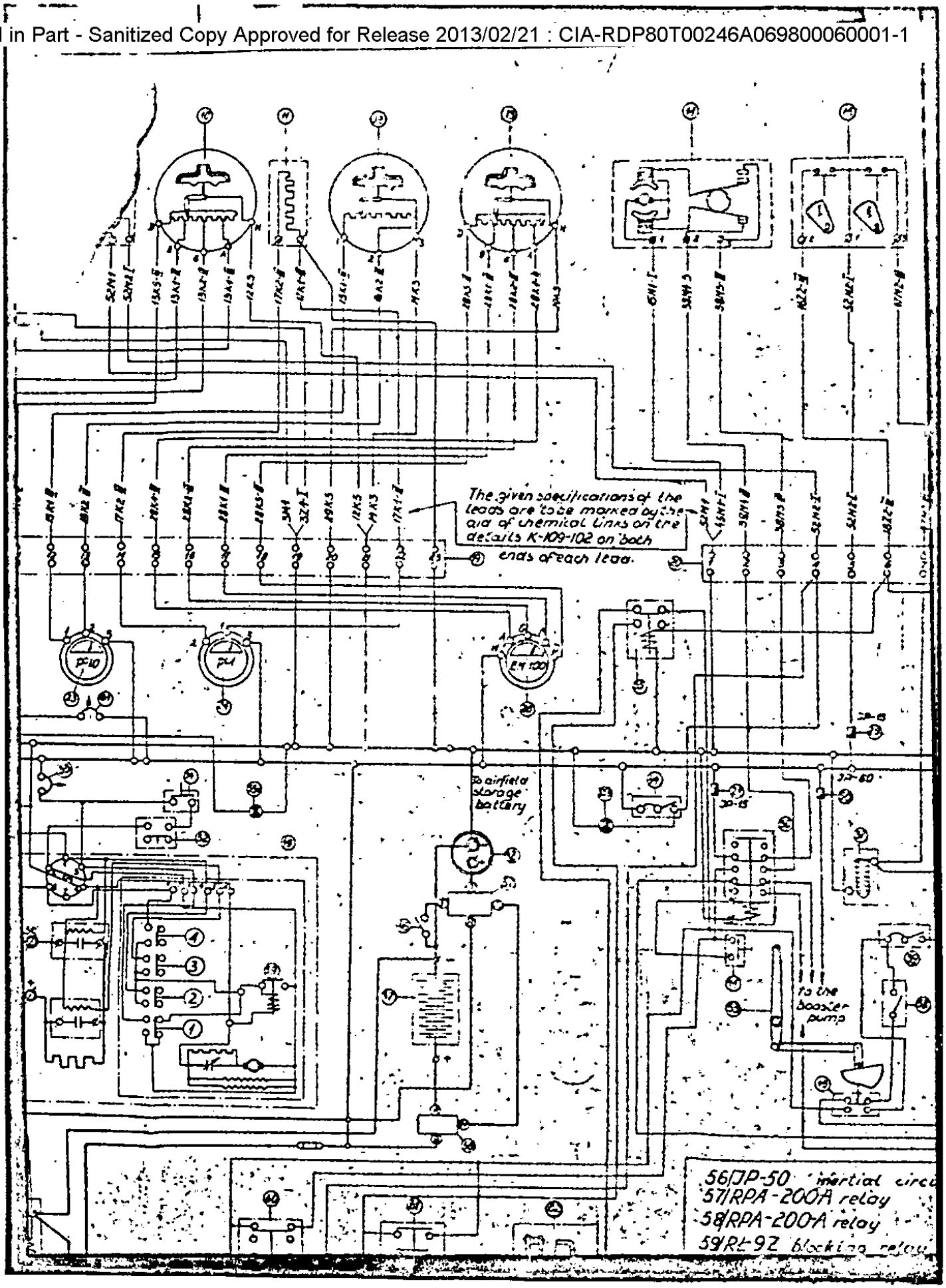
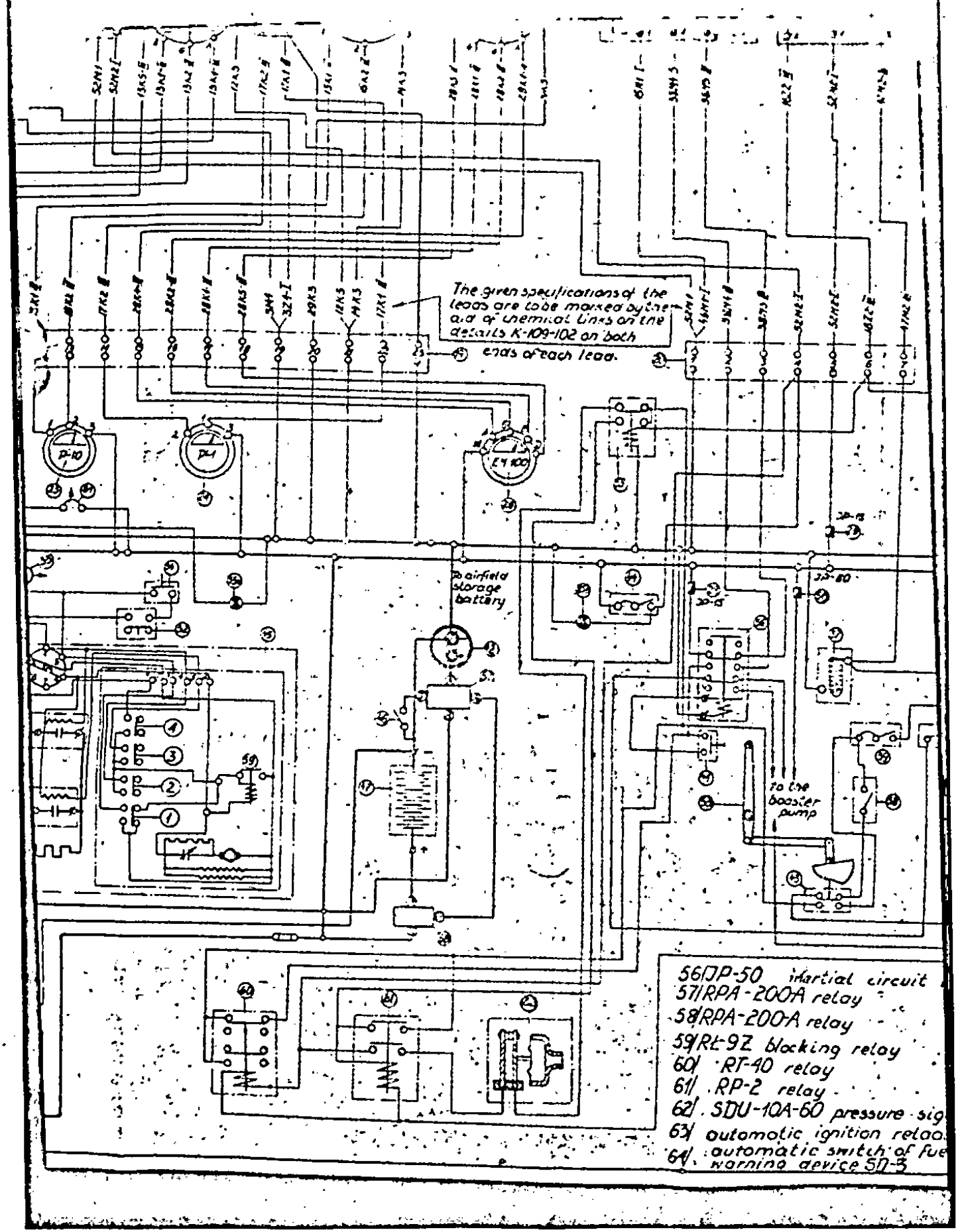
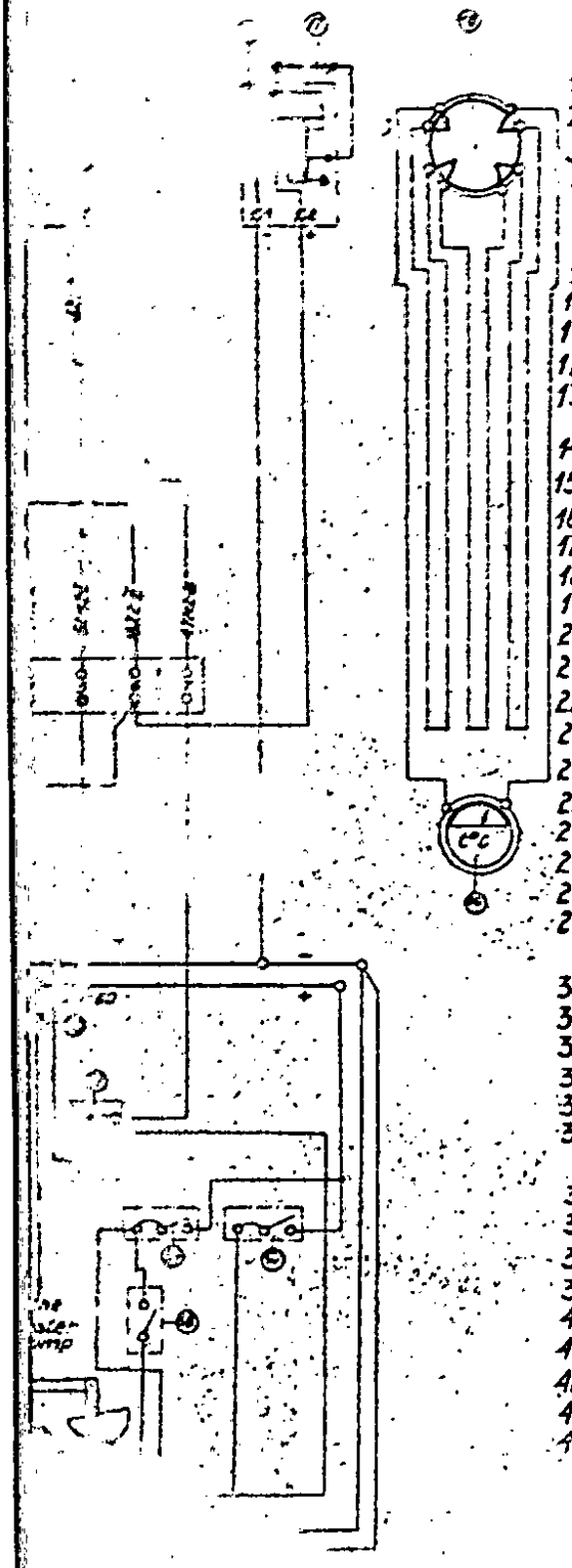
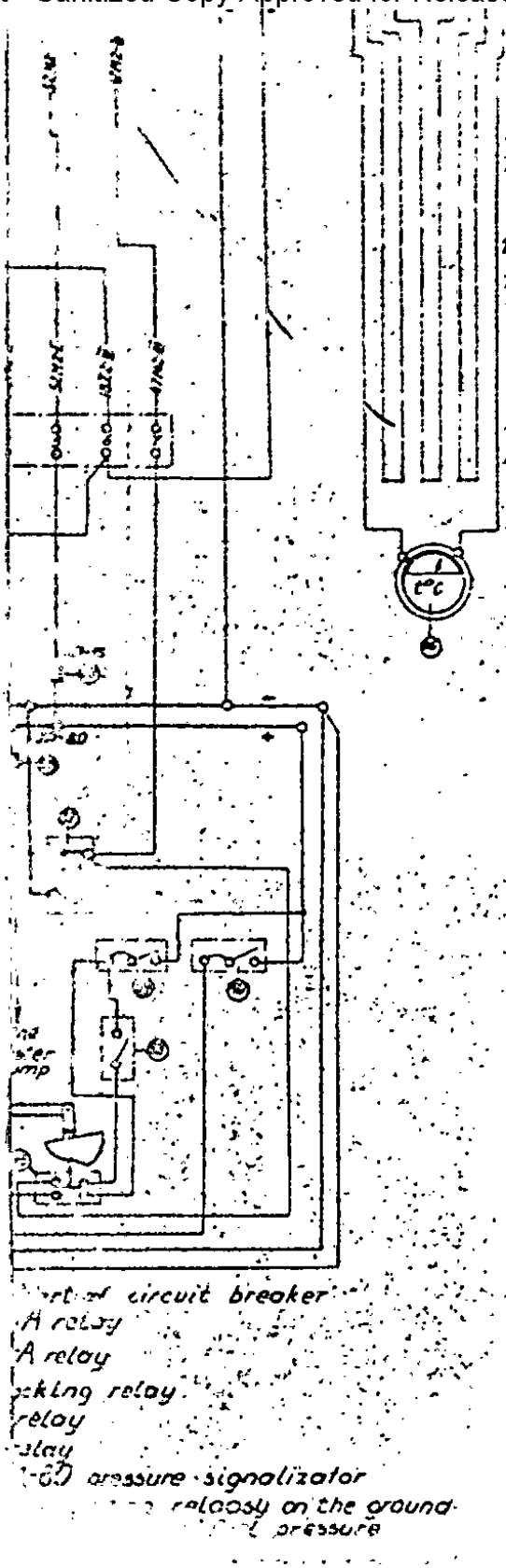




THE ENGINE ELECTRIC SYSTEM DIAGRAM



1 — Electric starter
2 — Transmitter TE-15 r.p.m. computer
3 — SJ-3 fuel pressure warning device
4 — motor of PNR-45B starting pump
5 — KR-1 ignition coil
6 — SD-55 ANM spark plugs
7 — UE-09-2 spark plug ejector
8 — starting burners solenoids
9 — emergency valve solenoid
10 — P-100 fuel pressure transmitter } Form one set EMI-3R
11 — P-1 oil temperature transmitter } Form one set EMI-3R
12 — P-10 oil pressure transmitter } Form one set EMI-3R
13 — EM-100 fuel pressure transmitter in the afterburner pipe line
14 — motor of MG-2 electric device
15 — afterburner switch
16 — KPM-1A ignition coil
17 — SD-92 spark plug of afterburner
18 — Thermocouples for jet temperature measuring
19 — SzR-23S main engine electric supply socket
20 — SzR-7S afterburner electric supply socket
21 — r.p.m. indicator of the TE15 r.p.m. computer
22 — fuel pressure indicator } Form one set EMI-3R
23 — oil pressure indicator } Form one set EMI-3R
24 — oil temperature indicator } Form one set EMI-3R
25 — the afterburner fuel pressure indicator EM-100
26 — jet temperature indicator
27 — RT-10 blocking relay
28 — IP-15 inertial circuit breaker
29 — K-50 D relay /shunting the series winding of the electric starter/
30 — RT-10 relay
31 — starting overswitch / relighting in the air/
32 — blocking button
33 — main switch
34 — starting button
35 — signalisations lamps { fuel pressure — a; emergency valve — b; ignition switching — c
36 — MR-2 relay of the MG-2 electric device reversal
37 — hydraulic valve solenoid
38 — variable nozzle switch
39 — AZS-10 automatic circuit breaker
40 — AZS-50 automatic circuit breaker
41 — KN-6A afterburner microswitch
42 — aerodrome socket
43 — KN-6 blocking microswitch
44 — automatic circuit breaker and the emergency valve switch AZS-5
OS-2W starting panel
itch /battery ground supply/



8 — starting burners solenoids
9 — emergency valve solenoid
10 — P-100 fuel pressure transmitter
11 — P-1 oil temperature transmitter } form one set EMI-3R
12 — P-10 oil pressure transmitter }
13 — EM-100 fuel pressure transmitter in the afterburner pipe line
14 — motor of MG-2 electric device
15 — afterburner switch
16 — KPM-1A ignition coil
17 — SD-92 spark plug of afterburner
18 — Thermocouples for jet temperature measuring
19 — SzR-23S main engine electric supply socket
20 — SzR-7S afterburner electric supply socket
21 — r.p.m. indicator of the TE15 r.p.m. compressor
22 — fuel pressure indicator } form one set EMI-3R
23 — oil pressure indicator }
24 — oil temperature indicator
25 — the afterburner fuel pressure indicator EM-100
26 — jet temperature indicator
27 — RT-40 blocking relay
28 — IP-15 inertial circuit breaker
29 — K-50 D relay /shunting the series winding of the electric starter/
30 — RT-40 relay
31 — starting overswitch /relighting in the air/
32 — blocking button
33 — main switch
34 — starting button
35 — signalisations lamps { fuel pressure — a emergency valve — o ignition switching — c
36 — MR-2 relay of the MG-2 electric device reversal
37 — hydraulic valve solenoid
38 — variable nozzle switch
39 — AZS-10 automatic circuit breaker
40 — AZS-50 automatic circuit breaker
41 — KW-6A afterburner microswitch
42 — aerodrome socket
43 — KW-6 blocking microswitch
44 — automatic circuit breaker and the emergency valve switch AZ S-5
45 — PS-2W starting panel
46 — battery switch /battery ground supply/
47 — 12-SAM-28 storage battery
48 — R-25A voltage regulator
49 — adjustable resistance
50 — DRM-400A differential-minimum relay
51 — generator switch
52 — generator
53 — engine control lever
54 — KBM-31 condenser

...rt of circuit breaker
...A relay
...A relay
...cking relay
...relay
...lay
...-6D pressure signalizator
... relaxsy on the ground
... pressure

engine auxiliaries drive box.

Inside the body on the steel sleeve are fastened four poles each by two screws, assembled of electrotechnical steel sheets, on which the excitation coils are placed, the shund winding being placed inside and the series winding outside the excitation coil.

One end of both exciting and series winding are led onto the first pair of brush holders. The first pair of brush holders is connected with a special clamp in the face part of the front face, marked /-Ш/.

The other end of the shunt winding is connected with the other pair of brush holders, which are connected by a lead with clamp / + / on the terminal box. The other ends of the series winding are led onto the clamp / - / of the terminal box.

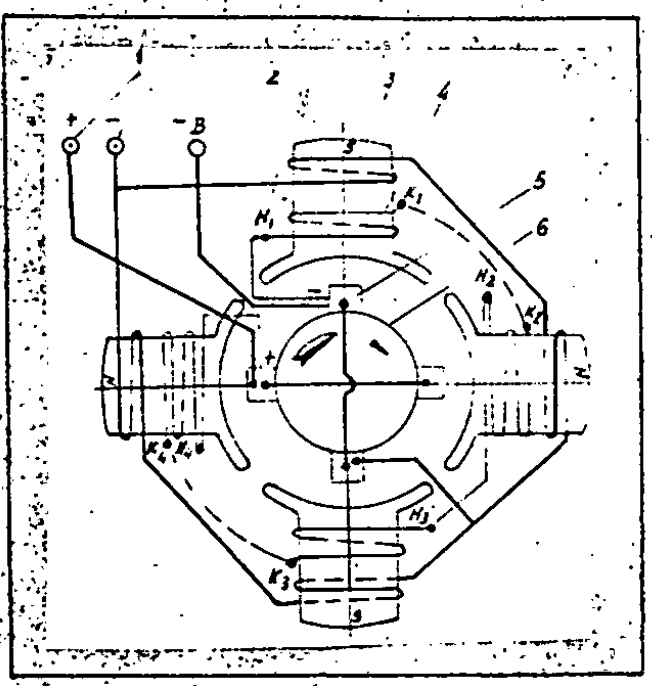


Fig.75. Basic Diagram of the Starter Motor.

1-outlet clamps, 2-series winding, 3-pole bodies, 4-shunt winding, 5-brushes, 6-rotor of starter.

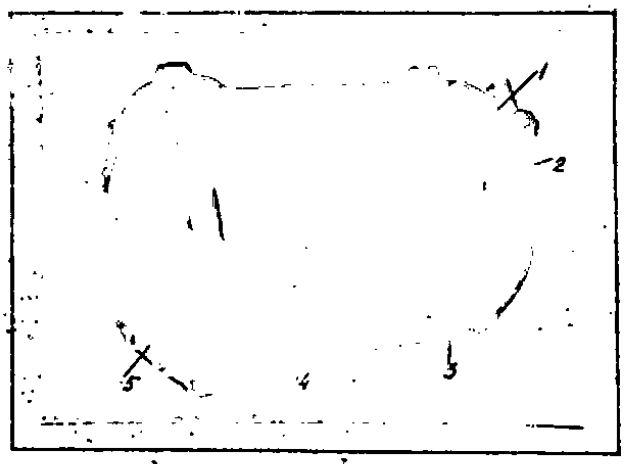


Fig.76. Starter Motor.

1-outlet clamps, 2-clamp box, 3-protecting strip, 4-body of starter, 5-rear face plate, 6-shaft of the rotor.

The face from the side of the collector is made of aluminium alloy. From inside of the face is mounted a support with four cast brush holders, connected in pairs by copper leads and besides that the brush springs. In the central part of the front face is pressed-in a steel bush for mounting of the rotor bearing. The face 5 from the side of the drive is made of steel, and there is mounted the ball bearing of the rotor and the sealing gland for protection of starter motor against intruding of oil into the starter. The face plate has two bedding collars, by which it is assembled in the body and in engine auxiliaries drive box. Both face plates are fastened by screws to the starter body.

The starter rotor consists of a shaft, on which a pack of electrotechnical sheet steel is pressed on, on one end of the shaft are splined for connection with the gear for engine drive and on the other end is thread for fastening of the front bearing assembly.

In the open grooves of the pack is inserted the rotor winding made of rectangular copper core. Ends of the rotor winding are nobbled in the cogs of the collector laminas and are soldered, the winding being tightened together by binding made of steel wire.

The collector of the rotor is made of collector copper plates, the plates of the collector being clamped together by steel cones, tightened by nut. The rotor is seated in oper bearings, mounted in the face plates and is fastened by nuts. For the ST-2-48W starter are used brushes mark MGS-5, dimension 10 x 25 mm.

The starter is mounted on the engine auxiliaries drive box on the left side and is fastened by eight stud bolts. The starter ST-2-48V is calculated for a short-term operation and allows three successive runs 40 second each with interruption between each run 2 minutes.

The fourth starting /switching on/ is allowed only after full cooling of the starter. At voltage on the current source 29 V and rotational speed 3000 r.p.m. the intensity of current consumed is maximum 350 A and the torque moment equals 2,3 kgm.

2. Starting Automat PS-2W

The starting automat PS-2W serves for control of automatical engaging of the starter and provides a three-stage starting of engine.

The starting automat is fed by d.c. within limits of 15-28V. The electric diagram of the automat is shown in fig.77. The automat is assembled in a metal chest 1 of rectangular form /fig.78/ The cover 2 of the box is removable. On the bottom and on the walls of the box are placed all elements of the automat: the ti-

ming relay AWI-1W "3", two power contactors P-300 "4", reducing resistor "5", having R=0,14 $\pm^{0,015}_{-0,01}$ Ohm, the electric connector "6" and the terminal box "7". All mounting leads of the automat are assembled into two braids and are bound together each 15 ÷ 20 cm by a raw thread. Mounting of the power circuit is performed by uncovered leads of rectangular cross-section. The cover of the box is put on the walls of the box and is fastened to it by four special locks /pin locks/ "8". The starting automat is fastened on the framework of the aircraft.

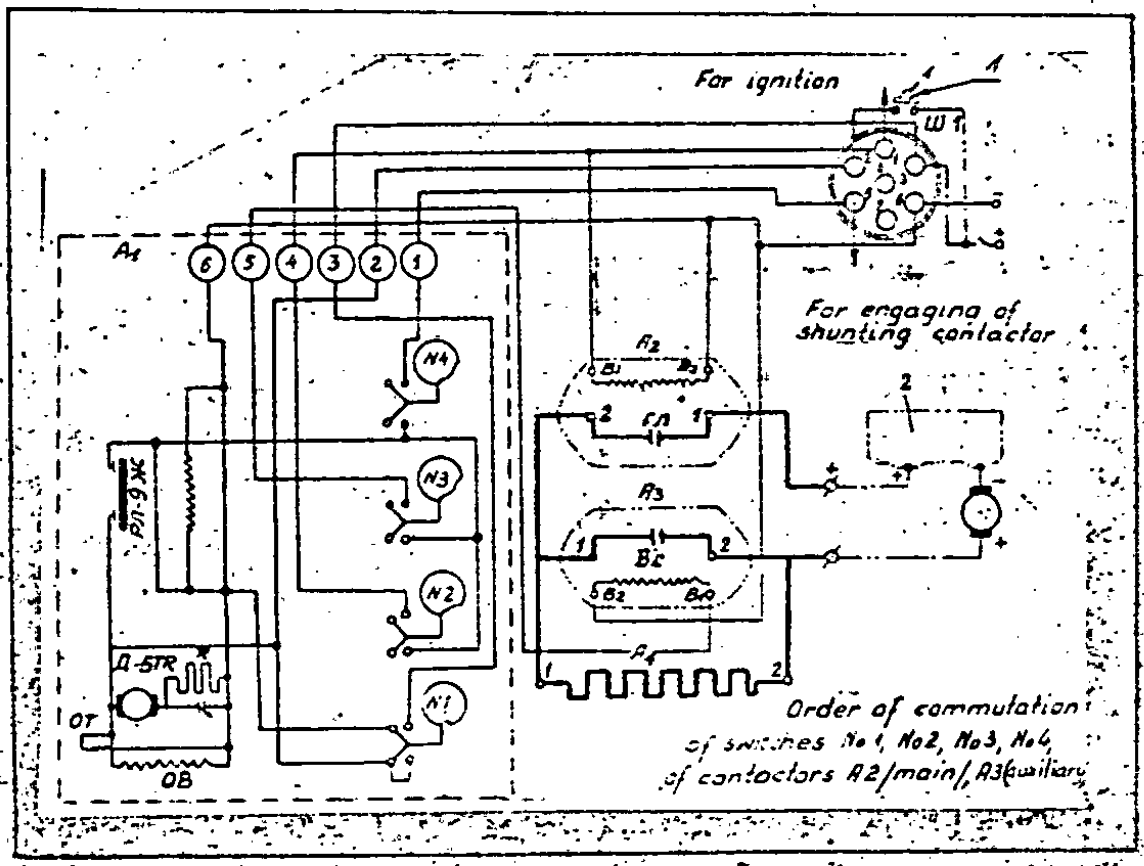


Fig.77. Electric Diagram of PS-2W Starting Automat.

1-starting button, 2-power source, 3-electric connector, St-starter, A_1-timing automat AVP-1W, A2-main contactor, A3-auxiliary contactor, A4-resistor R = 0,14 $\pm^{0,015}_{-0,01}$ Ohm, No.1, 2, 3,4 - switches, OT-braking winding, OB-exciting winding.

3. Ignition Coil.

The ignition coil /fig.79/ serves for obtaining a spark discharge on the electrodes of the plug and for ignition of the working mixture in combustion chambers of the engine. In the aluminium body 9 are placed two inductance coils 3, interconnected electrically in parallel.

In the body of each coil is a core, on which are provided two windings: the primary one, made of copper wire diameter 0,8 mm, the secondary one, made of copper wire with diameter 0,07mm and a capacitor. The beginning of the primiary winding is led out to the mass of the frame by means of a plate contact, connected with cast body, and the end of the secondary winding is connected with the contact bush in a special boss 1 of the housing, to which is connected the contact mechanism of the high voltage lead - plug. From outside of the face of the inductance coil is placed an electromagnetic vibrator /interrupter/ consisting of armature 6 with a movable contact 8 and two plates 5, connecting in parallel the windings of the coils. On each coil is placed a screw with immobile contact 7 of the vibrator and the connecting lead from the terminal box.

In parallel with the contacts of the interrupter is connected the capacitor for reducing of sparking on the contacts. The vibrator is connected in series with the primary winding of the inductance coil and serves for interrupting of direct current of the primary winding.

The ends of the primary windings of both coils are led out on the terminal panel of KR-1, mounted in the body under the screening jacket 2.

The terminal panel 4 consists of two terminal boxes per three

clamps. To one of the terminal boxes through the relay T-25A is led the „plus" lead of the aircraft mains, to the other the „minus" lead is connected.

The two other clamps of the terminal boxes serve for connecting of the leads of the starting burner electromagnet of the right and left ignition assemblies.

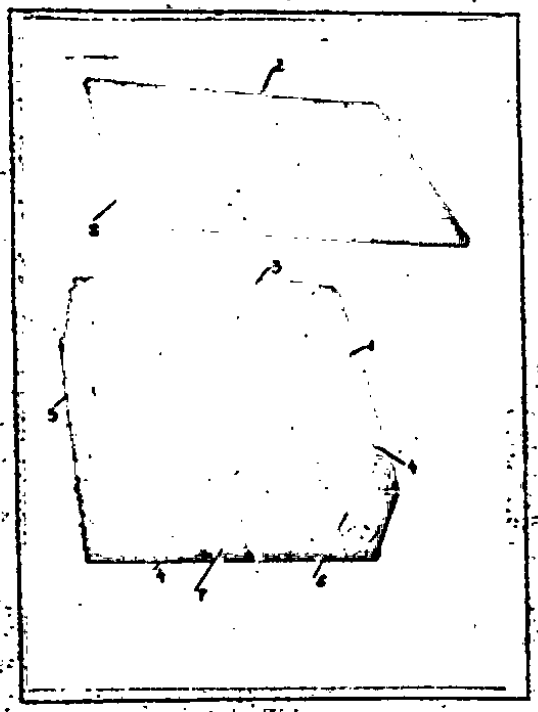


Fig.76.

PS-2W Starting Autocat.

1-metal chest, 2 cover, 3-timing relay AW-1W 4-power contactors Z-300, 5-reducing resistor R-14 ± 0,015 / 0,01 Ohm, 6-electric connector, 7-terminal box, 8-pin locks.

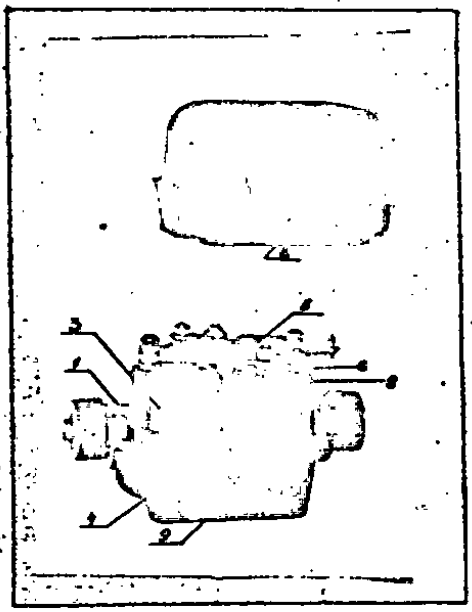


Fig.77.

Ignition Coil KR-1.

1-boss of high voltage outlet, 2-screening jacket, 3-inductance coil, 4-terminal box, 5-plates, 6-armature, 7-screw with immobile contact, 8-mobile contact, 9-body.

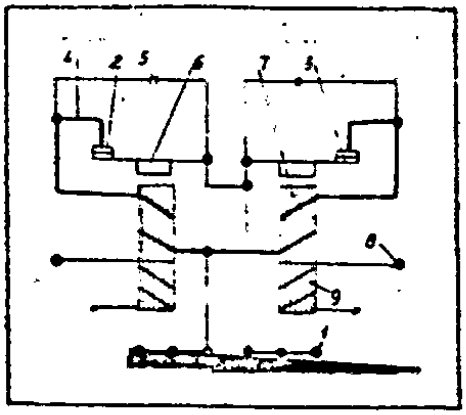


Fig.80. The Basic Diagram of KR-1 Ignition Coil.

1-terminal panel, 2-immobile contact of the vibrator, 3-mobile contact of the vibrator, 4-primary winding of the coil, 5-capacitor, 6-armature, 7-core, 8-high voltage outlet, 9-secondary winding of the coil.

The basic diagram of the KR-1 starting coil is shown in Fig.80. When the voltage is switched on into the primary winding, the circuit is connected through the regularly connected contacts of the vibrator and in the core a magnetic field occurs.
In result of this field the armature of the vibrator is attracted to the core and interrupts the primary circuit, at which the magnetic field vanishes and the armature of the vibrator returns into its initial position. Thus in the core of the inductance coil the magnetic field occurs and vanishes with a frequency, equal to frequency of interruption of the primary circuit. In the instant of interruption of the primary circuit in the secondary winding a high voltage current occurs, which is led to the high voltage leads and farther to the electrodes of the plug.

The ignition coil KR-1 on the engine M-1F is mounted in vertical position / low voltage outlets down / above the front sieve of the air intake of compressor and is fastened by three bolts on a special bracket.

[illegible] in one body. [illegible] ...ic screened plug with [illegible] ...al electr[illegible] are in the body of the i[illegible] assembly. Th[illegible] the fuel-air mixture in the combustion chambers [illegible] engine is being started. The starting burner consists of a body, common for the coil of the electromagnet, and a bush with [illegible]...mizer.

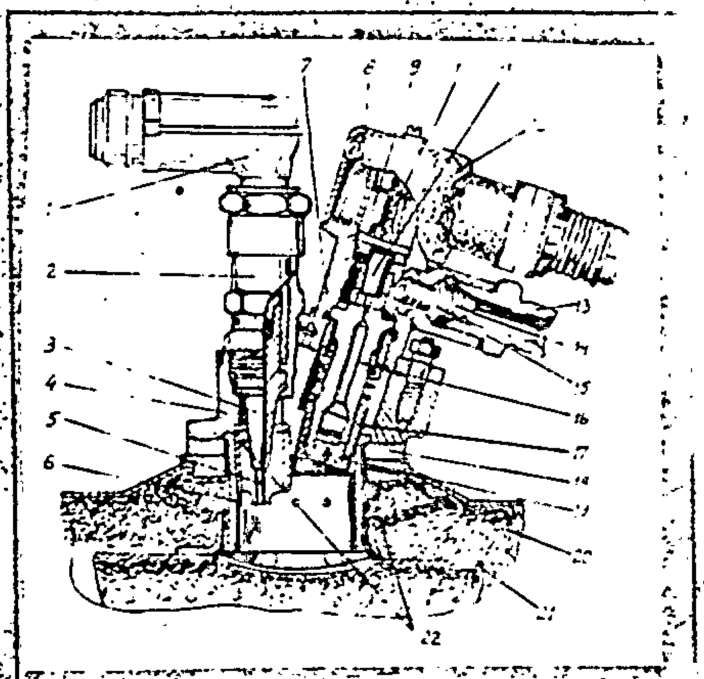


Fig.81. Ignition Assembly.

1-elbow joint of spark plug, 2-spark plug, 3-core, 4-body of starting burner and of plug, 5-central electrode, 6-side electrode, 7-body of starting burner, 8-winding of the electromagnet, 9-core of the electromagnet, 10-spring of the needle, 11-needle, 12-jacket of the electromagnet, 13-neck, 14-spring of the filter, 15-filter, 16-bush of the atomizer, 17-nut of the atomizer, 18-sealing, 19-atomizer, 20-jacket of combustion chamber, 21-inner shell of the combustion chamber, 22-holes of the vent channel.

The electromagnet of the starting burner is an attraction type electromagnet with closed magnetic system and serves for automatic remote control of the needle, which opens access of fuel into combustion chamber during starting. In order to prevent formation of carbon on the plug electrodes there are two channels made in the body of the ignition assembly, through which from the combustion chambers an additional stream of air is brought, which blows off any formation of carbon from the starting burner and from the electrodes of the ignition plug.

The ignition assemblies are placed in the combustion chambers No 3 and 8.

5. RT-40 relay

The RT-40 relay serves for :

a/ engaging and disengaging of the starting pump, ignition coil and the ignition assembly on the ground.

b/ engaging and disengaging of over mentioned aggregates for relighting in flight.

c/ interrupting of current circuit to LR-2 relay.

The RT-40 relay is mounted on board of the aircraft.

Nominal data of the relay :

Voltage	24 V
Current intensity	40 A

The relay consists of following main parts /fig.62/ : solenoid, transmission mechanism and the contacting device.

The solenoid consists of a body /1/, in which a winding is mounted, and of mobile armature /2/.

In the upper part of the body on eyes /3/ are fastened return springs /4/ which are covered by cover 5.

The transmission mechanism consists of a lever /6/, transmitting the motion onto the mobile bridge /7/ and of lever /8/ of the return spring. The contacting device consists of a mobile bridge 7 with the contacts, of a plate /9/ with fixed contacts /10/ and stand /11/.

The relay is fastened to the aircraft framework by means of a bracket /12/.

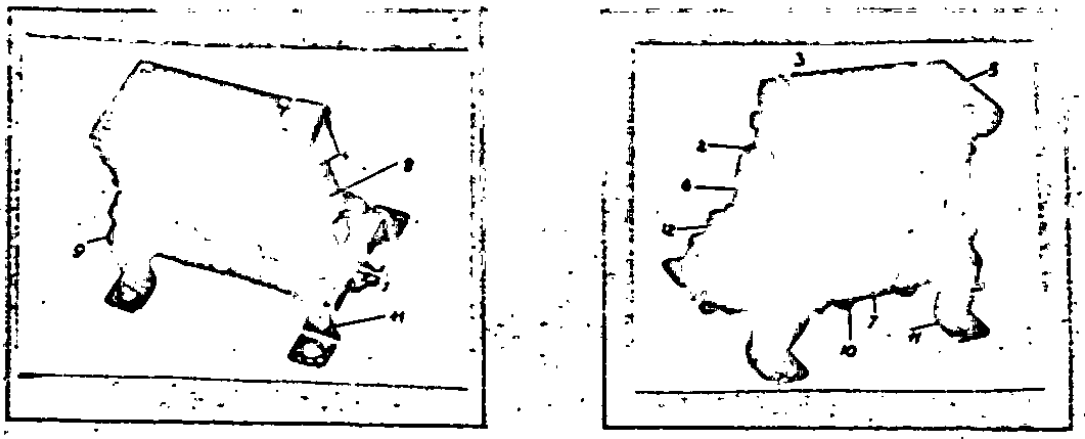


Fig.82.- Relay RP - 40.

1- body of the electromagnet, 2- mobile armature, 3- eye, 4- return spring, 5- cover, 6- lever, 7- mobile bridge, 8- lever of return spring, 9- plate, 10- immobile contacts, 11- stand, 12- bracket.

Principle of Function of the Relay

When voltage is switched on to the winding of the electromagnet, the mobile armature is shifted and transmits its motion through the transmission mechanism to the contact bridge. The contact bridge disconnects its regularly connected contacts and connects the regularly disconnected contacts. When the voltage is switched off, the contact bridge is returned by the return spring into its initial position. In order to secure the needed value of contact resistance on the contacts and for an even distribution of the thrust on each contact, special springs are provided for each contact pair in the mobile bridge.

6. Motor D-17

The motor of the starting pump is a two-pole electromotor of direct current feeding with compound excitation and serves for driving of the starting pump PM-45, the bracket of which is fastened on stud bolts to the housing of the front bearing. The direction of rotation of the electromotor - to the left from the side of the drive. Feeding of the electromotor is performed through a two-pole connector.

Nominal data of the electromotor :

Torque on shaft	0,5 kgcm
Voltage	24 V
Current intensity	7,3 A
Rotation speed	15000 r.p.m.

For the electromotor are used brushes EG-8K with dimension 5 x 6,5 mm. The electromotor consists of the following assemblies: body, face plates and rotor /fig. 83/.

The assembly of body consists of a steel sleeve 1, two pol 2 and exciting coils 3. The sleeve is made of steel. The poles are compact, forged of steel and are fastened to the body by two screw 4 each. In the body the windows are made for access to the brushes. The windows are covered by a cap 5. The face plates ar made of aluminium alloy. On the face plate 6 from the side of drive four stud bolts are screwed in for fastening of the starting pump.

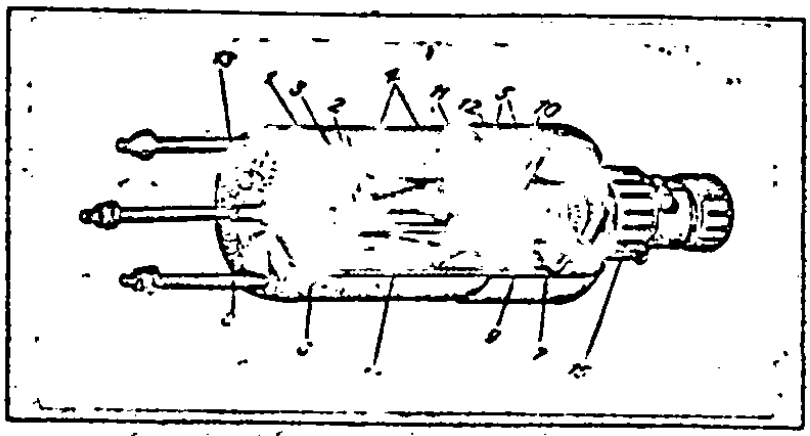


Fig.83. Motor D - 150.

1-sleeve, 2-pole, 3-exciting coil, 4-screw, 5-cap, 6-7 - face plates, 8- *stud bolts* -support, 10-clamp ring, 11-brush, 12-spring, 13-stud bolt, 14-rotor, 15-electric connector.

On the face plate 7 is fasten support with two cl for brushes 11, thrust on the brushes being secured by The face plates are clamp by stu bolts 13. On outer surface of the face pl fast two-pole el tric connector 15.

Assembly of the rotor 1 consists of a shaft, a pack of and a collector. In the grooves of the rotor iron body i insert the ends of which are soldered in into the cogs of collector plates. The rotor is mounted on the face plates on one-row opened ball bearings.

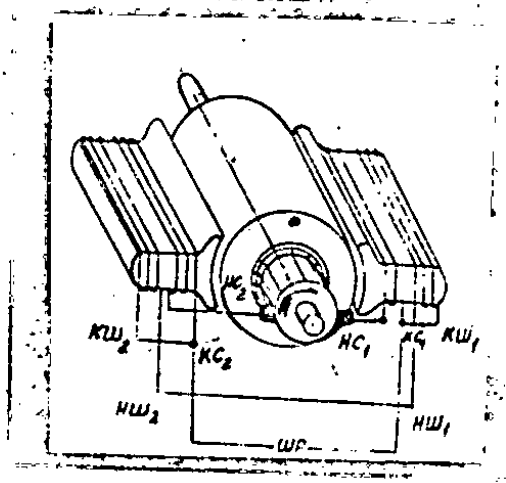


Fig.36. [illegible]

[illegible] Contactor K-3[illegible].

The contactor [illegible] in fig.74/ is an electromagnetic relay and [illegible] the series winding of the starter in the desired [illegible] of engine starting procedure /third stage of starting/. The contactor is counted in the air frame.

8. Storage Battery 12 SAM-28.

As source of electric energy for the autonomous starting of engine in the board storage battery type 12SAM-28, recharged during flight from the d.c. power generator, mounted on the aircraft auxiliaries drive box. The accumulator battery is acid-based, with pressure 24V and capacity 28 A/hours. The storage battery is mounted in the aircraft.

9. Function of the Engine Starting System on Ground.

The engine WK-1F is started by the starter motor ST-2-48W

from the storage battery 12SAM-28, mounted in the aircraft, or from ground sources of energy, used for feeding of this starter. Below is described the function of the system, when the engine is started from the board storage battery /see electric diagram in fig.74/.

Before starting of the engine the switch 31 of ignition should be set into position OFF and the starting selector switch into position "ground". Then turn in the main switch 33, now the "plus" from the mains gets to the starting button, on the clamp /5/ of the electric connector of the starting automat 45 and through connected contacts of the signaller 3 to the warning lamp 35 a. The "minus" of the board mains is connected directly with clamp /6/ of the electric connector of starting automat. The warning lamp will glow. The glowing lamp informs that fuel pressure in the pipeline before the fuel pumps is under 0,3 atm., i.e.below the minimum permissible pressure. In order to increase the pressure it is necessary to engage the fuel booster pump by setting the control switch of the booster pump 40 into "ON" pi[illegible]. The booster pump build up the necessary pressure of [illegible] the pumps /1,1-1,5 atm./ when the pressure in the pipelin[illegible] ceeds 0,3 atm., the warning lamp of pressure switch goes o[illegible]. Only now, not earlier, it is possible to begin with starting of engine. The switch of the booster pump should remain "ON" during all run of the engine. Starting of the engine begin[illegible]ng the starting button 34. Now the "plus" of the mains thro[illegible] starting button is directed to the clamp /2/ of the electric connector, further to the rotor [illegible]-57R, which begins to drive the cam mechanism of timing automat and through the normally connected contacts of the microswitch 1 to the winding of the blocking relay RL-3259. The "minus" is given to the electromotor [illegible]-57R and

to the blocking relay from the clamp /6/ of starting automat electric connector. After engaging of the blocking relay RL-92 the feeding of its winding is performed through its own contacts and therefore connection of the microswitch No.1, which gets in during 1,5 seconds after pushing of the starting button, does not interrupt feeding on the winding of the blocking relay, only transfers it to the clamp /3/ of the electric connector. Through locked contacts of the blocking relay RL-92 the "plus" is directed to the clamps of the microswitches No.2,3 and 4, thus making them ready for further work.

Not later then after 1,8 seconds after pushing of the press-button the contacts of the microswitch No.2 get closed and direct the power through the clamp 4 of the automat to the winding of the main contactor and to the clamp /1/ of the starting automat electric connector.

The main contactor, after having connected its regularly disconnected contacts, connects the starter to the source of electric energy through a resistor of 0,14 OHM, thus securing the first stage of the starting procedure. This stage is intedend to limit the torque on the starter shaft in the beginning of starting, which protects the clutch from sudden blows and consequently from being broken. Limiting of the torque on the shaft of the starter and protection of the clutch from overload is performed by lower voltage on the clamps of the starter by the registor 0,14 Ohm, connected in series with the starter.

Simultaneously with engaging of the main contactor the voltage from clamp /1/ of the starting automat through the starting selector switch and switch of ignition relay is directed to the winding of ignition relay and connects its contacts. The "plus" is led through the melting fuse and through connected contacts

of ignition relay to the ninth clamp of the connector 1). From the ninth clamp of the main electric connector the voltage is directed to the motor of the electric pump PNR-45B, the ignition coil KR-1 and the electromagnets of starting burners. These accessories are on for the whole period of starting. Thus, in the instant of connecting of the main contactor the starter is coupled with the engine rotor, the ignition is ON and the combustion chamber is supplied with fuel, which is being ignited. Further 1,7÷2,3 seconds after connecting of contacts of the main contactor the contacts of the microswitch No 3. of the automat are connected, thus directing the voltage through clamp 5 to the winding of the auxiliary contactor. Now the auxiliary contactor connects its contacts, thus avoiding the resistor. The starter begins to gain rotational speed /second stage of starting/.

3 ÷ 7 seconds after connection of the auxiliary contactor the contacts of the microswitch No.4 of the automat get closed, thus directing through the clamp 1 of the AWP-1W automat voltage to the clamp /5/ of the starting automat electric connector. From the clamp /5/ of the electric connector of starting automat the "plus" is directed to the winding of contactor K-50 "23". The minus is directly connected with the other end of the winding. The contactor /relay/ 21 engages the shunt of the series winding of the starter 1, thus reducing the magnetic field in the poles of the starter, in result of which the starter rotational speed increases /the third stage of starting/. Thus, to the end of starting, calculated to last 42 ± 3 seconds, the starter drives the rotor of the engine at 1000-1100 r.p.m. After passing of 42 ± 3 seconds from pushing the starting button, the cam mechanism of the timing automat accomplishes its full turn and sets the contacts of the microswitches into initial position, thus

switching off the voltage from windings of all contactors, controlling starting of starter. By this the starting procedure is accomplished and the engine begins to tun by its own power. In case of temporary cut-off of the feeding during the starting, the electromotor D-5TR of the timing automat may stop at such position, where contacts of some microswitches are connected. In this case /but for the blocking relay/ after restoring of feeding a full voltage might be directed immediately to the starter, which would cause breakage. To avoid this, the blocking relay is provided in the system /mark RL-92, pos.59/, through the contacts of which are connected winding of all contactors, controlling the starting procedure. The blocking relay, however, is fed only in initial position of the microswitch No.1, as the winding of the relay is connected to the source through the regularly connected contacts of this microswitch. In any other position the relay cannot be engaged. Consequently, after restoring of the feeding and in case of continuing in work of the starting system after such interruption it is necessary to switch on the main switch, the timing automat goes on to accomplish its cycle and sets the cam mechanism into initial position, however, without engaging the contactors, controlling the starting procedure. Only after that a new starting may proceed.

For starting of engine from the ground source of energy it is necessary to turn off the storage battery and to connect to the aircraft connector 42 the ground source of electric energy.

10. Operation of Engine Starting System in Flight.

When starting the engine during flight, the starter and the starting accessories are not engaged. In this case it is necessary to switch on only the ignition and to open way to the starting fuel

into the combustion chambers. It is not necessary to work on the starter, as the rotational speed owing to autorotation will never drop under 1000 r.p.m. For starting it is necessary to set the selector switch of starting into position "airborne", by switching in the by which starting overswitch 31, the voltage will be directed to the winding of ignition relay 27 and same will be engaged. After the ignition relay connects its contacts, voltage will be directed to the ignition coil, to the starting pump and to the starting burners electromagnets and same will be switched on. After switching on of these accessories the starting pump will deliver fuel into the starting burners, the electromagnets of the burners open the way of fuel into the combustion chambers and high voltage current from the ignition coil, directed to the ignition plugs, sets afire the fuel.

After beginning of combustion in the combustion chambers the starting switch must be set into position "Ground", and turn off the ignition, the starting pump and the starting burners electromagnets.

ELECTRIC SYSTEM OF THE AFTERBURNER

The electric system of the afterburner comprises the following accessories, description of which is given below.

1. Electromechanism MG-2

The electromechanism MG-2 serves for remote control of the afterburner and consists of the following assemblies: electromotor D-12ЭГ two-stage reducing gear of planetary type, the contact device, friction clutch, assembled inside the outlet gear, and the electric connector Sm.2ОР.3Г s6. The electromotor D-12ЭГ /fig.85/ is a two-pole electromotor with d.c. feeding, with series winding, closed type, on ball bearings, with flange fastening

The motor D-125W is reversive. Reversing is performed by alteration of the magnetic fields.

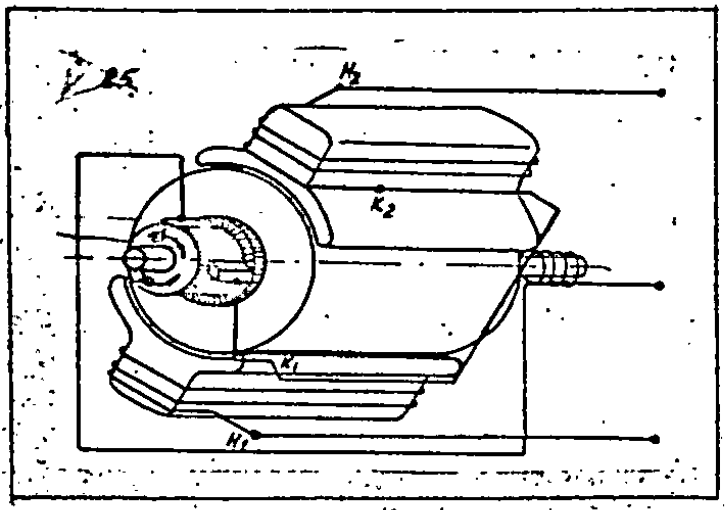


Fig.85. Diagram of the Electromotor D-125W of MO-2 Mechanism.

For this purpose in the engine two independent field windings are provided, engaged alternatively according to which direction of revolution is desired. The direction of current in the winding of the rotor is unchanged, switching over from one field winding to another one is performed by reversing relay RT-40.

The electromotor is provided with a braking electromagnetic clutch, serving for reducing of inertial run of the rotor after switching off the electromotor from the current supply. The coil of the electromagnetic clutch is connected in series into the circuit of the rotor of electromotor. From the electromotor three outlets are let out: one common minus and two plus leads, connected alternatively in dependance on desired sense of rotation. The support of the electromotor is made of tectolite plate, to which are riveted stamped brass clamp rings of the brush holders. In the electromotor are used brushes mark M-6. The reducing gear is two-stage planetar type and serves for multiplying of the torque

and for reducing of the number of revolutions, transmitted from the electromotor to the number, required on outlet shaft of the mechanism. The reducing gear has gear ration 1:1365 and consists of two pairs of gears. On the eccenter shaft 1 /fig.86/ on a ball bearing is placed a double satellite gear. The gear 2 /of large diameter/ is in mesh with immobile gear 3, fastened in the body of the reductor, and the gear 4 /of minor diameter/ is in mesh with the driven bell-like gear 5.

The contact mechanism serves for limiting of angle of turn of the outlet shaft within the desired limits. On the insulating contact panel 6 are placed stand of immobile contacts 7 and those of mobile contacts 8. The mobile contacts are fastened on elastic plate springs with copper conducting plates, fastened to the springs. The springs secure the necessary contact thrust for switching on and rapid disconnection for switching off. On the same springs are fastened the steel teeth 9, insulated by bushes and washers made of textolite in order to prevent connecting of contacts with mass.

The contact springs and also the immobile contacts are fastened to the stands made of phosphorous bronze angles. On the same stands are placed clamps 10 for fastening of leads. On the outlet gear 5 is fastened a cam bush 11. The friction cluth serves for protection against possible mechanical and electrical overloads during service of the electromechanism MO-2. The clutch consists of a set of eight discs 12 with inner splines, and 8 discs 13 with outer splines, filid one be one in turn. The splines of the discs 12 enter the splines of outlet shaft terminal.

On the periphery of the ring 18 are evenly distributed the cylindrical springs 16. The value of torque, at which the clutch

slides, is adjusted by regulation of thrust of these springs, which is performed by nut 15. After the definite regulation of the friction clutch the nut is locked by screw 17. The torque from the outlet shaft of the mechanism through the frictions discs, connected by force of friction, is transmitted to the gear 14, put on freely on the outlet shaft. If the load moment on the gear exceeds the torque, at which the friction clutch slides, the gear remains motionless and the outlet shaft will revolve till the mechanism is turned off.

The electromechanism MG-2 is fastened on stud bolts of oil pump box of the engine.

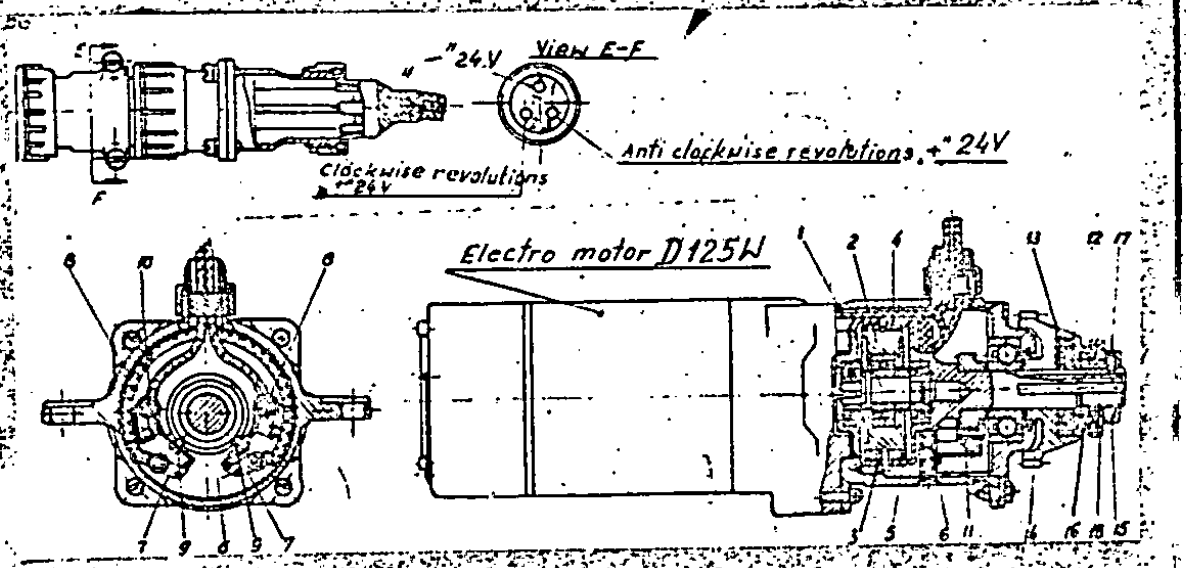


Fig.86. Design of the MG-2 electromechanism.

1-eccenter shaft, 2-gear of larger diameter, 3-immobile gear, 4-gear of minor diameter, 5-driven ball-type /outlet/ gear, 6-contact plate, 7-immobile contacts, 8-mobile contacts, 9-steel teeth, 10-clamps, 11-cam bush, 12-disc with inner splines, 13-disc with outer splines, 14-gear of outlet shaft, 15-nut, 16-cylindric springs, 17-screw, 18-ring.

Principle of Function of the MG-2 Mechanism.

The electrokinetic diagram of the electromechanism MG-2 is shown in fig.37. The elektromechanism MG-2 is switched on into the circuit by means of an electric connector. Starting and reversing of the mechanism is performed by means of relay RT-40. When the electromechanism is connected to the network, in the same time the electromagnetic clutch is switched on, thus unbreaking the rotor of the electromotor. The revolutions from the electromotor shaft are transmitted to the eccentric shaft. The latter, while revolving in bearings, drives the satellite gear which rolls on the immobile gear. The other satelitte gear, made as one piece with the first one, rolls on the bell-like gear and makes it to turn. By means of the friction clutch the torque is transmitted from the shaft of the bell-like gear to the outlet gear. The outlet shaft of the mechanism can occupy two end positions. Stopping of the mechanism is secured automatically by means of the contact device described above. When the outlet shaft revolves, the cam bush revolves with it. The teeth of the contact springs slide on the cam and after having reached the sloping profile of the cam they fall down and the contacts get apart. When the cam revolves in opposite direction, the sunk tooth is elevated on the same pfofile and connects the contacts.

Technical Specification of the Electromechanism.

Nominal voltage 26 V. Range of working voltage 23,4÷28,6V Maximal load torque on the outlet shaft — 20 kgcm. Intensity of current at nominal voltage on the clamps of the electromotor and the maximum load torque: max.7,5 A. Angle of displacement of the outlet shaft is $190^{\circ} \pm \frac{12^{\circ}}{5^{\circ}}$. Running order of the mechani

repeated short time, consisting of 20 runs, then full cooling. As "run" is meant a turn of the outlet gear from one extreme position to the other, 10 seconds interruption.

NOTICE: It is precissible to switch on the mechanism five times without interruption with obligatory coolin down after that.

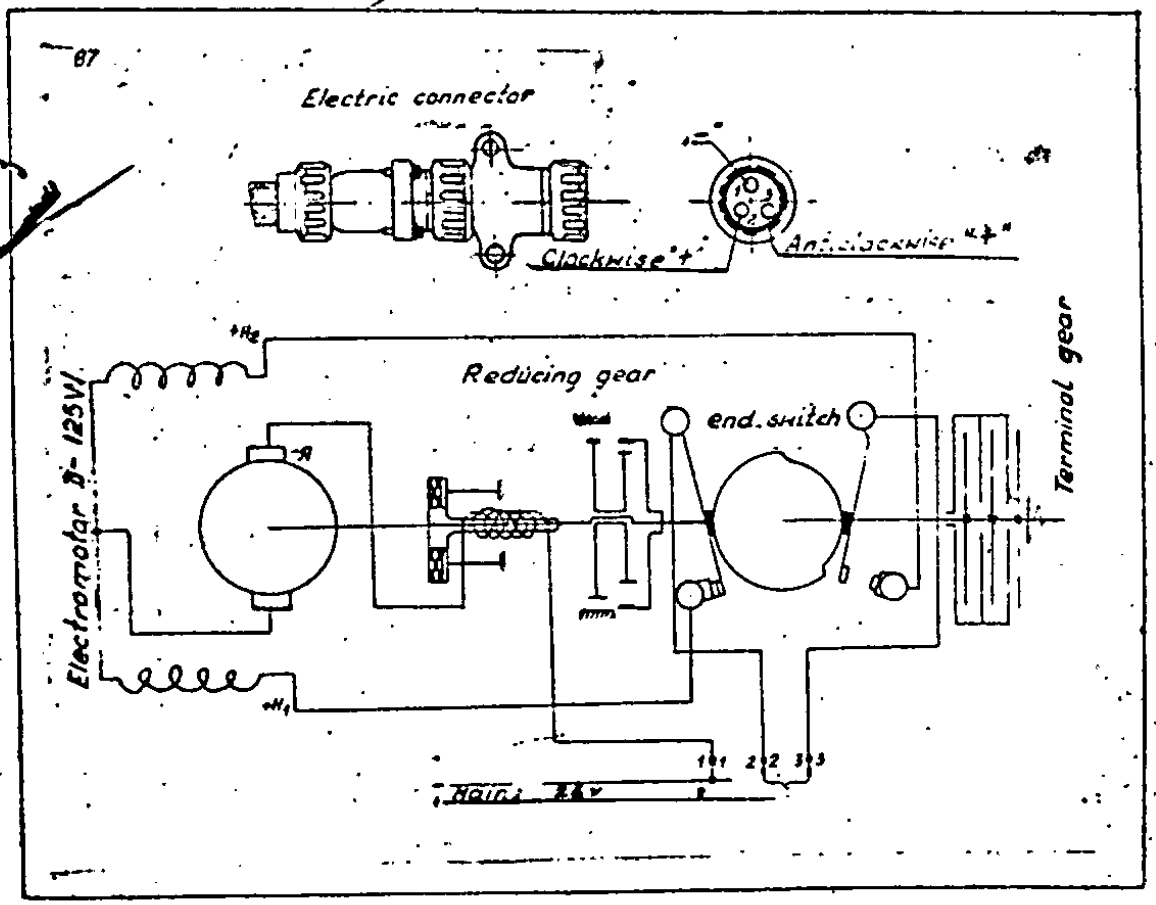


Fig.87. Blecktrokinematic Diagram of the Electromechanism MC-2.

2.Reducing Gear.

The reducing gear of the electric drive serves for transmission of the torque moment from the mechanism MC-2 to the fuel distributor ARI-144. Gear ratio of reducing gear is 2:1. The reducing gear consists of the following parts /fig.88/: driving pinion 1 with number of teeth 13, driven bevel gear 2 with 26 teeth, dur-

aluminum body, consisting of two halves: the upper one 3 and lower one 4, interconnected by bolts 5 and tang 6. The driven gear 2 is fastened on the terminal of the slide valve shutter of ART-14A valve. The driving pinion 1 is fitted in a tang 6, which revolves in a bronze bush 7, pressed in into the body. The driving gear /pinion/ with the tang are connected by a T-shaped bolt 8. Clearance of meshing of gears is regulated by washers 9.

The reducing gear is fastened on three stud bolts of ART-14A distributor flange. The tang of the reducing gear is connected by a cross-like duralumin washer 10 with the duralumin clutch 11, which has a splined connection with the outlet gear of the electromechanism MG-2. The axial travel of the clutch 11 is limited by stop ring 12. The splined connection of the clutch with the outlet gear of the electromechanism serves for setting of the afterburner system initial position. The position "closed" /afterburner off/ is checked by alignment of marks, written on the clutch and flange of the MG-2 mechanism.

c. Afterburner switch.

The afterburner switch, [illegible], serves for engaging and disengaging of ignition of the afterburner and for controlling the hydraulic drive of controllable jet nozzle. The switch is fastened on the rear flange of ART-14 distributor body. The shaft of the switch is connected with slide valve shutter of ART-14A distributor and when shaft turns the switch turns by the same angle. On the shaft are fastened segments, which with turning of shaft switch on the microswitches, which connect the feeding circuits of the starting ignition coil and of electrohydraulic valve electromagnet. For switching on, the shaft of the switch must revolve in clockwise direction /if observed from the side of ART-14A/

The main assemblies of the switch are: body, angle, shaft with segments, block of microswitches with levers and cover /see fig.88/.

The body 1 of the switch has three holes for fastening of the switch to the fuel distributor AR1-14A. In the flange of the body are screwed in two stud bolts 2, serving for fastening of the cover, and in the middle part of the body is pressed in a bush 3, which serves as bearing for the shaft with the segments.

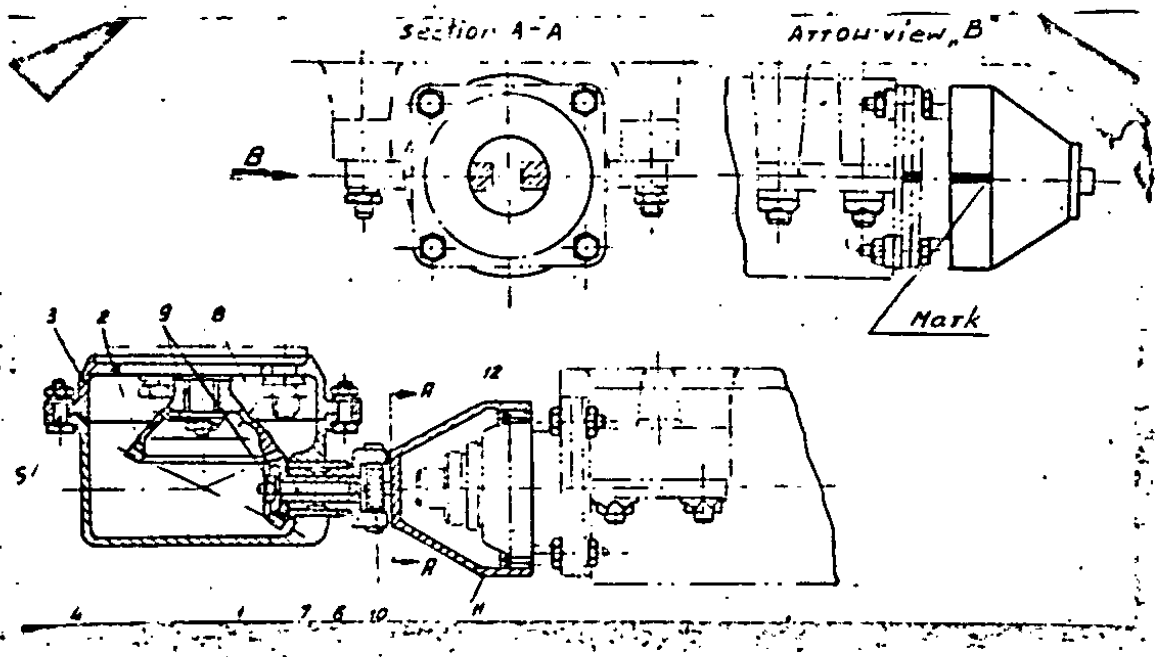


Fig.88. Reducing Gear.

1-driving conical gear /pinion/, 2-driven bevel gear, 3-upper part of body, 4-lower part of body, 5-bolt, 6-ring, 7-bush, 8-T-shaped bolt, 9-regulating washer, 10-cross-shaped washer, 11-clutch, 12-stop ring.

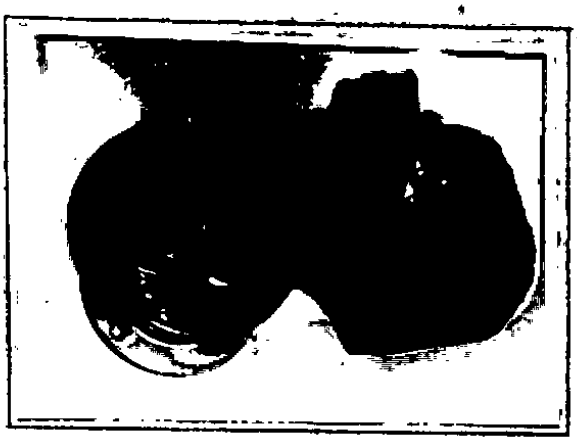


Fig.89. General View of Afterburner Switch.

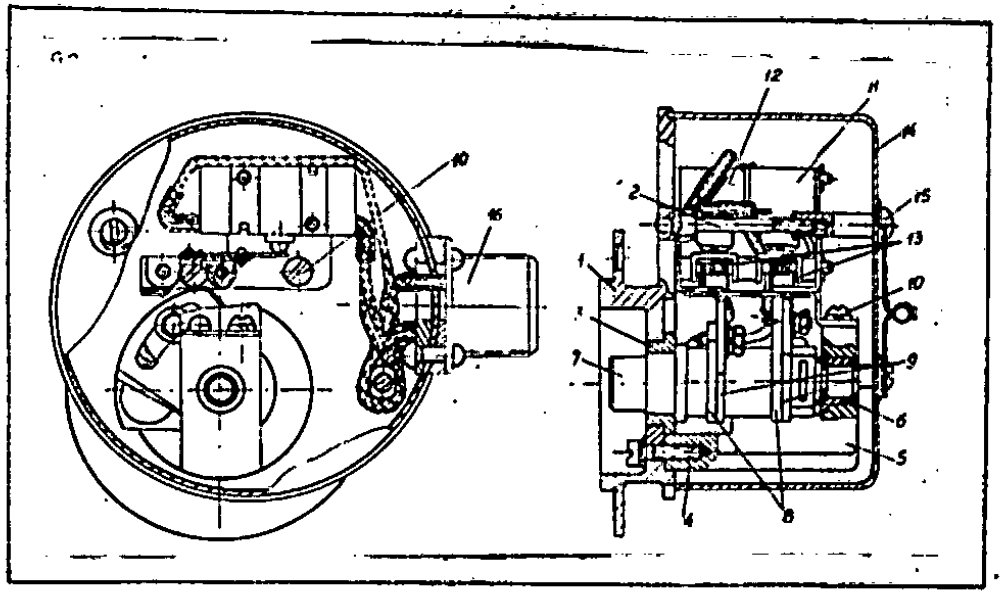


Fig. 90. Design of Afterburner Switch.

1-body, [illegible] bolt, 3-bush, 4-screw, 5-angle, 6-bush, 7-shaft, [illegible] segments, 9-mobile segments, 10-screw, 11-micro[illegible] position system, 12-microswitch of hydraulic drive [illegible], 13-levers, 14-cover, 15-special nut, 16-electric connector.

[illegible] to the body by means of the screws 4 is fastened an [illegible], [illegible] bush 6 is pressed in, serving also as bearing for the shaft with the segments.

The shaft 7, revolving in bushes of the body and angle, has two immobile segments 8 and two mobile segments 9, which are set for a certain angle of engagement beginning of the microswitches. By the screws 10 to the body and to the angle is fastened a block of microswitches, which consists of a microswitch 11 of afterburner ignition system, of the microswitch 12 controlling the regulable jet nozzle hydraulic system and further levers 13, by which the motion of the segments 9 is transmitted to the buttons of the microswitches 11 and 12. The cover 14 serves for protection from mechanical damaging and from access of humidity and oil ect.into the inner part of the switch. By special nuts 15 the cover is fastened to the stud bolts of the body. On the cover is fastened an electric connector 16, serving for connection of the switch with the accessories, controlling the engaging and disengaging of the afterburner.

4. The Starting Coil KPM-1A.

The starting coil serves for inverting of the direct current of low voltage into pulsating current of high voltage.

Nominal data:

Voltage of primary winding: 24 V

Current intensity of primary circuit: 2 A

Voltage of secondary circuit from the KPM-1A, led to the spark plug must secure a continuous discharge between the electrodes of the spark plug at a clearance of 1,8 $\pm$ 0,1 mm both on ground and during flight up to 18000 metres.

The starting coil /fig.91/ consists of a body 1 and cover 2, which is fastened to the body by four bolts 3. Inside the body is mounted an induction coil 4 and capacitor 5, from the outer side of the body by four screw 6 is screwed on an electric connector

SzR16U2ESx5 and to the opposite wall is rivetted a neck 8 for screening of the electric lead of high voltage, running to the spark plug of the air charger. Inside of the coil 4 is a core. On two stud bolts 9 of the coil body is screwed on a copper plate 10, into which an immobile contact of the interrupter is screwed in. By the immobile contact the gap between the interrupter contacts is regulated. For checking of the contact in the housing holes are provided, overlapped by flap 12.

The body of the starting coil has four holes "a" for fastening of the starting coil on the aircraft framework. The electric diagram of the starting coil is shown in fig. 92.

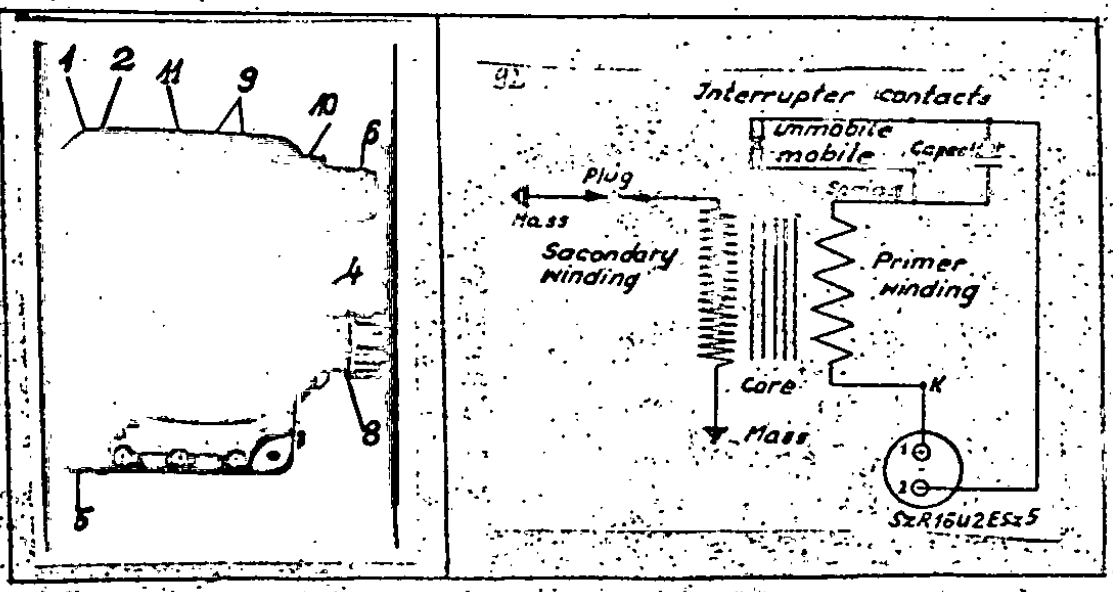


Fig. 91.
Starting Coil KP-1A.

Fig. 92.
Electric Diagram of the Starting Coil KP-1A.

1-body, 2-cover, 3-bolt, 4-induction coil, 5-capacitor, 6-screw, 7-electric connector, 8-neck for screening of the conductor to the spark plug, 9-stud bolt of the body, 10-copper plate, 11-immobile contact of the interrupter, 12-flap, a-hole for fastening of the coil in the aircraft frame work.

5. Spark Plug SD-92

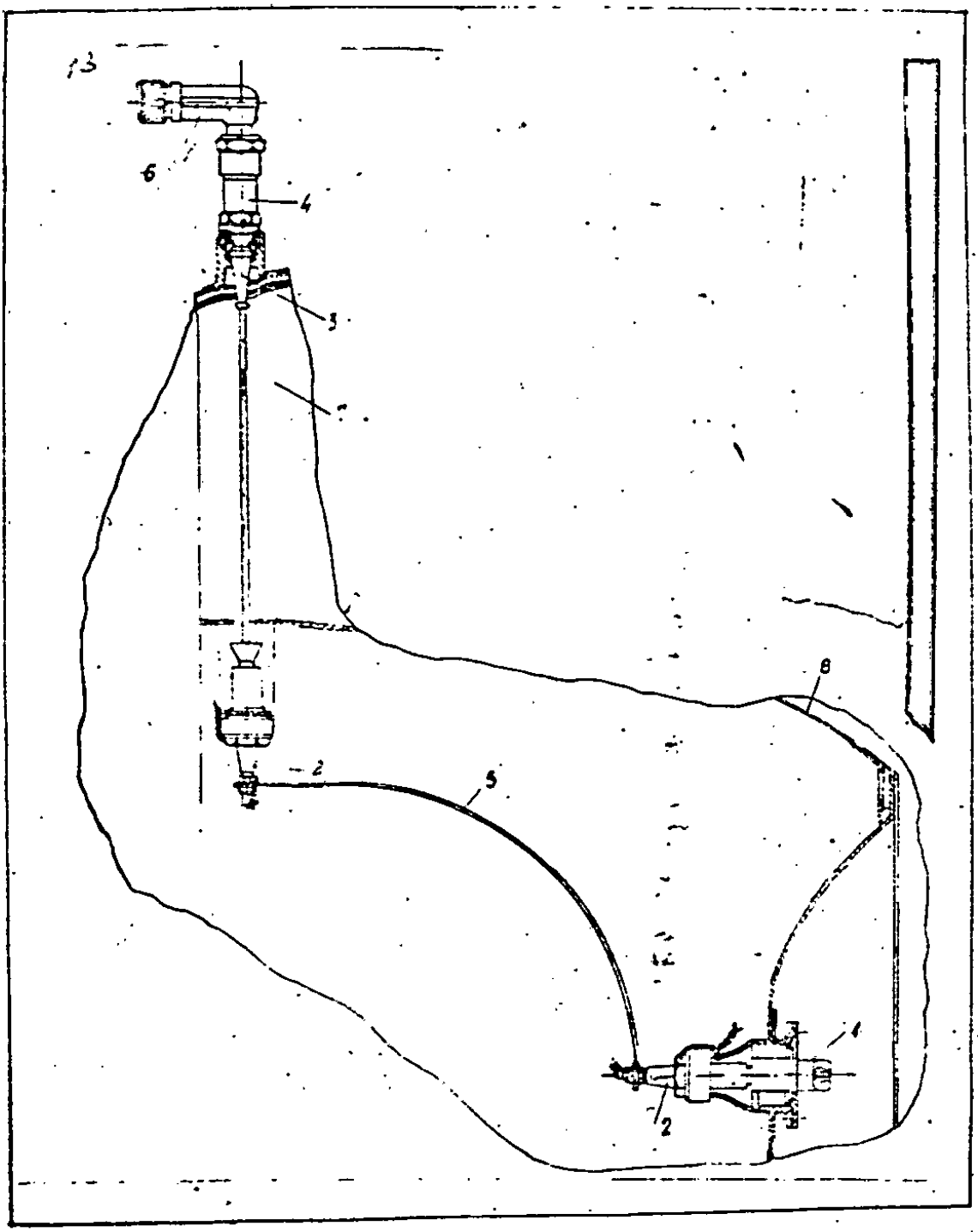
The spark plug serves for ignition of fuel in the afterburner. The central electrode of the spark plug is made of a stem, enclosed into a ceramic insulator. The side electrodes of the spark plug are made as one piece with the spark plug body. The body and the central electrode of the spark plug are made of heat-resistant steel. The spark gap equals 1,8 ± 0,1 mm. The spark plug is fastened in the centre of the afterburner inner cone bottom /see fig.93/. High voltage is led to the spark plug from the ignition coil IPM-1A through a high voltage screened lead, through a screened elbow SB-09-4, screen 259-A, through the metallic stem of the ceramic insulator IP-02, placed in the firing of the afterburner, and through metallic stems of insulators IP-01, placed in the inner cone of the afterburner. The metallic stems of the ceramic insulators IP-01 are connected by a conducting strip, made of heat resistant steel.

6, MR-2 relay

The electromagnetic multicontact relay MR-2 /fig.94 and 95/ serves for simultaneous engaging and disengaging of some d.c. ourcuits. The relay is designed for changing of rotating sense of electromechanism MI-2. It is mounted on the board of the aircraft.

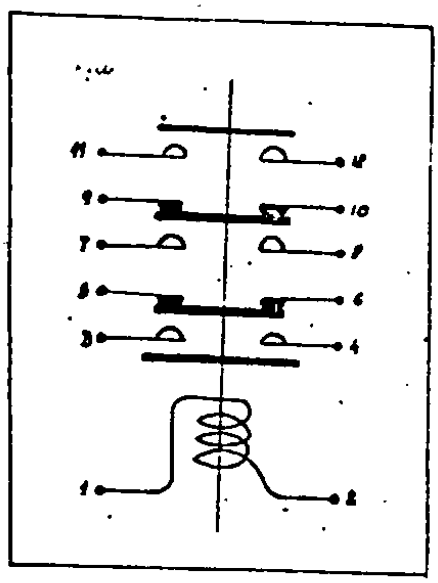
Nominal data of the relay :

1. Voltage . . . . . 27 V
2. Current intensity . . . . .
   a/ on the main clamps at the real loading . 15 A
   b/ on the main clamps at the inductive loading L/R = 0,02 sec. . . . . 10 A



Pog. 93. Design of Afterburner Ignition Assembly.

1- ignition plug SD-92, 2- insulator IP-01, 3- insulator IP-02 4- screen with lock50- 554, 5- conducting strip, 6- screening elbow UE - 09 - 4, 7- fairing, 8- inner cone.



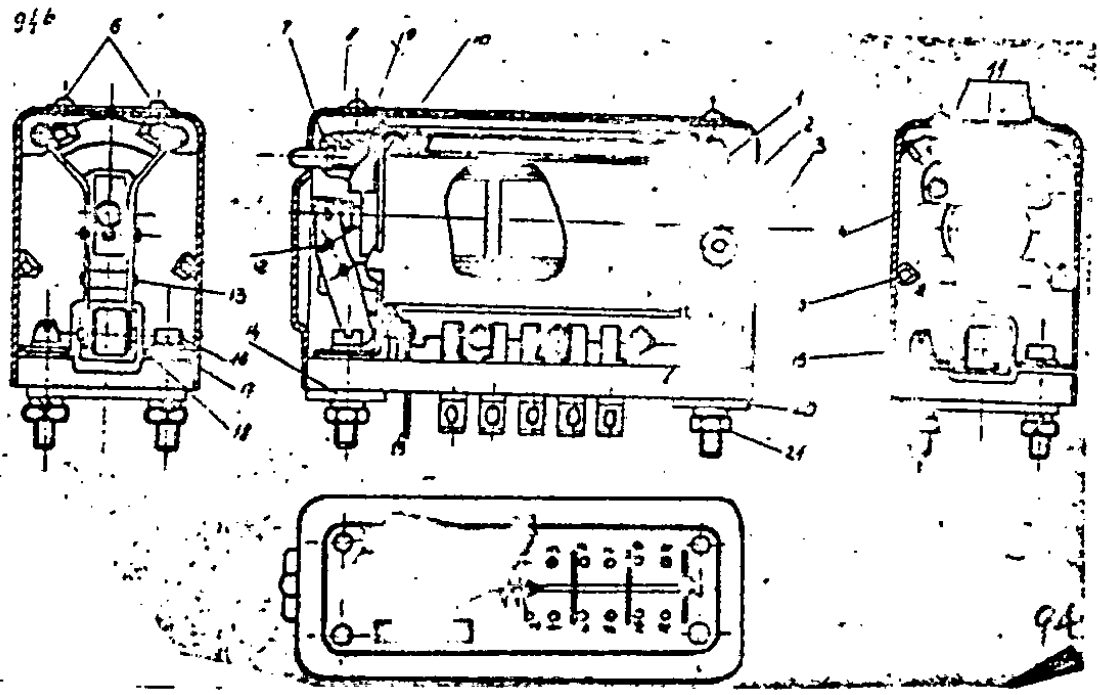


Fig.94b. Design of the MT - 2 relay.

1- Electromagnet body, 2- mobile lever of the relay, 3- contact plate, 4- lock, 5- cover, 6- spring, 7- lock, 8- bolt, 9- spring, 10- distance ring, 11- screw, 12,13-cable, 14- washer, 15- screw, 16- screw, 17- spring washer, 18- adjusting washer, 19- contact bolt. 20- washer, 21- nut.

7. Microswitch Type KW-6A.

As microswitch of afterburner 41, mounted on a special stop of the engine control lever, and microswitch 43, coupled with the engine control lever / see the electric diagram in fig 74/, the microswitches type KW-6A are used.

The microswitch /fig.95/ consist of a plastic mass body 1, cover 2 and lock 3, which connects the body with the cover, of four immobile contacts 4 and two mobile contacts 5, mounted on the contact bridge 6, of return spring 7 and of button 8.

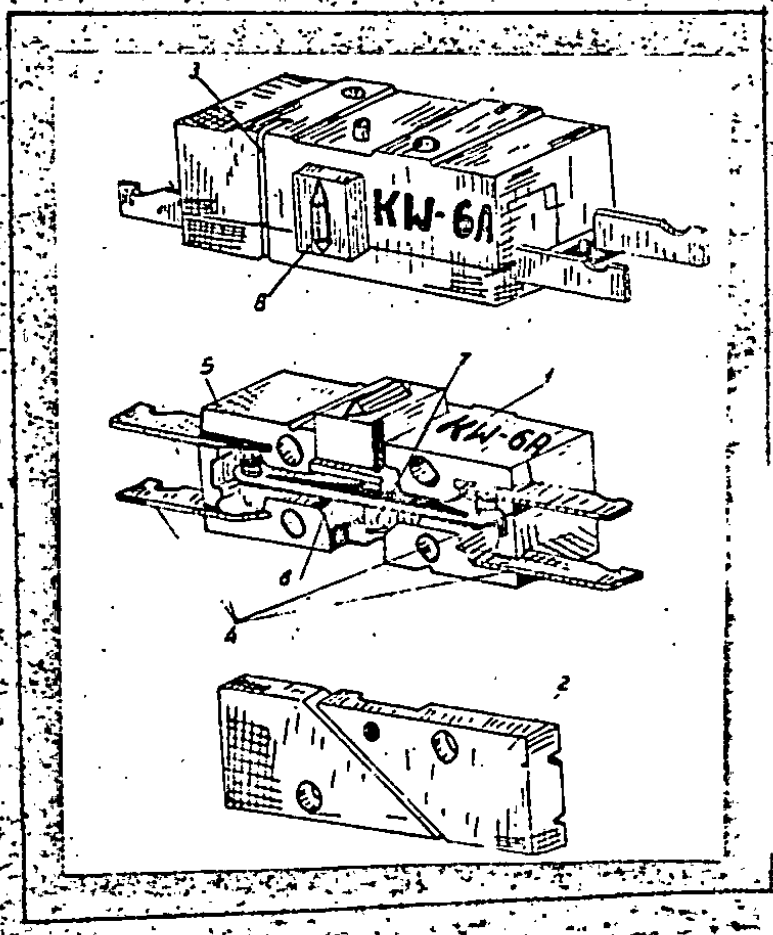


Fig. 95. Microswitch KW-6A.
1- body, 2- cover, 3- lock, 4- immobile contacts, 5- mobile contacts, 6- contact bridge, 7- return spring, 8- button.

8. Electrohydraulic valve GA-15u/3

The electrohydraulic valve arranged the aircraft hydraulic system, is a two position slide valve with electromagnetic control /pilot electromagnet/ and serves for engaging into operation of the power jacks controlling the opening and closing of the adjustable jet nozzle.

9. Operation of the Electric system of the Afterburner

For switching of the afterburner it is necessary to switch on the main switch of afterburner 39 /see Fig.74/ which is simultaneously serving as circuit breaker /switch 40 is switched on during starting/.

Operation of the afterburner is started by switching on of the microswitch 41. The "plus" of voltage, having passed through switches 40 and 3. and through the connected contacts of the microswitch 41, is directed into the winding of the relay 36 which connects its regularly disconnected contacts.

Simultaneously with switching on of the microswitch 41 the "plus" of voltage is directed to the relay of the booster pump, which switches over the fuel tank booster pump /by increasing its rotational speed/ to higher output. With switching on of the relay 36 - "plus" passes through its connected contacts and through the control device of the electromechanism and gets to the motor of the electromechanism 14.

Simultaneously the attraction winding of the [illegible]-2 relay is feeded from the main [illegible], independently from the microswitch 41.

The electromechanism starts to open the slide valve shutter [illegible] through the channels of which the fuel runs to the burners of the afterburner system, and to turn the switch 15 by a certain angle, successively changing its microswitches.

Approximately one second after switching of the microswitch 41, the electromechanism turns the shaft of the switch by 7° and switches on the microswitch 1.

Through the connected contacts of the microswitch I the "plus" of voltage runs to the starting coil 16 and engages come into operation.
The high voltage current from the starting coil is directed to the ignition plug of the afterburner /17/, which afired the fuel mixture in the afterburner chamber.

Contemporary is the excitation winding of the relay 55 feeded and the certainly open circuit will close. The excitation winding of the relay 61 is also feeded, whereby the circuit which at switching on of the afterburner should be closed, will close.

2-2,5 seconds after switching on of the microswitch 41 the electromechanism turns the shaft of the switch by 32° and switches on the microswitch II. Through the connected contacts of the microswitch II the "plus" is directed to the electromagnet of the electrohydraulic valve 37.

The electrohydraulic valve sends pressure into the working chambers of the hydraulic cylinders /power jacks/, the pistons are shifted to the extreme position thus releasing the gills of the controllable jet nozzle, which under pressure of discharged exhaust gasses go apart.

In case when the electrohydraulic valve 37 not acts /is no current/ contacts of the signalisator 62 closes the circuit by means of excitation winding of the relay 60, feed-circuit of relay 56 is interrupted, whereby switching on of the afterburner is impossible - then emergency switch valve 9 will automatically switched off.

Further 3-5 seconds after switching on of the microswitch 41 the electromechanism turns the shaft of the switch by 73°; the microswitch I disconnects the circuit of the starting coil 16, in result of which the starting coil interrupts its operation and high voltage pluses cease to be directed to the electrodes of afterburner ignition plug.

Relay 55 goes in its top, certain position the upper contacts are closed.

5÷6 seconds after switching on of the microswitch 41 electromechanism turns the shaft of the switch by 90° opens completely the channels of the slide valve shutter ART-14A and stops.

Now the microswitch II does not disconnect the circuit of the power jack electrohydraulic valve and conseguently, the gills of the controllable jet nozzle remain in opened posiotion.

The circuit of return operation of the electromechanism is connected in this instant by the contacts device without, however, being fed for return operation, as the regularly connected contacts of the relay 36 are disconnected. The microswitch 41 remains ON for the whole period of operation of the afterburner.

For disengaging of the afterburner it is necessary to disconnect the contacts of the microswitch 41 and 43 by shifting of the throttle lever 53.

During time period between switching off the microswitch 41 and switching off of the microswitch 43 engine rotational speed and switched on afterburner can be stabilize in a range from 11560 r.p.m. to 10870 r.p.m. When the microswitch 43 is switched off then follows the feed circuit interruption of windings of relays 36 and 31.

The booster pump runs with normal, for the engine reguired output. Relay 36 closes one contacts pair and opens the other one. Electromechanism runs accordingly backwards. It opens the valves of the ART-14A unit and closes the gills of the adjuStable jet nozzle.

The microswitch I, engaging the ignition, gets now engaded during return operation of the electromechanism and the microswitch II, switching on the electrohydraulic valve, is switched off 2,5 ÷ 4,5 seconds after switching off the microswitch 41.

The electromechanism is stopped because the contact device has disconnected the circuit of the motor of the electromechanism. The contact device will be in initial position now.

When in effect of failure function of the valve 37 appears closing of the adjustable jet nozzle during afterburning then automatically afterburner is emergency - switched off, which is announced by the signal lamp 35b.

In case of failure of the electromechanism 14 when the afterburner has to be switched off, it is necessary to switch the switch 44, which directs the "plus" voltage to the electromagnet of the emergency valve of the fuel pump PN-14A. The emergency valve operates and shifts the fuel pump PN-14A into position of minimum ouput by which after/burner is practically off.

Operation of the power jacks may be chacked without engaging the microswitch 41. For this purpose the switch 38 is to be switched on. With switching on of the switch 38 the "plus" voltage passes through the connected contasts of the switches 39 and through the connected contacts of the blocking microswitch 43 goes to the electromagnet-winding of the electrohydraulic valve 37.

The electrohydraulic valve sends pressure into working chambers of power jacks, shifts the rods of the pistons into terminal position and thus it releases the gills the controllable jet nozzle.

In case that for any reasons the switch 38 after switching on of the engine control lever 55 towards increase of rotational speed the microswitch 43, blocked up with the control lever disconnects the circuit, feeding electromagnet of the electrohydraulic valve, which changes its position of closed gill of the controllable jet nozzle.

FEEDING SYSTEM OF THE AIRCRAFT BOARD MAINS

The feeding system of the aircraft board mains consists of the following accessories, description of which is given below :

1. Power Generator Type GSR-3000 or GSR-6000.

The power generator serves feeding of the electric board mains of the aircraft and for rechaging of the storage battery 12SAM-28. It is driven from the engine rotor through the aircraft auxiliaries drive box. The GSR-3000 power generator is a shunt-wound direct current dynamo / fig. 96/ with wide range of

working revolutions. The power generator is seated on closed bearings, has a fastening flange, is screened and is driven through a torque shaft. The generator is cooled by blowing through by a stream of unheated air from dynamic pressure. Quantity of air, pumped through the generator, should be minimum 40 litres per sec, which corresponds to a static pressure of air on the inlet pipe branch of generator 150 mm. water column.

The power generator has four poles and has four additional poles. Sense of rotation - to the left, if observed from the side of drive shaft, and is designed for normal operation up to 15000 metres at ambiet air temperature from 60 degree Centigrade below zero to + 50 degree above zero and at a relative humidity of air up to 98 per cent.

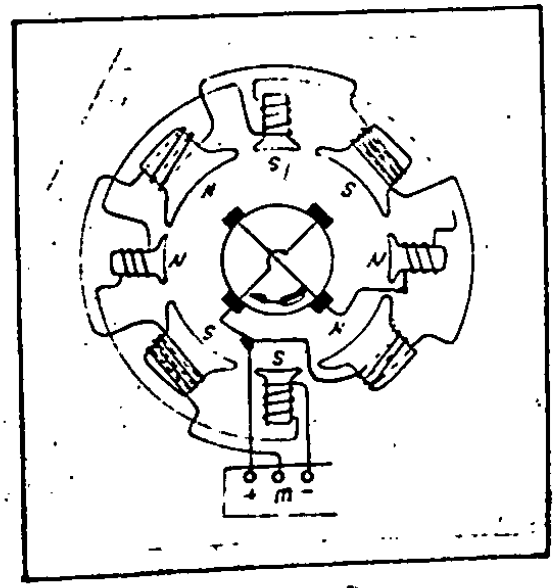


Fig. 96. Electric Diagram of Connections in Generator GSR - 3000.

Technical Data of the Generator.

Nominal voltage	28,5 V
Output	3000 W
Nominal load current	100 A
Rotational speed/ range of rotational speed/	4000-9000 r.p.m.
Order of service	continuous
Maximum permissible current within range of 5000-8000 r.p.m.	150 A
Maximum ten seconds load within range of 5000-8000 r.p.m.	200 A
Maximum persmissible load current without blowing through for 30 minutes	30 A
At rotational speed 3400 r.p.m. and voltage 28,5 delivered current minimum	30 A
Working ability at rotational speed 4000-8000 r.p.m. and load current 100A	continuous

For the generator are used four brushes mark MGS-7 with dimension 7,5x25x25 mm.

D e s i g n

The generator /fig.97/ has a round flange with six holes for fastening stud bolts. The rotor of the generator is driven by a torque shaft 1, the outer end of which has sixteen grooves for coupling with the aircraft auxiliaries drive box. The other end of the torque shaft is conical and has a wedge and is fastened from the side of commutator in the front part of the holow shaft of rotor 2 by nut 3. The torque shaft damps the gusts caused by dynamic loads.

The generator consists of the following assemblies: body, rotor with commutator, face plate and branch. The face plate of the monoblock has a round flange with six holes for the fastening stud bolts of the aircraft auxiliaries drive box. The outer surface of the body is zinc coated and has ribbing, increasing the

cooling surface. To the body by means of screws 5 and 6 are fastened the main poles 7 and additional poles 8 with coils 9 and 10. The screws 5 and 6 are locked by centre punch in grooves.

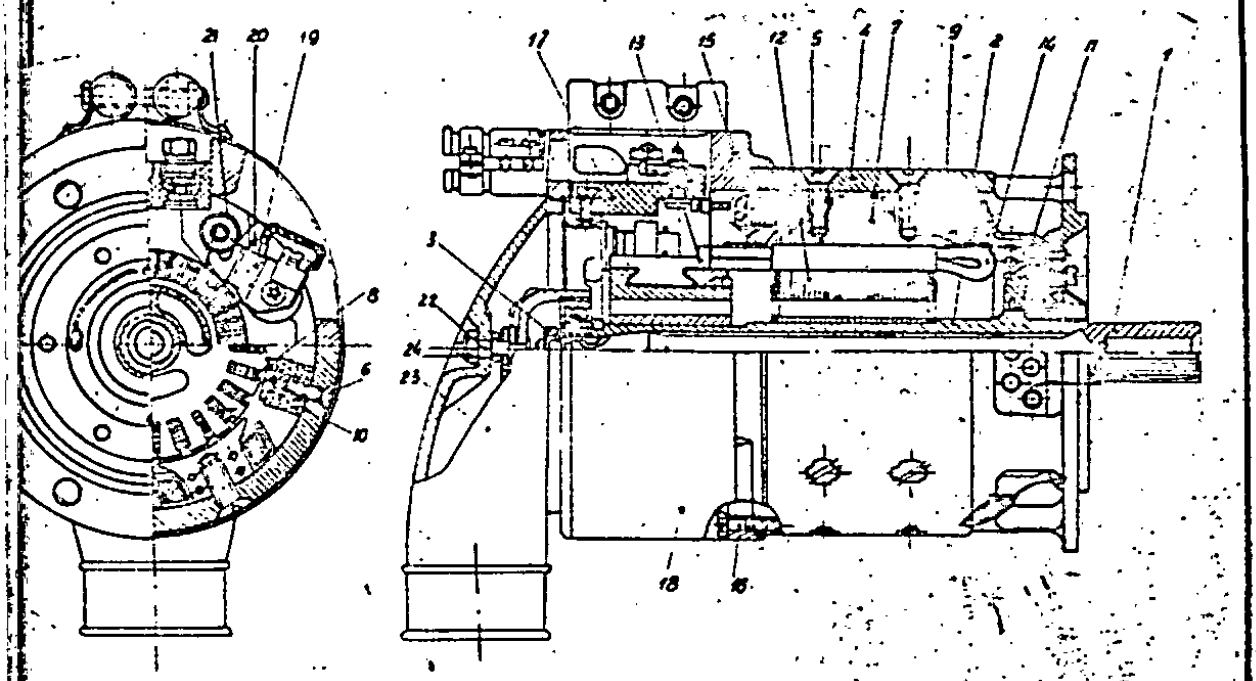


Fig. 97. Desing of the Power Generator.

1- torque shaft, 2-hollow shaft, 3- nut, 4- body, 5-6- screws, 7- main poles, 8- auxiliary poles, 9- shunt winding, 10-winding of additional poles, 11- jacket, 12- pack of rotor, 13- commutator, 14- winding of rotor, 15- face plate, 16- bolt, 17- terminal box, 18 protecting strip, 19- clamp of brush holder, 20- brush, 21- spring, 22- stud bolt, 23- pipe branch, 24-selflocking nut.

The main poles 7 are sheet built, the additional 8 are compact, being made of ARMCO iron.

The winding 9 of the main poles 7 /shunt / is made of round load mark PEW-2 and is soaked by special substance for securing a reliable operation and resistance in humidity.

The winding 10 of the additional poles 8 is made of bare copper mark MM with insulation between the turns and the pole. In the body 4 from the side of the flange are provided windows, serving for outlet of cooling air from the generator. In order to prevent foreign matters from intruding into generator body the windows are covered from inside by jacket 11 with holes. The jacket is riveted to the face of the monoblock. The pack of the rotor 12 is assembled of single sheets of electrotechnical steel and is pressed on a hollow shaft 2. In the pack of the rotor there are vent holes, through which blows the cooling air.

The grooves of rotor pack have rectangular form and are half opened. There are 25 grooves. The shaft 2 is hollow and in the place where the pack 12 and commutator 13 are placed, it has a longitudinal ribbing, preventing the pack and the commutator from sliding. Inside the hollow shaft 2 is inserted the torque shaft 1. The winding of the rotor 14, made of condustor copper mark PSxD is soaked by bakelite lacquer. The ends of the sections of the rotor winding are soldered to the cogs of the commutator plates by pure tin mark 02. For protection against untwisting of the rotor winding on its face parts are placed wire bindings. The rotor is balanced dynamically by soldering of pure tin on the binding.

The commutator 13 consists of 75 commutator plates, insulated from each other by plates of mica "muscovite" 0,5 mm thickness. The commutator plates are collected on a metal bush fastened on the cast aluminium cross-piece and are fastened by a washer and nut, which is screwed on the bush. From the bush and washer the commutator plates are insulated by micanite. The commutator 13 is pressed on the hollow shaft 2. The rotor is set and revolves on ball bearings of closed type, in which is provided greasing

already in the producer's plant, producing the ball bearings.

The face plate 15 from the side of the commutator is cast of aluminium alloy and is fastened to the body 4 by means of bolts 16, screwed in into the body. For protection against corrosion the face plate is anodized. In the face plate 15 is provided a boss, serving for placing of the terminal box 17 made of plastics and having three contact bolts.

The windows, placed in the face plate 15 and the terminal box 17 are covered by a protecting steel strip 18. The clamp rings of the brush holders 19 are fastened by means of screws to the face plate 15. From the face plate 15 and from screws the clamp ring of the brush holders 19 are insulated by textolite insertions and bushes. The clamp rings of the brush holders 19 are made of brass by stamping. Thrust on the brushes 20 is 1000 ± 50 grams and is developped by spiral steel springs of clock type 21.

To secure the necessary value of thrust on the brushes it is possible to regulate the thrust by means of turning of the bush, on which is placed the spring 21, after which the bush must be fastened on the pin of the brush holder by pegs. On the face plate 15 is fastened by nobbling a stud bolt 22, serving for fastening of the pipe branch 23.

The pipe branch 23 is made of aluminium alloy and is fastened to the face plate 15 by means of a stud bolt 22 and a self-locking nut 24. On the pipe branch 23 is put a hose, through which is delivered the cooling air from outside the aircraft. For protection against corrosion the pipe branch 23 is anodized.

2.Voltage Regulator R - 25A

The carbon pile voltage regulator R-25A automatically operating serves for maintaining of a constant value of voltage of

the generator at varying load and rotational speed.

Technical Data

Nominal voltage	28,5 V

The regulator works in the following conditions :

a/ ambient air temperature	from - 60°C to + 50°C
b/ altitude	up to 15000 metres
c/ relative humidity of ambient air	up to 98 per cent
d/ vibration of fastening points with frequency 30-60 1/s at overload	up to 4 g
e/ short time shock with frequency from 30 to 100 shock per minute at overload	up to 4 g

Range of voltage, maintained by the regulator at varying rotational speed of the generator in the working range and at varying load from zero to nominal value is 2 Volts and in conditions, stated sub a,b,c,and d, the range is 3 Volts.

Limits of regulation of the voltage by the rheostat of the regulator from the initial position /marked by a line on the rheostat/ is + 1,5 V or - 3,0 V. Maximum absorded output in the carbon pile 3AR-1A exceeds not 85%. The resistance of the carbon pile at thrust 5 g is minimum 30 Ohms, at thrust 5 kg - maximum 0,2 Ohm. Variation of height of the carbon pile by change of thrust from 5 g to 5 kg is 0,30 mm.

Principle of Function of the Regulator

The regulator consists of two main elements :

a/ electromagnet, feeling the voltage variation of generator /sensitive element of the regulator/.

b/ carbon pile, changing its resistance and controlling thus the values of exciting current of the generator /executive member/.

Mutual action of the electromagnet and carbon pile is effected through the armature of the electromagnet.

The elementary diagram of the carbon pile is shown in fig.98.

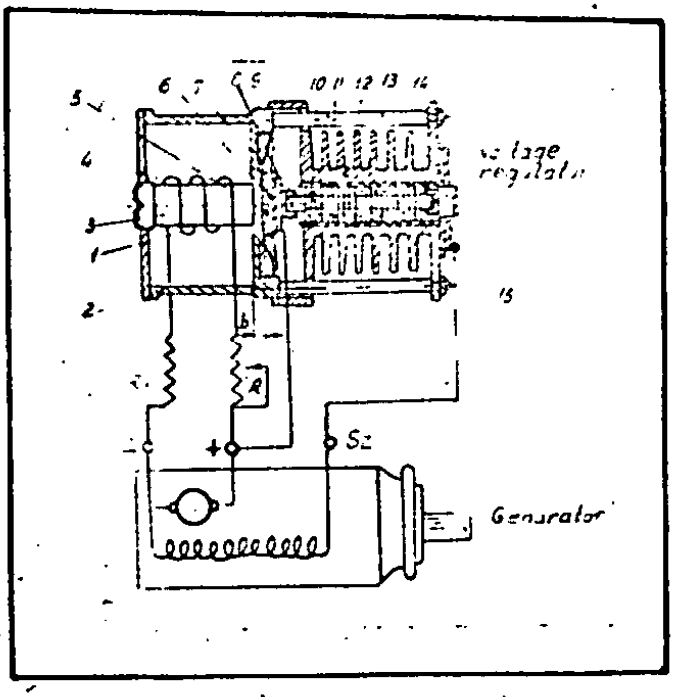


Fig.98. Diagram of the Carbon Pile Regulator

1- winding of the electromagnet, 2- body, 3- core, 4- cover, 5- armature, 6- flat springs, 7- cone ring, 8- carbon contact, 9- holder, 10- carbon pile, 11- ceramic tube, 12- ribbed body, 13- stands, 14- carbon contact, 15- regulating screw, 16- flange, R- rheostat, R_1- resistor of thermal compensation, b-air space.

The winding 1 of the electromagnet, enclosed in body 2, is connected to the terminals of the generator through resistor of thermal compensation R_1 and regulating resistor R. The core 3 of the electromagnet is connected by its threaded part with the cover 4. Turning of the core in the body allows to adjust the air space "b" between the face of the core and the armature 5. Against attraction of the armature 5 to the core of the electromagnet are opposed the flat springs 6, fastened rigidly on the armature and leaning on a diamagnetic conical ring 7, placed in the seat of the body 2.

On the carbon contact 8, placed in the holder 9 of the arma-

ture, leans the face of the carbon pile 10. The carbon pile 10, consisting of a set of thin carbon plates, is enclosed in insulating ceramic tube 11, fastened in a ribbed body 12. The body 2 of the electromagnet and the ribbed body 12 of the carbon pile are mutually connected by steel stands 13. The opposite end of the carbon pile leans on the other carbon contact 14, fitted in the regulating screw /holder/ 15, which is fastened in the flange 16 of the body 12. The carbon contacts 8 and 14 are insulated from the body and armature of the regulator. When the regulating screw 15 is tightened into the flange 16, the carbon pile 10 is compressed between the contacts 14 and 8 and is exposed to pressure developped by the springs of the armature in bent state. The carbon pile in such state is a resistor, the value of which is variable and varies by changes of thrust, developed by the armature of the electromagnet. The carbon pile is connected in series the circuit of the shunt winding of generator exciting.

When the regulator operates with a generator and the voltage of the generator exceeds the desired value, the electromagnet attracts the armature to the core by which the thrust on the carbon pile is increaseed and the exciting current of the generator drops and consequntly the whole voltage drops to the desired value. Just opposite, when voltage of the generator drops to the desired value, the armature of the electromagnet goes apart from the core, pressure on the carbon pile increases and resistance of the carbon pile drops, the exciting current is increased and voltage of the generator reaches the desired value.

In the carbon pile regulator on the armature of the electromagnet the following forces are acting: thrust from own springs,

developed in result of their bending, opposed power of the electromagnet and the elastic deformation fo the carbon pile. In this case, when the three forces are balanced, the armature is immobile. When the balance of the forces is disturbed, the armature is shifted, thus increasing or reducing the air space between the armature and core of the electromagnet as long as the forces are balanced again.

Attracting force of the eletromagnet of the carbon regulator depends from the value of voltage if the generator. If voltage of the generator is much less than the nominal value or is zero, the clearance between the core and the armature of the electromagnet has maximum dimension and the springs of electromagnet armature exert the maximum thrust on the carbon pile. The resistance of the carbon pile regulator is now very low /approximately 0,5 - 0,8 Ohm/ and the exciting winding of the generator is practically connected directly to the clamps of the generator.

By adjustment of the electromagnetic characteristic / i.e. dependance of the attracting force of the electromagnet from the dimension of the air gap between the core and the armature/ and of the mechanical characteristic /i.e. dependance of resulting mechanical thrust, which is variation of elastic deformation of the carbon pile and of thrust of armature springs from the same air gap/ we get the necessary variation of the resistance of the carbon pile, at which the voltage of the generator approaches the desired value.

When the regulator is operating, the armature of the electromagnet travels only when condition of operation of the gene - rator are changed. At any stable rating of the operation of generator /stable lead and rotational speed/ the armature is in

unchanged position in relation to the core of the electromagnet, according to the individual conditions of operation of the generator. When rotational speed of the generator increases or load of generator drops, the voltage of the generator increases and consequently the electromagnetic power of the regulator is increased, too. In result of this, the armature approaches the core of the electromagnet and reduces the thrust on the carbon pile, by which the exciting current of the generator will drop and voltage of generator will be limited. The armature of the regulator settles down in a new position, appropriate for the new working conditions of the generator. New balance of forces is given by increased electromagnetic thrust and opposedly increased thrust of the springs, caused by their deeper deformation.

When the rotational speed of the generator drops or the load is increaseed, voltage of the generator will drop and consequently the regulator of the electromagnet will lose part of its power. In result of this the armature goes away from the core of the electromagnet and increases its thrust on the carbon pile, by which the exciting current of the generator will be increased. Drop of voltage will be stopped and the armature of the electromagnet will get into balanced condition in a position, characterised by lower electromagnetic thrust and lower opposed thr of the springs. This new position of the armature is appropriate only for the individual conditions of operation of the generator. All informations, given above, are in force only in the operat range of generator.

D e s i g n.

The voltage regulator is a set of assemblies and elements

united into a common electric system, which comprises: t
ly of regulator with resistor, box with contacts and ter
adjustable resistance and capacitor MBM-31.

A. Assembly of regulator with resistors consists of the following elements /fig.99/: regulator 1, rheostat 2, ther
compensating resistor 3 /stable wire glazed resistor PO-27 -
20 Ohms/, stabilizing resistor 4 /stratiform resistor type MG-
1W-1600 Ohms/ and base 5, on which all the system of all elements is assembled. The regulator of voltage consists of the following main assemblies and parts /fig.100/: body of electromagnet as - sembly 1, support ring 2, armature assembly 3, carbon pile 4, insulating tube 5 of the carbon pile, body 6 of the carbon pile, flange 7 for fastening of the holder of regulating carbon con - tact and three stands 8, connecting the body of the electromagnet with the body of the carbon pile.

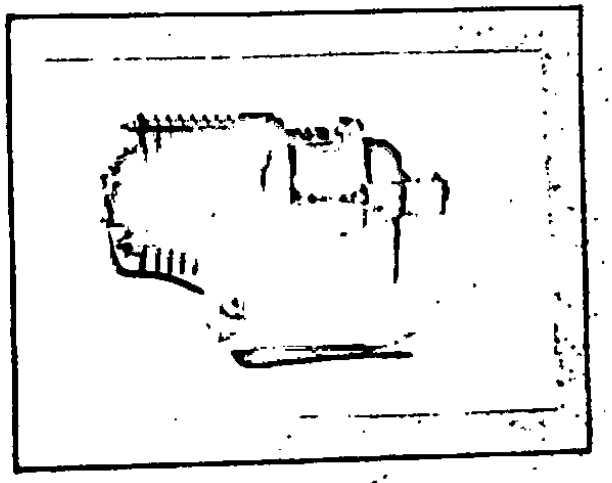


Fig.99. General View of Assembly of Regulator with Resistors.

1- regulator, 2- rheostat, 3- thermal compensaiton resistor, 4- stabilizing resistor, 5- base.

Assembly of electromagnet body 1 comprises: a/ parts of magnetic conductor - body 9, cover 10, core 11: b/ coil 12 of the electromagnet.

The body 9 is made in form of a buch with two round flanges on its ends. In the bottom of the body is a through-going round hole for the core 11. In the body from outside of the bottom is turned a seat for the support ring 2 and for the diamagnetic round insertion 13. The flange of the body, facing the armature, has a through going round hole for outlet of the armature. For fastening of the parts, which are to be connected with the flanges of the body, in each of the flanges per three threaded holes are provided. On the cylindrical surface of the body is placed a cut-out for outlets of the coil. The cover 10 is made in form of a ring with a fitting collar for assembly on the body 9. On the cover are six holes, of which three smooth holes serve for fastening of cover to the body 9, one large with thread - for connecnection with the core 11 and two little threaded holes for screw, fixing the position of the core 11. The core 11 has a cylindric form and is connected with the cover 10 by thread. For easier screwing in of the core into the cover and for easier regulation of the air gap in the electromagnet on the outer face of the core a segmental groove is cut out for the screw driver. All parts of the magnetic conductor are made of electrotechnical steel.

The coil 12 of the electromagnet is of a cylindric form and has three windings: the working winding 14, the thermal compensation winding 15 and the balancing winding 16. The windings of the coil 12 are placed on a frame 17 made of plastics.

The coil 12 of the electromagnet is placed in the cavity of the body 9 and its fastening is performed by clamping by the

cover 10. The clearance between the coil 12 and the cover 10 is eliminated by insertion of sealing washers 18 made of electro-technical pasteboard. The support ring 2 is turned of aluminium alloy. The face of the ring, which serves as support surface for the armature springs, has a conical turned dimple. The conical surface on the face of the ring allows during operation of the regulator to change the eficient length of the armature springs and thus their characteristic, which is made analogical to the characteristic of the electromagnet.

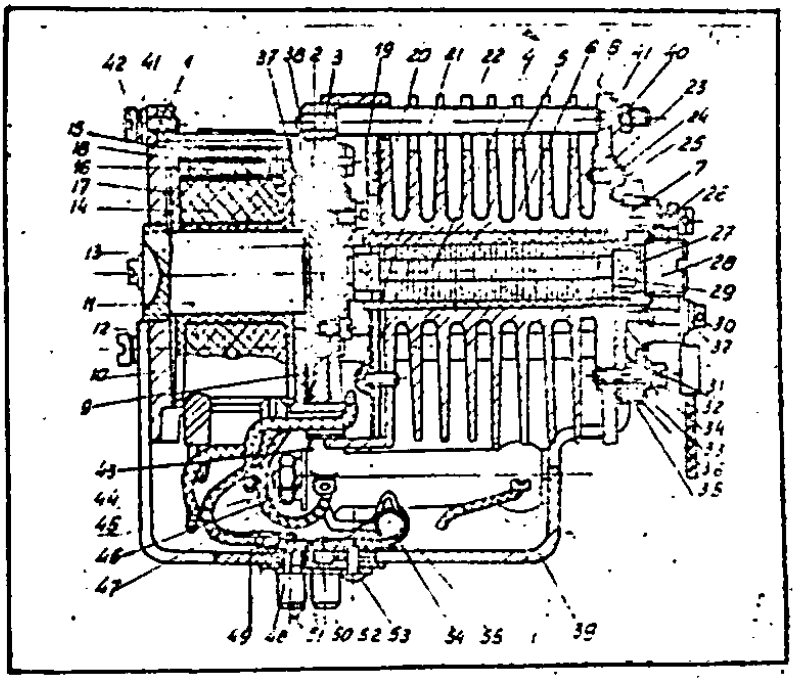


Fig.100. Assembly of Regulator - Cutaway View.

1- assembly of electromagnet body, 2- support ring, 3- armature assy, 4- carbon pile, 5- insulating ceramic tube, 6- body of carbon pile /ribbed body/, 7- flange, 8- stand, 9- body, 10-cover, 11- core, 12- coil of electromagnet, 13- diamagnetic insertion, 14- working winding l_1, 15- winding of thermal compensation l_2, 16- balancing winding /parallel operation - S /, 17- [illegible] coil, 18- sealing washers, 19 - mica rings of the screen, 20- supporting-spacing rings, 21- screws, 22- spring washers, 23- stop plates, 24- screw, 25- spring washer, 26- screw, 27- regulating carbon contact, 28- holding screw, 29- carbon contact, 30- mica insertion, 31 - mica insertion, 32- screw, 33- support ring, 34- spring washer, 35- mica washer, 36- ceramic bush, 37- /right/ screw, 38- spacing washers, 39- base, 40- nuts, 41- washers, 42- screw,

43-resistor of thermal compensation PO-20 /20 Ohms/, 44-screw, 45-support rings of bush, 46-lock washer, 47-nut, 48-contact pins, 49-brass washer, 50-51 - insulating insertion, 52-insulating rings, 53-rivet, 54-clamp ring, 55-stabilizing resistor /WS-1-W - 1500 Ohms/.

On the other face of the ring is made a cylindrical cavity, which limits the support surface.

The armature assembly /fig.101/ consists in principle of a series of stamped parts. As base of the armature assembly serves the disc 1 made of electrotechnical steel and the steel hexagonal insertion 2, on the edges of which six groups of plate springs 3 are distributed. Each group of springs consists of three steel plates, bent in a angle of 169°. For elasticity of the assembly between the springs in places where same are fastened two thin /0,1 mm./ hexagonal brass insertions 4 are inserted. The insertion 2, springs 3 and insertions 4 alternating with the springs, are fastened together with the disc 1 by a round thrust washer 5 and three screws 6. By other three screws 7 and by support washers 8 to the disc 1 over the washer 5 a brass holder 9 is fastened on which is fastened the carbon contact 10. The holder 9 is insulated from the washer 5, from screws 7 and from rings 8 by a mica insertion 11, by ceramic bushes 12 and mica rings 13. For increasing of resistance of insulation of the holder 9 its fastening parts and insulating parts are covered at assembly by bakelite lacquer. After the assembly the armature is undergoing a drying procedure at elevated temperature.

The carbon contact 10 of the armature is connected with the system of regulator by an insulated lead 14, the end of which is rolled in into the holder 9 by means of a special brass ring 15 and a copper hollow rivet 16.

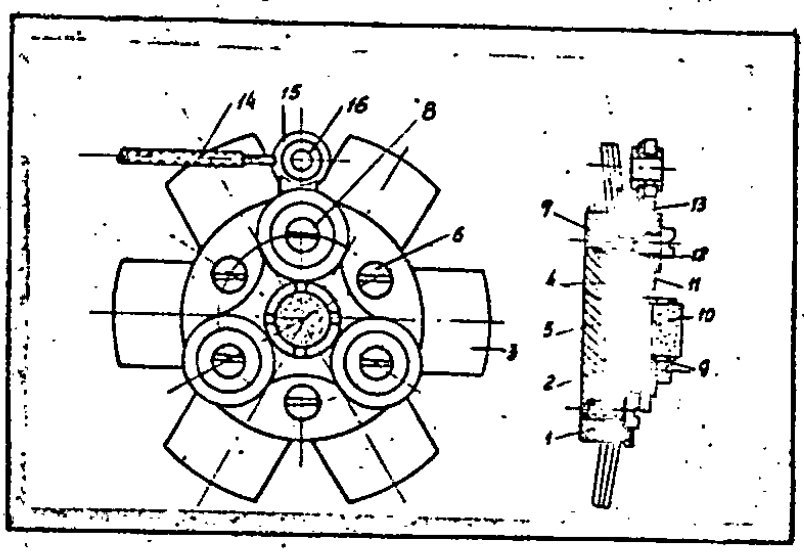


Fig. 101. Armature of the Regulator.

1-disc, 2-sealing, 3-plate rings, 4-insertions, 5-thrust washer, 6-screw, 7-screw, 8-support washer, 9-holder of the contact, 10-carbon contact, 11-mica insertion, 12-ceramic bush, 13- mica washer, 14-connecting lead, 15-special ring, 16-hollow rivet.

The carbon pile /see fig.100/ 4, type S2R-1A, consists of a set of rings, made of special electrographit treated carbon. The number of the carbon disc and their thickness in the pile are not exactly given, but depend on its electromechanical parametres with respect to the limits of variation of the resistance and the linear deformation at the corresponding thrust values. Height of the carbon pile is $50 \pm 0{,}5$ mm.

The insulating tube 5 is made of special ceramic mass, having high insulating and mechanical qualities. For fastening, the tube on the outer surface has a segmental groove. The body 6, made in form of a hollow cylinder as casting of alluminium alloy has two flanges /the outer and the inner one/ and also seven disc-shaped ribs, distributed evenly on the length of the body between its flanges.

The ribs are cast on the body 6 and increase the surface area of the latter and thus increase exchange of heat, radiating from the operating carbon pile into the ambient air. In the body 6, along its axis is placed a hole for an insulating bush of the carbon pile. On the outer flange of the body stands 8 are fastened by one their end, the other end of them is screwed to the body of the electromagnet 1. On the flange are also fastened the locking plates 23, determining the position of the insulating tube 5 in the body and the flange 7 with adjustable carbon contact. For this purpose the flange has on its side, facing the ribs, an annular groove for contact with steps on the stands 8 an three holes, placed in an angle of 120°, for threaded ends of the stand 8, protruding through these holes out of the body.

On the opposite of the flange is placed a cavity with a thread hole for fastening of stop plates 23 and also thread holes for fastening screws of the flange 7. The opposite end of the body 6, facing the armature 3, is ended by a hollow flange. The cavity in the flange is made by the projecting guide collar and serves for insertingof the armature 3. On the inner face of the flange is fastened a heat insulating screen for protection of the armature 3 and of the electromagnet winding against heat, radiated by the operating carbon pile of the regulator.

The heat insulating screen consists of two mica rings 19, between which an air space is occured by nine steel supporting-spacing washers 20. The screen is fastened on the face of the flange by means of three screws 21 and by means of locking sprin washers 22. In the spot where the stands 8 are running, along the body 6, in its ribs cutouts are made and in the hollow f are made holes, excluding any contact of the stands with t low flange and with ribs of the body.

The insulating ceramic tube 5 is fastened in the body 6 by locking plates 23, ends of which are put into the segmental groove of the tube and are fastened in the seat of the outer flange of body 6 by screw 24 and lock washer 25. The flange 7 is made as a shaped bronze casting. The support surface of the flange is flat and has form of a triangle, in corners of which are drilled holes for fastening screws. From outside of the flange is an oval boss with a flat faces, in the axis of which is placed a threaded hole. This large threaded hole serves for inserting of the regulating carbon contact 27 and the cylindrical cavity serves for projection of the end of the insulating ceramic tube 5. In the upper part of the oval boss, parallel with its face, is placed a cutout, dividing the threaded hole for the regulating carbon contact. On the face of the oval boss of the flange are placed two threaded holes. One of the holes serves for the screw 37 /see pos. 37 right/, fastening the outlet of the carbon pile. Into the other holes is screwed in a screw 26, contracting the cutout and locking thus the regulating carbon contact in the flange 7.

The flange 7 is fitted in the centre of the outer flange of body 6 and is insulated from same by mica insertions 30 and 31. The fastening parts of flange 7, i.e. screws 32 with washers 33 and 34 are insulated from the flange by mica washers 35 and by ceramic bushes 36. The regulating carbon contact 27 comprises the holding screw 26 and the carbon contact 29. In order to eliminate possibility of magnetic sticking of the armature 3 on the core, between the body 9 of the electromagnet and the support ring 2 is inserted a brass insertion 37. Here also i.e. between the support ring and the insertion 37 are put spacing brass rings 38, by which is determined the air space between the core

of the electromagnet and the armature.

B. Rheostat /fig.102/: is made in form of a ring shaped resistance 1 with slider 3 revolving on axle 2. The winding of the resistor 1 is made of enamel coated constantan wire /PSK/ and is wound with an exact pitch on a plate frame 4 made of fibre. The resistor 1 with the insulating insertion 5 made of electrotechnical pasteboard is rolled in into the annular space of the body 6. In the centre of the body 6 is rolled in the bush 7, which has on its outer end thread.

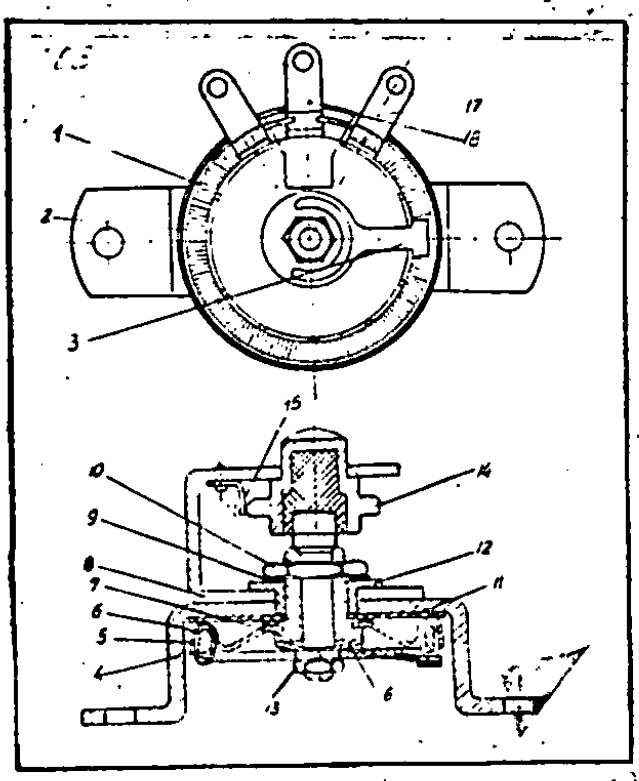


Fig.102. Rheostat of the Regulator:

1-wire resistor, 2-axle, 3-slider, 4-frame of resistor, 5-insulating insertion, 6-body of rheostat, 7-bush, 8-yoke-bracket, 9-washer, 10-nut, 11-insulating washer, 12-bush made of plastics, 13-nut, 14-wheel of the rheostat, 15-spring fixator, 16-spring washer, 17-contact plates, 18-contact plate.

The bush 7 determines the position of axle 2 and holds the body 6 on the yoke bracket 8 by means of the ring 9 and nut 10. The body 6 and its bush 7 are insulated from the yoke-bracket 8 by a textolite washer 11 and by the bush 12 made of plastica. The slider 3 is fastened on the plabes of the axle 2 by its shaped eye and is fastened by a nut 13. The slide 3 slides on the resistor 1 when the ring 14 turns, which is connected by its seat /for insulation coated by plastica/ with the end of axle 2 and by the upper part with the yoke bracket 8. Spontaneous shifting of the slide 3 is made impossible by the spring fixator 15, fastened on the yoke-bracket 8 and meshing with the ribbing of the wheel 14. Enamel is removed from the working face of the resistor 1 for securing a proper electric contact between the elastically mounted bronze slider 3 and the winding of the resistor 1. The electrical contact of the slider 3 with the body 6 is secured through the axle 2, bush 7 and through the elastic bronze washer 16.

The rheostat is connected into the system of the regulator by a lead, soldered to the contact plates 17, placed on the ends of the resistor 1 and to the contact plate 18, soldered to the body 6.

The base 33 /see fig.109/ made of aluminium sheet, has four large stands, two little stands and three wedge projections. The four large stands serve for connection of the regulator with the base, two of them by their holes are connected with the thread ends of the steel stems from the side of the outer flange of the ribbed body 6 and are fastened on them by nuts 40 with washers 41 and the two other stands are connected with the [illegible] of the body of electromegnet by screws 42, simultaneously holding the cover on the body. On one of the stands is simultaneously mounted the

thermal compensation resistor 43 /wire built glazed resistor PO-20-20 Ohms/, fastened by steel screw 44. The two little stands and three projections-wedges on the base serv for fastening of regulator assembly on the contact-clamp plate.

On the base are also fitted five brass contact pins 48, which connect the system of regulator assembly /through the contact-spring plates on the contact-clamp panel/ with the clamps of the outer connection. The contact pins, leaning on the contact rings 49, are insulated from the base by insulating insertions 50 and 51 and by washers 52. The pins are fastened by nobbling of their terminals and by soldering. In the sixth seat of the insulating insertions of contact pins a clamping sleeve 54 is fastened by a rivet. In this clamp sleeve is fastened a stabilizing resistor 55 /stratiform resistor WS-1 W - 1600 Ohms/.

C. Contact clamp panel with shock absorbers /fig.103/, serves for:

a/ protection of regulator assembly from the vibration and shock of the aircraft,

b/ connection of the carbon regulator of voltage into the network.

The panel secure a reliable and rapid mounting of the regulator assembly and also removing of same without use of tools.

The base of the panel is a rectangular textolite plate with six large round cutouts and with a series of little cutouts and holes for fastener and clamp screws.

The following parts are assembled on the panel:

a/ five clamp screws 1 for connection of connecting leads,

b/ five elastic contact plates 2 made of bronze,

c/ four armoured disc shock absorbers 3 with mounting stud bolts, with nuts for fastening of the panel on the air frame

of stop 4, two yokes 5 and two arc shaped clamps 6, by which the regulator assembly is fastened on the panel.

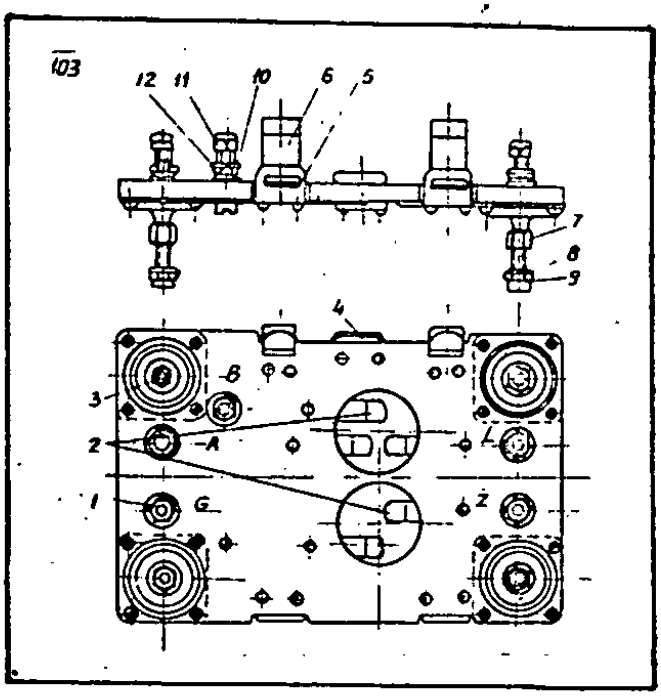


Fig.103. Contact-clamp Panel.

1- clamp screw; 2- contact plate, 3- shock absorber, 4-stop, 5- yoke; 6- spring clamps, 7- stud bolt, 8- washer, 9- nut, 10- washer, 11- lock nut, 12- spring washer.

...er-oil capacitor [illegible]-31, capacity 4 uF is enclosed ... rectangular metallic jacket. One of the areas of the capacitor is connected with the insulated outlet, placed on the jacket, the other one is connected directly with jacket of the capacitor. The capacitor is fastened and connected with the "mass" by two eyes of the jacket by screws M 3.

3. Differential minimum relay DMR 400 /undervoltage relay/.

The undervoltage relay DMR-400 is a combined apparatus, consisting of two relays and one contactor. The main task of the undervoltage relay DMR-400 is the automatic switching-on of the power generator into the aircraft mains. It fulfills the following tasks:

a/ connects the power generator to the mains, when voltage of power generator exceeds a little the voltage of aircraft mains;

b/ switches off the generator from the mains, when the voltage of power generator dropped and undervoltage occurs /into generator reverse current is running/;

c/ makes impossible to switch on the generator into the mains when its poles are connected incorrectly.

Besides that, the undervoltage relay DMR-400 makes possible to switch on and off the power generator by hand.

Technical Data of the Undervoltage Relay DMR-400.

a/ nominal voltage	28,5 V
b/ current in power line up to	400 A
c/ undervoltage relay switches on the generator into main when voltage of generator exceeds voltage of main by	0,3 - 0,7 V
d/ reverse current, by which the undervoltage relay switches off the generator from the mains.	15 - 35 A.
e/ voltage by which the contactor and the auxiliary relay PMR-2A are brought into action:	

Contactor			Relay DMR-21		
Connecting voltage	Disconnecting voltage	Contact thrust on two pairs of contact at connecting voltage and at 4,3 V	Connecting voltage	Disconnecting voltage	Contact thrust on each contact
In cool.mas. state 15V at ambient air temper. +.20°C.	max. 3,5 V	minimum 5,5 kg	13,5 ÷ 16 V	max. 4 V	minim. 40 g

Undervoltage relay DMR-400 should operate reliably in following conditions:

a/ variation of ambient air temperature from 60° below zero to + 50°C.

b/ relative humidity of air up to 98 per cent

c/ altitude above sea level up to 15000 metres

d/ vibration of fastening points with frequency 20-80 c/s at an amplitude, corresponding to acceleration 4 g

e/ linear acceleration up to 8 g

f/ short-time shocks of fastening points with frequency from 60 to 100 shock per minute at acceleration 4 g max.

Principle of Action.

The basic diagram of undervoltage relay type DMR-400 is shown in fig.104. When the rotor of the power generator is immobile or if its rotational speed is low, the voltage on generator clamps is zero or lower than voltage of aircraft mains

maintained by the aircraft storage battery. The generator cannot deliver power into mains.

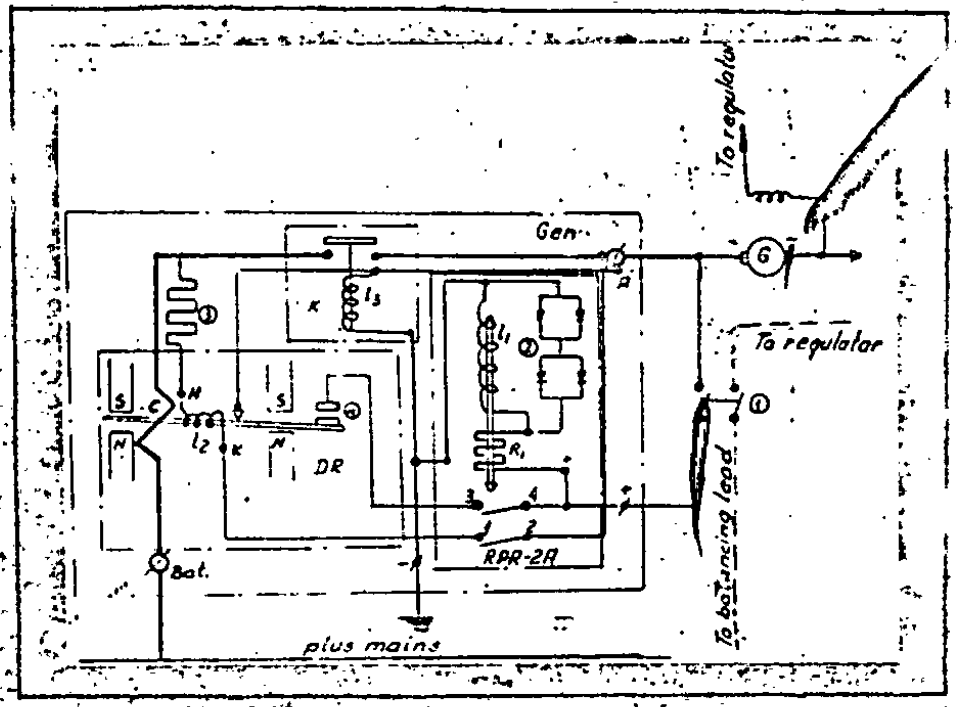


Fig.104. Basic Electric Diagram of DMR-400 Undervoltage Relay.

K-contactor, DR-differential relay, RPR-2A - auxiliary relay, G-generator, L_1-working winding of RPR-2A relay, R_1-additional resistor of RPR-2A relay, L_2-working winding of the differential relay, L_3-winding of the contactor, G-series turn, ①switch, ②selenium rectifier, ③glazed resistor, ④contacts of differential relay, ①③- immobile contacts of RPR-2A relay, ②and ④mobile contacts of RPR-2A relay, "BAT", "GEN" "A", "+" "-" clamps of DMR relay.

NOTICE: Switch, selenium rectifier /valve/, resistor and contacts in fig. are shown in rings.

On the contrary, if connected to the mains, the generator becomes consumer, it will be fed by electric current, which would uselessly consume the power from the mains and might cause a burning of the generator. The same might occur, when the voltage of the generator begins to drop owing to drop of rotational speed of the engine, from which the power generator is driven.

Therefore the instant of connecting of the generator to the mains must be determined by the excess of voltage of the generator above the voltage of the mains and switching off of the generator must be controlled in accordace with value and direction of current in the generator. The DMR-400 undervoltage relay operates when the difference between the generator voltage and the mains voltage occurs, therefore it is called "differential relay". In the case, where no voltage, or if voltage is below 20V, the differential minimum relay DMR-400 operates as a usual minimum relay. The generator is switched on into the mains at voltage of 13,5÷20 V at a load, having a resistance maximum of 6 Ohms.

Design of the Relay.

The differential relay DMR-400 consists of the following main assemblies: dofferential relay, contactor, auxiliary relay EPR-2A, glazed register PO-10-10/, 10 ohms and panel. The differential relay /fig.105/ is a relay, polarised by means of permanent magnets and consists of the upper 12 and lower 1 plates, serving as parts of magnetic conductor.

The plates are mutually connected by three screws 20, passing inside the permanent magnets 16. In the middle part of the upper plate by means of two screws 23 is fastened a steel yoke 22 with an armature, fastened on the yoke. The yoke is insulated from the plate 12 by buches 26 and by insertions 27. The armature of the relay is a narrow steel plate 15, which in the middle part is fastened by means of a bronze spring plate 28 and by two screws 21 to the yoke 22. From one side of the ar-

mature 19 is fastened a spring bronze plate 2 with contact 3, which is balanced by a balance 14, placed on the other end of the armature.

On the right and on the left side of yoke 22 to each plate is fastened by screws 7 one pole 8, facing each other by their pole terminals.

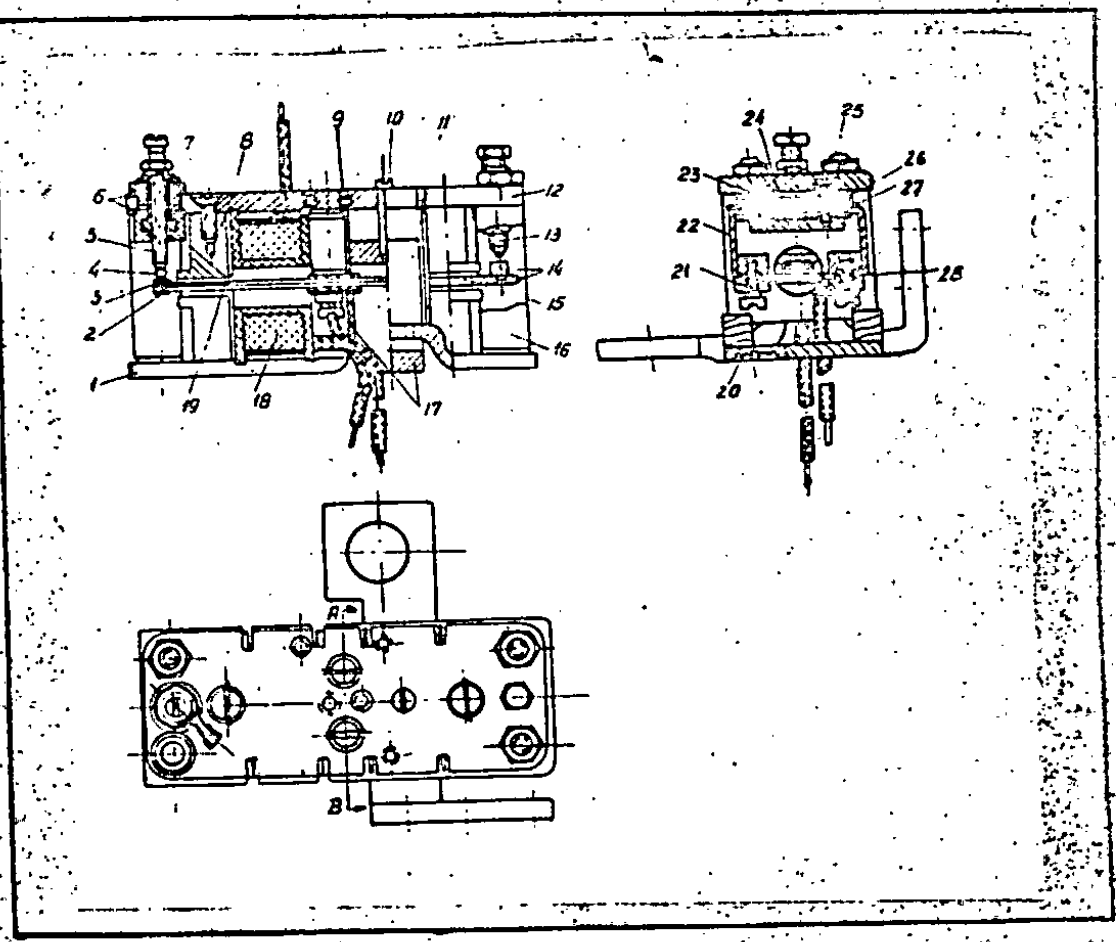


Fig.105. Differential Relay.

1-lower plate, 2-plate, 3-contact, 4-silver contact, 5-contact screw, 6-bushes, 7-screw, 8-pole, 9-screw, 10-screw, 11-series turns, 12-upper plate, 13-stop screw, 14-balance, 15-plate, 16--magnet, 17-insertions, 18-coil, 19-armature, 20-screw, 21-screw 22-yoke, 23-screw, 24-insertions, 25-nut, 26-bush, 27-insertion, 28-plate.

Between the poles are placed at the left from the yoke- the coil 13 /parallel winding/ on a bobbin made of plastics, at the right from the yoke - the series turn 11 /series winding/, [illegible] between the insulating insertions 12. The armature of the relay 13 passes freely over the hole in the bobbin of the coil 13 and of the series turn 11. The right and left part of the armature 13 pass in the magnetic space between the pole terminals.

Angle of travel of the [illegible] is limited by the contact screw 5, on the other [illegible] stop screw 15, which is screwed in into the upper plate. The end of the stop screw is coated by insulating mass. The contact screw 5 is insulated from the upper plate by two bushes [illegible] of insulating material and has on one end a pressed-in silver contact 4.

The contact screw is placed opposite the mobile contact 3 of the armature 13. By means of the contact screw 5 is regulated the intensity of reverse current /disconnecting current/ and with aid of the stop screw 15-value of voltage at which the differential relay closes its contacts.

The symmetrical position of the armature 13 in the magnetic space between the pole terminals is regulated by insertions 24 and by screw 9, screwed into one of the thread holes of the upper plate. When screwed in, the screw 9 presses by its end on the edge of the yoke 22 and deflects same to one or other side.

The contactor /fig.106/ with an electromagnetic control and double disconnection of the circuit consists of the following part and assemblies: body 23, coil 24, cover of the body 18, armature 22, immobile core 27, mobile contact load 10, two immobile contact loads 7 and 1, buffer spring 20, return spring 4, panel 8 and cover 11.

The body 23 is made of steel, has a cylindrical form on one side leans on the stand 3, on the other side it is rolled in into the cover 18. The coil 24 is wound on a bobbin, consisting of two insulating rings 19 and 25 and brass bush 26, inside of which travels freely the core 22.The immobile core 27 is riveted to the stand 3. The body 23, cover 18, stand 3, mobile armature 22 and immobile core 27 are the main parts of the magnetic conductor.

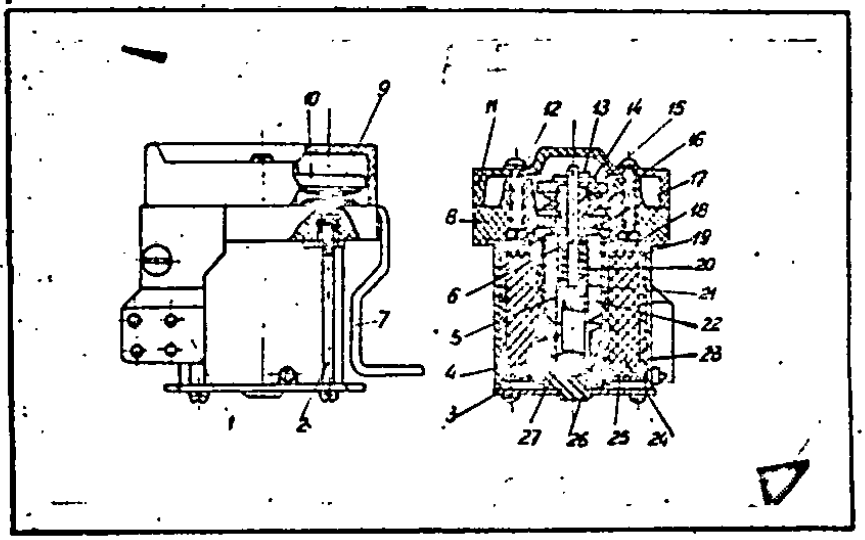


Fig.108. Contactor.

1-immobile contact lead, 2-screw, 3-stand, 4-return spring, 5-washer, 6-axle, 7-immobile contact lead, 8-panel, 9-contact, 10-mobile contact lead, 11-cover, 12-screw, 13-cotter pin, 14-washer, 15-bush, 16,17-washers, 18-cover of the body, 19-washer, 20-buffer spring, 21-washer, 22-mobile armature, 23-body, 24-coil, 25-washer, 26-bush, 27-immobile core.

To the mobile copper lead 10 are soldered two metaloceramic contacts /mark OK-12/ 9. The lead gets its position from the insulating guide bush 15, fitted on the axle, 6. In order to prevent revolution of the lead 10 round the axle, there are two guide projections on the panel made of plastics, which serve simultaneously for fastening of cover 11, made likewise of plastics. The mobile contact leads 7 and 1 are also made of copper and have for one soldered metaloceramic contact 9 and are fastened on the

[illegible] by means of [illegible], in Fig.107 the screws are not shown. All parts and assemblies of the contactor are fastened together by clamping bolts 2, running throught the stand 3 and screwed in into the panel 8. The contact clearance, equalling 2 ± 0,15 mm is regulated by washers 16. The magnetic gap, equal to 2,6 ± 0,[illegible] mm is regulated by washers 17.

The auxiliary relay MKR-2A /fig.107/ is an electromagnetic relay, whose polarity is secured by the selenium rectifying element /valve/. It has two pairs of regularly disconnected contacts.

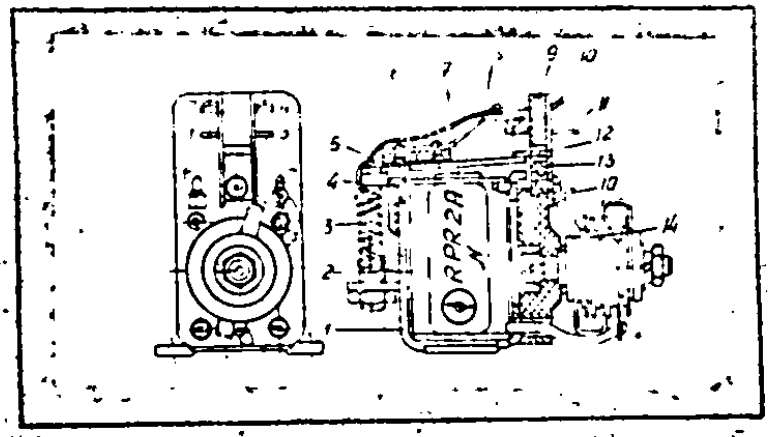


Fig.107. Auxiliary Relay MKR-2A.

1-body, 2-coil, 3-spring, 4-axle, 5-insertion, 6-panel, 7-core, 8-plate with contact, 9-panel, 10-clamp, 11-plate, 12-armature, 13-limiter, 14-selenium rectifying element /valve/.

The main parts and assemblies of the relay are: body 1, U-shaped, in its base has a hole for fastening of core 7. The armature 12, core 7 and body 1 are the main parts of the magnetic conductor. On the armature 12 are fastened two bronze plates 8 with silver contacts. They are insulated from the armature by panel 6 made of plastics and by insertion made of textolite 5. Two [illegible]bile silver contacts are soldered to the plates 11, fastened

panel 8 by means of screws /in fig.107 the screws are not shown/. All parts and assemblies of the contactor are fastened together by clamping bolts 2, running throught the stud 3 and screwed in into the panel 8. The contact clearance, equalling 2 ± 0,15 mm is regulated by washers 16. The magnetic gap, equal to 2,5 ± 0,15 mm is regulated by washers 17.

The auxiliary relay RPR-2A /fig.107/ is an electromagnetic relay, whose polarity is secured by the selenium rectifying element /valve/. It has two pairs of regularly disconnected contacts.

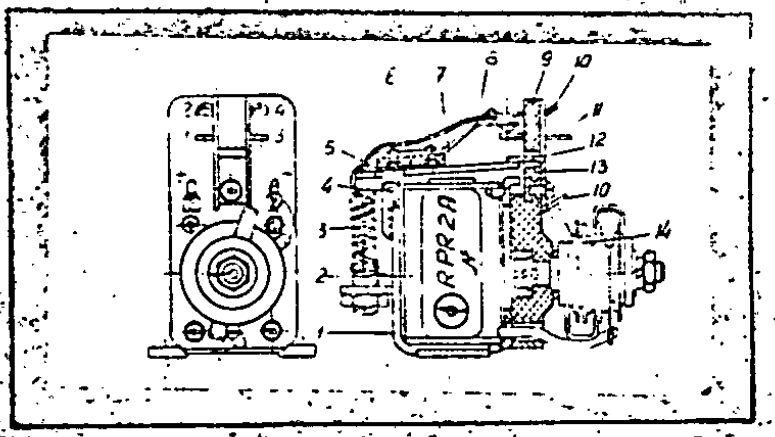


Fig.107. Auxiliary Relay RPR-2A.

1-body, 2-coil, 3-spring, 4-axle, 5-insertion, 6-panel, 7-core, 8-plate with contact, 9-panel, 10-clamp, 11-plate, 12-armature, 13-limiter, 14-selenium rectifying element /valve/.

The main parts and assemblies of the relay are: body 1, U-shaped, in its base has a hole for fastening of core 7. The armature 12, core 7 and body 1 are the main parts of the magnetic conductor. On the armature 12 are fastened two bronze plates 8 with silver contacts. They are insulated from the armature by panel 6 made of plastics and by insertion made of textolite 5. Two immobile silver contacts are soldered to the plates 11, fastened

in the panel 3, made of plastics. On the same panel is placed selenium rectifying element /valve/ 14 and the outlet clamps marked "1", "2", "3", "4", "+", and "-", by means of which the relay is connected to the mains. The coil 2 has two windings, on a bobbin, made of plastics. The armature of the relay 12 is held in disconnected position /when no current is in the coil/ by the spring 3. The magnetic gap 0,7-0,8 mm/ is regulated by means of a limiter 13, position of which can be changed. The contact gap /0,5 mm max./ is regulated by bending of the brass plates 8.

All elements of the DMR-400 relay are mounted of the panel 5 /fig.108/. The differential relay 6 is fastened to the panel by three screws 13. To the upper plate of the differential relay by means of two screws 1 is fastened the relay RPR-2A. Both relays are covered by one cap 10. The cap is fastened to the panel by three screws 15. On the panel 5 are two screws 3 /"BAT" and "GEN."/ for connection of the outer *silver* leads. On the bolt "BAT" is fastened by its one end the series turn, the other end of which is connected by four screws 14 with the immobile lead of the contactor. On the same lead by the screw 7 and nut 8 is fastened the glazed resistor 11, connected with the circuit of the parallel winding of the differential relay for thermal compensation.

On the bolt "GEN" is fastened the end of the immobile lead of the contactor. Three bolts, "+", "-", and "A"serve for connection of the leads of inner system of the relay and for connection of the outer control leads. The relay DMR-400 is fastened in the air frame by four holes "a", provided in the panel.

4. DMR-400A relay

In the electric installation of several WK-2F engines the differential relay DMR-400 may be replaced by the DMR-400A relay.

The DMR-400A relay is a combined apparatus, serving for engaging and disengaging of the GSA-3000 generator, during its operating with the battery. The relay consists of : voltage relay TRE-210B, differential relay DR and contactor K. The DMR-400A relay. For switching on and off of the generator serves the switch 1 /see fig.109/.

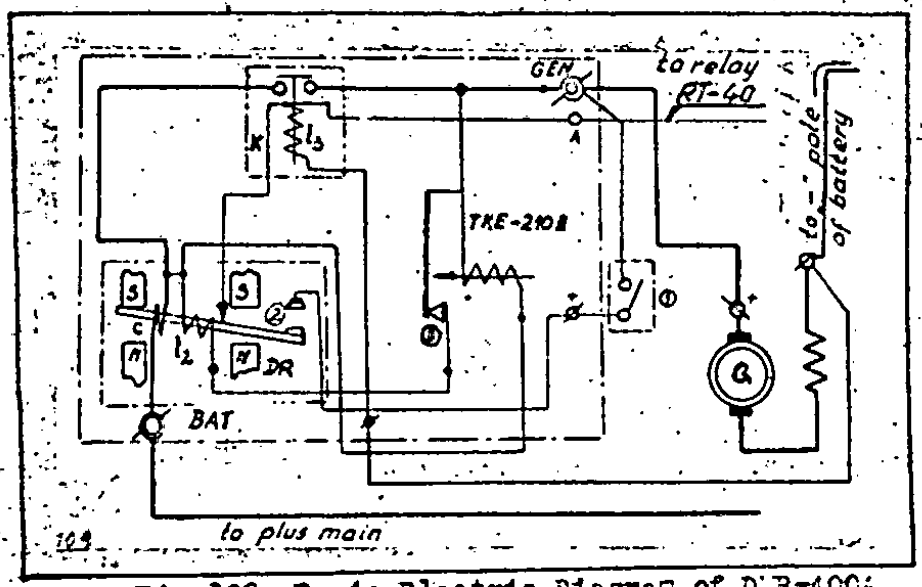


Fig.109. Basic Electric Diagram of DMR-400A relay.

K- contactor, DR- differential relay, TRE- 210B voltage relay, G- generator, l_2- working winding of the differential relay, l_1- winding of the contactor, C - series turn, 1 - switch, 2 - mobile contact of DR-relay, 3 - mobile contact of TRE-210B relay, "BAT", "GEN", "A", " + ", " - " clamps of DMR-400A relay.

Principle of action

The basic diagram of the DR-400A relay is shown in fig.109. When the relay coil DR-210B is under current, then the clamp 3 is di-connected and the generator cannot be supplied by the main. The relay coil is fed by electric current in following cases : when the generator roter is immobile, when its rotational speed is low, when the generator poles are connected incorrently and when the battery is not connected to the mains.

When the clamp 3 is closed follows also the engaging of the differential relay DR, clamps of which 3 will be connected as soon as the voltage of the generator terminals exceeds the voltage of the main about 0,3 - 0,7 V. After acting of the DR relay the generator will be connected with the main by the contactor K.

In case when the voltage of the generator terminals is lower than the voltage of the battery, so that from the battery to the generator runs a reverse current of a value 15 - 30A.

At that time the series turn "C" of the differential relay overhelms the force of the coil l_2, owing to that follows disconnecting of the clamp 2 the fuel supply to the coil l_3 of the contactor K is interrupted and the spring opens the clamps of the contactor.

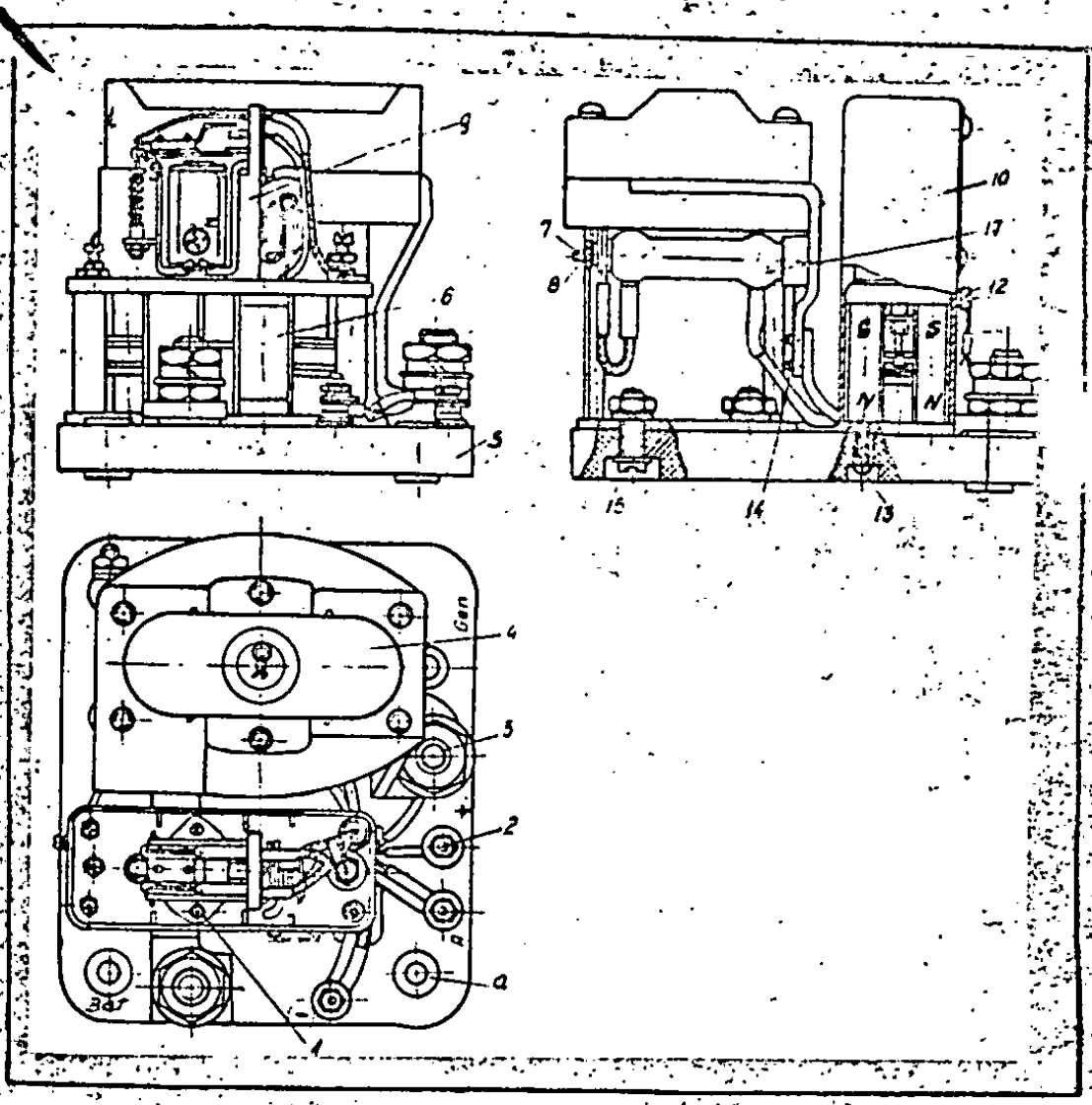


Fig.10B. Differential Minimum Relay.
/undervoltage relay/ DMR-400.

1-screw, 2-contact bolt, 3-contact bolt, 4-contactor, 5-panel, 6-differential relay, 7-screw, 8-nut, 9-auxiliary relay KH-11, 10-cap, 11-glazed resistor, 12-13-14-15- screws, a-hole in panel for fastening of the relay.

5. Operation of the Mains Feeding and Battery Charging System.

The mains feeding and battery charging system is an electric system, independent from that of starting. With acceleration of the engine voltage on the clamps of the generator rises. When the rotational speed of the generator reaches the initial value /n = 4000 r.p.m., which corresponds to 5300 r.p.m. of engine/, voltage on the clamps of the generator reaches 28,5 V and will be maintained by the voltage regulator R-25 A without regard to further increasing of the rotational speed and variation of load. When the rotational speed of the generator is lower, it operated with short circuited shunt.

The first time the storage battery is charged in the charging station according to instructions, delivered with each battery. For recharging of the battery during flight it is necessary before starting of the engine to set the switch of the generator into ON position. After the starting with increasing rotational speed the voltage on the clamps of the generator will increase. As soon as the voltage on the generator terminals exceeds the voltage of the storage battery the power contactor of the differential minimum relay will connect its contacts. Through the connected contacts of the power contactor "plus" voltage of the generator is connected with the "plus" clasp of the storage battery and thus the storage battery recharging circuit is closed.

The "minus" of the storage battery is directly connected with the "minus" of the generator. When the engine is stopped or its rotational speed is lower than the initial value for generator, the voltage on the generator terminals will drop. When the voltage on the generator terminals drops under the value of voltage of the storage battery, a reverse current will run from the storage battery

through the series winding of the pilot relay, thus in the [illegible] winding the magnetic attracting power so that the return spring will disconnect its contacts. And as the winding of the power contactor is fed through the contacts of the pilot relay, the power contactor will be disconnected and the battery charging and mains feeding circuit will be interrupted.

ELECTRIC INSTRUMENTS CONTROLLING OPERATION OF ENGINE.

On the engine are mounted the following instruments, description of which is given below.

1. EMI-3R /Three-pointer Electric Indicator of Engine.

The three-pointer electric indicator of engine type EMI-3R serves for remote control of engine operation. The EMI-3R is a compound instrument, measuring pressure of fuel and pressure and temperature of oil. The three pointers on the united dial indicate the measured values. The set of EMI-3R instrument consists of two pressure pickups, one temperature pickup, remote control electric indicator and electric connectors.

The indicator unites three measuring instruments in one body, each of the instruments with its pickup forms an independent measuring system. The three-pointer indicator is fastened on the instrument panel in the pilot's cabin.

The fuel high pressure pickup on the engine is mounted on a special bracket, fastened on the fastening stud bolts of the front frame of compressor between the inlet necks of the combustion chambers No.5. and 6. From the neck of the fuel collector of engine to the fuel pickup fuel is led through special damping hose, fastened on the aircraft framework.

The oil pressure pickup is fastened on the left side of the pump box, for which on the stud bolts of the box flange a special fittings are fastened. The oil pressure pickup is inserted into the opening of the fitting and is fastened by a special nut.

The oil temperature pickup or the probe is placed beside the oil pressure pickup. The pipe of the pickup enters the oil pump box and is splashed by oil, the temperature of which is measured by the sensitive element of the termometer.

Main Characteristics:

1. Range of measuring:

a/ fuel pressure gauge — from 0 to 100 atm.

b/ oil pressure gauge — from 0 to 10 atm.

c/ oil thermometer — from - 50°C to + 150°C.

2. The permissible errors of readings of the instruments /total errors of instrument on dial / are:

For the scale	Checked points on scale	Permissible errors at temperature:		
		+ 20°C	+ 50 and - 43°C	- 60°C
Fuel pressure gauge	10, 20, 40, 60, 80, 90, 0, 100	± 3 kg/cm2 ± 5 kg/cm2	± 5 kg/cm2 ± 8 kg/cm2	± 6 kg/cm2 ± 10 kg/cm2
Oil pressure gauge	0, 2, 4, 6, 8, 10	± 0,4 kg/cm2 ± 0,6 kg/cm2	± 0,5 kg/cm2 ± 0,8 kg/cm2	± 0,6 kg/cm2 ± 1,0 kg/cm2
Oil thermometer when tested without pickup	-40, 0, 50, 100, 130, -50, +150	± 4°C ± 6°C	± 6°C ± 8°C	± 8°C ± 10°C
Oil thermometer when tested with pickup	0, 100	± 6°C		

3. Variation of the readings /hysteresis/ at normal te... does not exceed:

For scale:	Checked points of scale	Permis... value
Fuel pressure gauge	40, 60, 80	3 atm.
Oil pressure gauge	4, 6, 8	0,4 atm.

4. Tightness of the oil pressure gauge pickup must be such th... at a pressure of 850 mm mercure the drop does not exceed ... mercury per one minute.

The body of fuel pressure gauge pickup is splash-proo... the side of the glass.

5. The dynamic systems of the pickups are tight at the follo...ng pressure:

a/ for I-10 ..... 15 atm.

b/ for I-100 ..... 120 atm.

6. The indicator sustains a vibration up to 1,5 g with frequency from 20 to 80 c/s. The pickups sustain a vibration up to 4 g.

7. Feeding of the set is performed from the board mains by d.c. 27V. Variation of voltage ±10 per cent does not cause error on scale beyond ±1 per cent of the maximum measure value.

8. Consumed intensity of current by the unit does not exceed 0,3 A.

9. Resistance of insulation of the instrument at normal temperature and at relative humidity from 30 to 80 per cent - minimum 20 Megohms.

Principle of Function.

A. Fuel Pressure Gauge. The measured pressure is feeled by the sensitive element - an elastic corrugated membrane, fastened in the base of the pickup. With increased pressure the membrane continues to deflect and by means of a multiplying mechanism it transmits the value to contact C, sliding on the rheostat DBCA /fig.110/. Each value of the measured pressure has a corresponding position of the contact C on one of the sections of the rheostat. The position of the contact C on the rheostat DBCA determines the correlation between the currents, running in the frames of the measuring element of the logometer. In the system of the pressure gauge of fuel is used a logometer with a moving permanent magnet, revolving in a magnet field of four immobile frames, I,II,III, and IV placed in pairs at 90° angle.

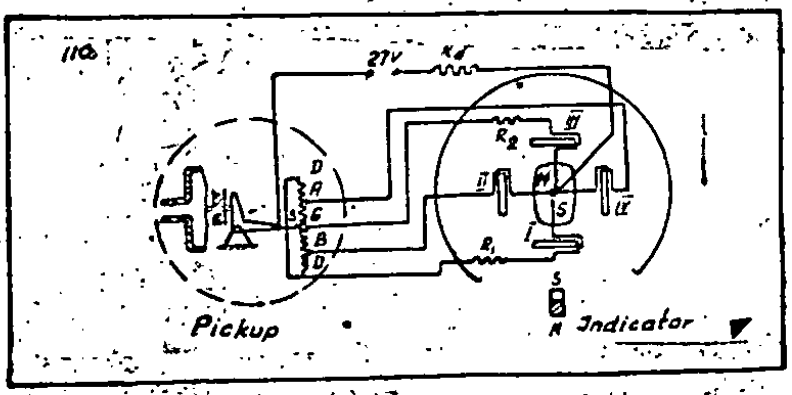


Fig.110. Diagram of Measuring of the Fuel Pressure Gauge.

Function of the logometer is based on the ability of revolving magnet to get into the direction of the axis of the resulting magnetic field, formed by frames, when electric current is running through them.

The diagram of fuel pressure gauge, when pressure varies zero to maximum value, secures a turn of the mobile magnet of the logometer by an angle of 270°. The resistors R_1 and R_2 of the system, connected in series with the frames I. and III., serve for regulation of the range of the scale and for securing of its uniformity. The resistor R_d serves for limiting of the current, consumed by the system.

When no pressure is in the pipes, the contact C occupies a position exactly in the middle of the section DB /fig.111, a/. Now the currents running in the frames I and II, are equal, and so will be the current values in the frames III and IV. The value of current in the frames I and II will be higher than that on frames III and IV, because in the second case the larger sections of the rheostat are connected in series with the frames /for frames I and II sections DB and BG, for frames III and IV respectively the sections GS and AS/.

Layout of the magnetic fields of the frames is shown in fig. 111 at the right. The direction of the arrows correspond to the direction of the magnetic fields, lenght of each arrow is proportional to the values of the magnetic field.

The mobile magnet of the logometer occupies a position, corresponding to the direction of the total /resulting/ magnetic field. With increased pressure the contact S, sliding on the rheostat, passes gradually the sections DB, BG, GA, AD. During this the value of current in the frames and consequently also the magnetic fields are changed. So that the axis of the resulting magnetic field revolves synchronously with the motion of the contact S. When pressure equals half of the maximum values, the contact S is in point G of the rheostat. The mobile magnet turns in direc-

tion of the axis of the resulting field /fig.111, b/, and the pointer shows the point on the scale corresponding to the pressure.

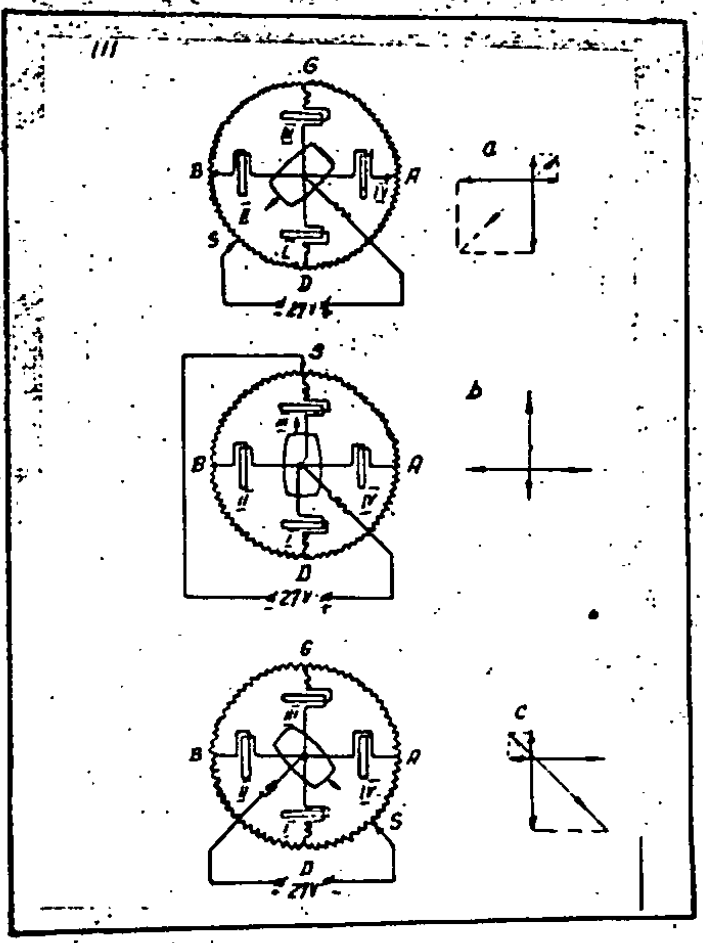


Fig.111. Diagram of Function of the Fuel Pressure Gauge.

In Fig.111, c. is shown the position of the mobile magnet and the direction of the resulting magnetic field at maximum pressure.

When the current source is off, the pointer of the logometer returns to the zero of the scale with the aid of an additional immobile magnet, cooperating with the main mobile magn.

A change of voltage of the electric current source causes a proportional change of the magnetic field intensities of all frames, the direction of the resulting magnetic field and consequently the position of the mobile magnet with the pointer remain without change.

B. Oil Pressure Gauge. The oil pressure gauge is a differential pressure gauge, measuring a difference between two pressure values, oil pressure and atmospherical pressure. The oil pressure is detected by a sensitive element - and elastic corrugated membrane, fastened in the base of the pickup /fig.112/. The atmospherical pressure is led into the tight body of the pickup and acts on the membrane from the opposite side. With increasing pressure of oil the membrane bends and through a transmitting-muliplying mechanism shifts the mobile contact C on the terminals of the potentiometer AB. The correlation between the arms of the potentiometer AC and BC is measured by meas of a magneto-electric logometer. In the measuring system of the pressure gauge of oil is used a logometer with mobile magnet and with immobile frames I and II, placed in a mutual angle of 120°. The mobile magnet occupies a position corresponding to the axis of the resulting magnetic field, formed by the frames when electric current is running through them. The position of the resulting magnetic field is given by correlation of fields of the frames I and II and consequently by correlation of the currents, running in the mentioned frames.

When the feeding voltage is changed the values of the magnetic fields change as well, but their mutual values are proportional. Therefore mobile magnet of the logometer does not change its position. The measuring system of the oil pressure gauge is

...derson bridge, which, unlike the Wheatstone bridge, has an additional half-diagonal /resistors R_3 and R_4/. The varying sections of the potentiometer AC and BC together with the constant resistors R_1 and R_2 form the arms of the bridge. Into the diagonal of the bridge are connected the frames of the logometer I and II. The resistor R_5, connected in series with the frame II, balances the resistance of the frames /because the frames have an equal number of turns and unequal dimensions/.

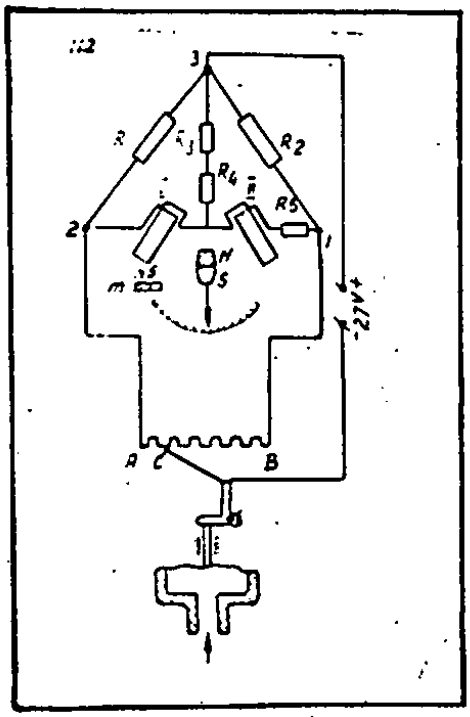


Fig.112. Measuring Diagram of Oil Pressure Gauge.

The diagram of function of the pressure gauge is given in fig.113. The currents, running through frames I and II of the logometer, may be considered as: a/ total of currents, running in the frames at middle position of the mobile contact I, and b/

...bridge, which, unlike the Wheatstone bridge, has an additional half-diagonal /resistors R_3 and R_4/. The varying sections of the potentiometer AC and BC together with the constant resistors R_1 and R_2 form the arms of the bridge. Into the diagonal of the bridge are connected the frames of the logometer I and II. The resistor R_5, connected in series with the frame II, balances the resistance of the frames /because the frames have an equal number of turns and unequal dimensions/.

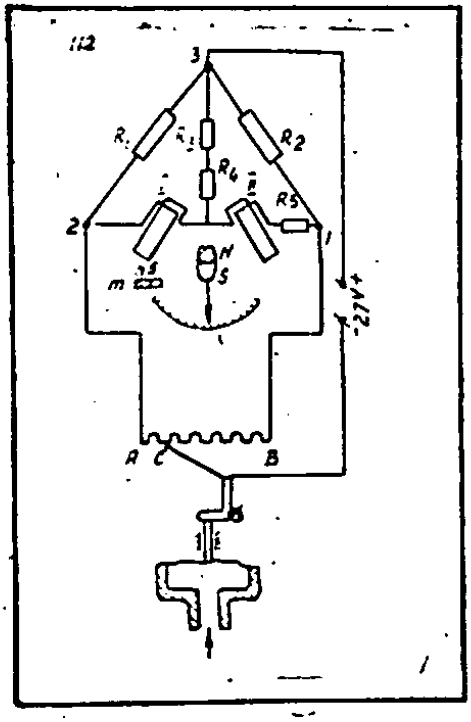


Fig.112. Measuring Diagram of Oil Pressure Gauge.

The diagram of function of the pressure gauge is given in fig.113. The currents, running through frames I and II of the logometer, may be considered as: a/ total of currents, running in the frames at middle position of the mobile contact I, and b/

total of currents, originated in result of

bile contact from the middle position "i". When the pressure of oil equals a half of the maximum value, the mobile contact C is exactly in the middle of the potentiometer AB /fig.113, b/. In this case the system is exactly symmetrical, because $R_1=R_2$ and, consequently, the potentials of the points A and B are mutually equalled /balanced Wheatstone's bridge/. The current, running throught the half-diagonal R_3 and R_4 is divided from point D, which is common for both frames, into two equal and as to the direction opposed currents. As the frames have an equal number of turns, the resulting field and consequently also the mobile system of the locometer, occupy a position, corresponding to the middle point of the scale.

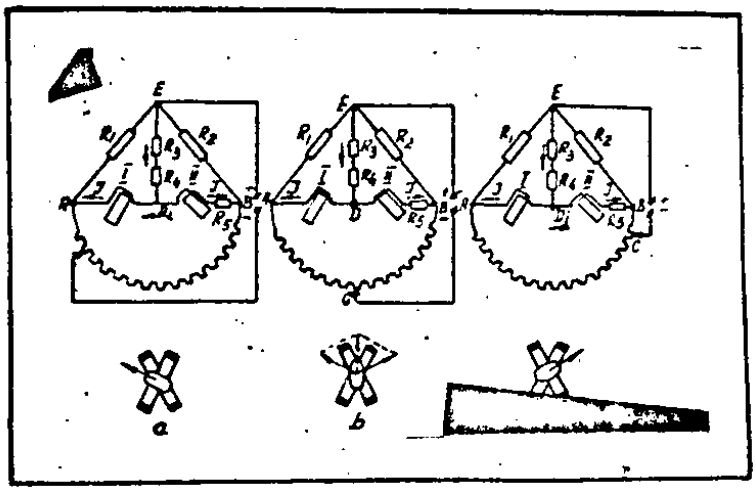


Fig.113. Diagram of Function of the Oil Pressure Gauge.

When pressure changes to either side from the middle position, the symmetry is disturbed. Between the points A and B occurs a difference of potentials /disbalance Wheatstone's bridge/ which is proportional to the difference between the middle and the measured value. This difference of potentials has the posi-

tive of negative character, which d[illegible]
side the mobile contact travels fr[illegible]
Such difference between potentials [illegible]
additional current "i" is generated, th[illegible]
equal in both frames. By existence of t[illegible]
ted the equality of currents on the fra[illegible]
because in one of the frames will run the to[illegible]
in the other fame the difference I - i.

The resistors of the system are chosen so that [illegible]
pressure is measured, the values of current[illegible] and [illegible] of
intensity. Thus, in the frame II the current [illegible] zero
in the frame I it will reach a double value. In this [illegible]
mobile system of the logometer will occupy a position along the
axis of the frame I and the pointer on the [illegible]
zero pressure value /fig.113a/. When the [illegible] are
its maximum values, the currents I and i [illegible] and the
mobile system of the logometer occupies a [illegible] with the
axis of the frame II and the pointer of the [illegible] indicates the
maximum value of pressure /fig.113,c/. When the source is
disconnected, the pointer of the logometer returns to zero of the
scale with aid of an additional immobile magnet, [illegible]
with the mobile magnet /see fig.112/.

For compensation of the thermal errors of the [illegible], c[illegible]
by change of resistances of the frames of the [illegible]
the resistor R_4, made of copper wire. The co[illegible]tion is
formed in the following manner. When the t[illegible] the
air drops, the resistance of the frames is [illegible] which
about increased value of the current i and [illegible]

I and i, which should equal in the ends

of the mobile contact. In order to eliminate this dependence of the equality of currents, it is necessary to make the current I to increase equally with the current i.

This is secured in the case, when a part of the total resistor of the half-diagonal R_4 is made of copper wire. It is very easy to learn, that in the middle points of the scale no thermal error occurs.

The resistance of the connecting leads is very low as compared with the resistance of other elements of the system and therefore it has no influence on the readings of the logometer.

3. Oil Thermometer. The diagram of function of the oil thermometer is shown in fig.114.

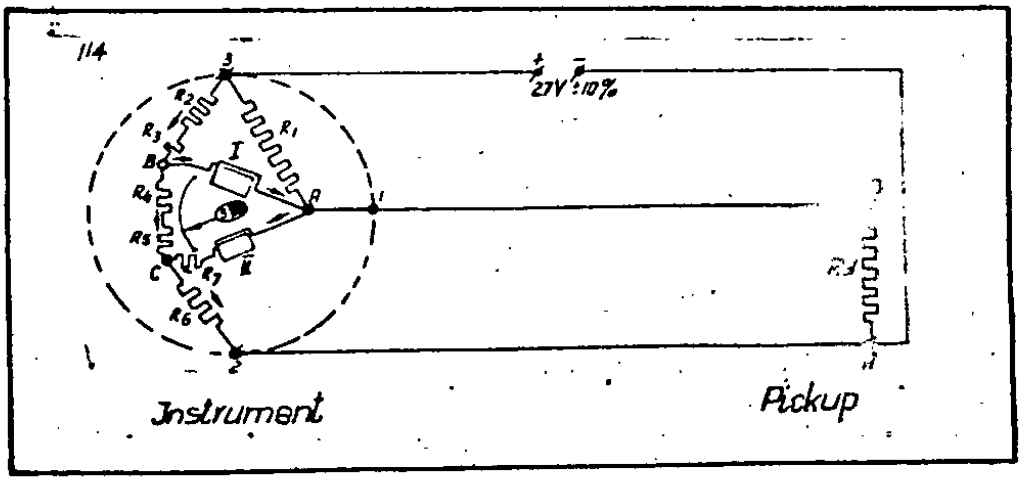


Fig.114. Diagram of Measuring System of the Oil Thermometer.

The function of the oil thermometer is based on utilization of the phenomenon that the heat measuring element of the pickup /nickel wire/ changes its resistance with the change of temperature of the measured space. To each value of measured temperature

corresponds only one [illegible]

The resistance of the pick-up is [illegible] an magneto-electric logometer. [illegible] of oil thermometer, is generally [illegible] used in the oil pressure gauge. The frames [illegible] meter are connected into a bridge system, [illegible] Wheatstone's bridge by two diagonals AB [illegible].

The system of the instrument is calculat[ed] [illegible] temperature of -50°C, when the resistance [illegible] ohms, the potentials of the points [illegible] and C [illegible] and the potential of the point B is higher [illegible].

In the frame I from point B to point A [illegible] run, but in the frame II no current will occur, [illegible] occupy a position along the axis of the fra[me] [illegible] of the instrument will indicate a temperature [illegible].

When the temperature will increase, the pi[ckup] [illegible] will increase, too, and simultaneously the po[int] [illegible] A will increase. At a temperature of + 50°C the [re]sistance pickup will reach 10,8 ohms. Now the difference of p[otentials] between the points B and A will equal the differ[ence] between potentials A and C. Current will run from B to A and f[rom] C whereat the currents in the frames will be mutually e[qual]. The mobile magnet will occupy the middle position and [the] pointer will show a temperature of + 50°C.

When the temperature goes on to increase, [the] potential the point A will approach the potential B and [then] morestill more the potential of the point C. The curr[ent] in frame I will drop and in the frame II it will [increase]

temperature of the measured space reaches + 150°C and the resistance of the pickup will be 153,25 Ohms, the current in the frame I will be zero and the current in the frame II will reach its maximum value. The mobile magnet will occupy a position along the axis of frame II and the pointer of the thermometer will indicate a temperature of 150°C.

For compensation of the thermal errors of the system as result of variation of resistance of the logometer frames during variation of ambient air temperature, there are used resistors R_2 and R_4 made of copper wire. The variation of the logometer frames resistance causes change of correlation of the currents and consequently a change in direction of the magnetic field. The values of resistors R_2 and R_4 are chosen so that the corresponding changes of potentials of the points B and C at different temperatures of ambiat air will correct the relations of currents to the values, corresponding to the normal temperature. The resistors of the cinnecting leads 1-B and 2-A are part of the system of the instrument, but in case of a correct assemblying, when the minus of feeding is connected immediately at the pickup, these leads are parts of two opposed arms of the bridge and thus they compensate each other.

Variation of voltage of the source of current in the thermometer system analogically as in the system of the oil pressure gauge, causes no additional errors.

Kinematic System and Design of the Instrument.
Indicator EMI-3R.

The indicator EMI-3R consists of three independent measuring elements - for fuel pressure, oil pressure:

and oil temperature, assembled in one base and covered by a body. In the front part of the body from inside is fastened the glass by means of a stamped ring. The side of glass, facing inside the instrument, is coated by a thin layer of gelatine, serving for protection of the glass against fogging. Each measuring element is fastened to the base of the indicator by means of a nut, screwed on on the connector plug. For levelling of scales of all three measuring elements during assembly is mounted a holder of the dials.

The body is fastened to the base by four screws. The round rubber insertion, inserted into a special groove of the base, serves the inner cavity of the indicator from intruding of splashes and dust.

The measuring element of the fuel pressure gauge consists of a logometer, a bridge with resistor coils and of a connector plug. The male connector is fastened to the bridge by two screws. Between the bridge and the electric connector is inserted a rubber shock absorber, serving for compensation of different height of the measuring elements. In the front part of the logometer to the stands is fastened a bearing, to which is fastened a scale dial. The main measuring element is a logometer of magneto-electric type with revolving magnet and immobile frames /fig.115/.

The axle 1 with journals 2 of cobalt-tungsten, the magnet with shroud 3 made of ALNICO alloy and the cross-piece with the balancing weights 4 form the mobile system of the logometer. One end of the axle journal enters the stone bearing 5 and leans on stone support 6, fastened in a damper 7. The end of the axle with the long journal runs through a stone bearing of the regulating screw 8, which is screwed in into the bridge 3.

To this end of the axle is fitted by [illegible] bush the pointer of the measuring element.

The mobile magnet is placed inside the copper damper, covered by the cover of damper. When the mobile system oscillates, in the damper the Foucault currents are generated, which brake the oscillations and thus dampen the pointer of the instrument. On the damper are fitted two pairs of frames 10 and 11, placed at mutual angle of 90°. The pair of frames 10 is inner, the pair 11 - outer. The frames of each pair are placed parallelly witch each other at a distance of damper projection and are fastened in such position by means of elastic metal yokes 12. For returning of the pointer into its initial position when feeding is stretched off, the immobile additional magnet 12 is fitted in a special yoke between the outer frames of the logometer.

Through the openings in the damper are running the stands of the logometer 14, which clamp by means of nuts 15 the cover of the damper with the damper. In the front part of the logometer to the stands by two screws is fastened the bridge. From the opposite side, also by two screws, is fastened a washer 16, which serves as base of the logometer.

The permalloy screen 17, enclosing the magnetic fields of the frames of the logometer and simultaneously protecting the logometer from influence of outer magnetic fields, is fitted freely on the logometer and its centre position is secured by groove on the washer 16.

The logometer together with the bridge and with the electric connector from an easily removable measuring element, which

allows a rapid exchanging of same in case of defect without disturbing of function of the indicator as a whole.

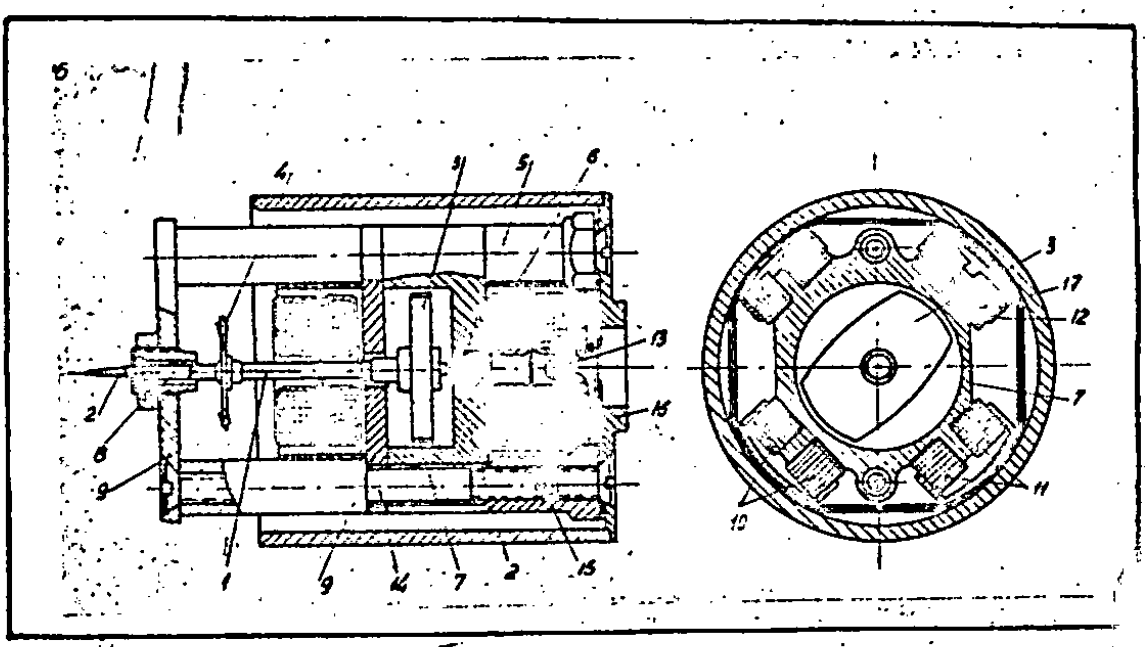


Fig.115. Logometer of Fuel Pressure Gauge.

1-axle, 2-cone journals, 3-magnet with shroud, 4-balancing weights, 5-stone bearing, 6-stone support, 7-damper, 8-regulating screw, 9-bridge, 10-small frames, 11-large frames, 12-yokes, 13-magnet, 14-stands, 15-nut, 16-washer, 17-screen.

The measuring element of the oil pressure gauge and oil thermometer. In principle, the design of the oil pressure gauge and of oil thermometer measuring elements does not differ from the design of the fuel pressure gauge measuring element. The differencies consist in forms of the scales and of the scale dial, and also in design of the logometer. The design of oil pressure gauge and oil thermometer logometers is the same /fig.116/.

Freedom of revolution of their mobile systems is limited, because their measuring systems allow deflection of the pointer only by 120°. Therefore the axles of the mobile systems 1 of the logometer with the conical journals 2 serve as supports; the pointer with cross-piece 3 is fitted directly on the axle.

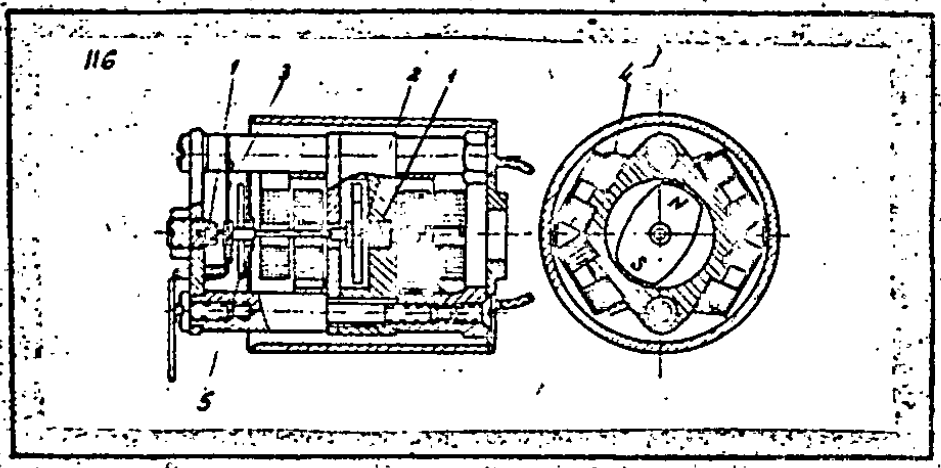


Fig.116. Logometer of Oil Pressure Gauge.

1-mobile system, 2-conical journals, 3-cross-piece, 4-washers, 5-returning magnet.

Besides that, the frames of the logometers are placed at 120° angle in pairs to each other and are fastened on the damper by means of two elastic square insertions 4, clamped by the stands. The projections of the damper, on which the stands lean, are placed also at 120° angle. The returning magnet 5 is placed on a special yoke in the upper part of the logometer and has freedom of revolution round the axle of the logometer. The logometers of the oil pressure gauge and oil thermometer differ from each other only by position of the poles of the returning

magnet 5. The pole S of the magnet of the mobile system is always placed below the pointer and the returning magnet is placed in such a manner, that the pole N is always directed to the pointer. The kinematic system of the oil pressure gauge and of oil thermometer is shown in fig.117.

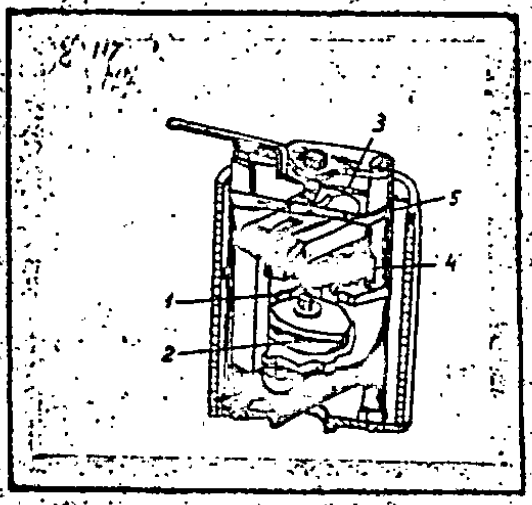


Fig.117. Kinematic System of Oil Pressure Gauge and Oil Thermometer.

1-mobile system, 2-conical journals, 3-cross-piece, 4-washers, 5-returning magnet.

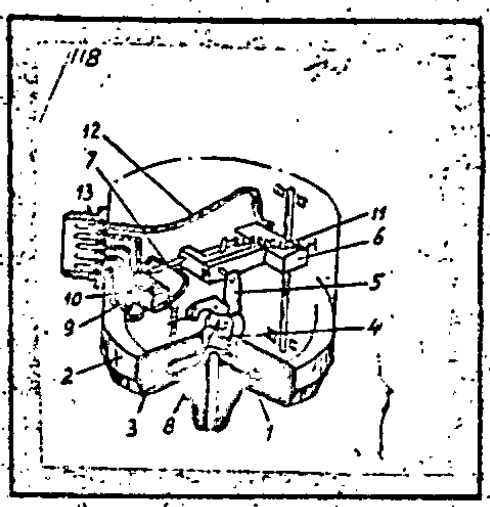


Fig.118. Kinematic System of Fuel Pressure Gauge Pickup.

1-membrane, 2-base, 3-cover, 4-rod, 5-rocker, 6-tang, 7-brush holder, 8-regulating stop, 9-brush, 10-rheostat, 11-return spring, 12-flexible lead, 13-male connector.

Fuel pressure gauge pickup. The kinematic system of the fuel pressure pickup is shown in fig.118. The sensitive element of the pickup is the membrane 1, fastened between the base 2 and cover, 3.
The measured pressure is led into the cavity under the membrane through the neck, made as one piece with the base. When pressure rises, the membrane 1 is bent and pushes the rod 4,

which depresses one of the arms of the rectangular rocker 5. The rocker turns and shifts by its other arm the tang 6, connected with the brush holder 7. The tang together with the brush holder turns round the axle, whereat the mobile contact /brush/ 9 slides on the rheostat 10, wound on a bakelite frame.

The return travel of the mechanism during drop of pressure is secured by the return spring 11.

The current is led to the brushes by means of the flexible lead 12. The contacts of the male connector 13 are connected with outlets of the rheostat by multicore leads in a polyvinylchloride insulation.

The multiplying-transmitting mechanism of the pickup and the electric system of the pickup are mounted inside of the aluminium splash-proof body, fastened together with the sensitive element by four screws.

For protection of the membrane from breakdown in case of excess pressure a regulating stop 8 is provided, which is screwed in into the cover of the sensitive element. The body of the pickup is covered by a cover, fastened by a threaded ring. The design of the fuel pressure gauge pickup is shown in fig.113.

Oil pressure gauge pickup. The kinematic system of the oil pressure gauge pickup is shown in fig.120. The design of the pickup of oil pressure gauge corresponds to the design of the fuel pressure pickup, but differs by thickness of the corrugated membrane. Besides that, the oil pressure pickup is differential, therefore the body of the pickup is made hermetical and has a static pressure neck 14, through which the atmospherical pressure is led to the outer side of the membrane 1. The rheostat

10 of the pickup, in accordance with the diagram of [illegible] system (fig.112), has no intermediary outlets and the electric connector 13 has three pins. The design of the pickup of oil pressure gauge is shown in fig.121.

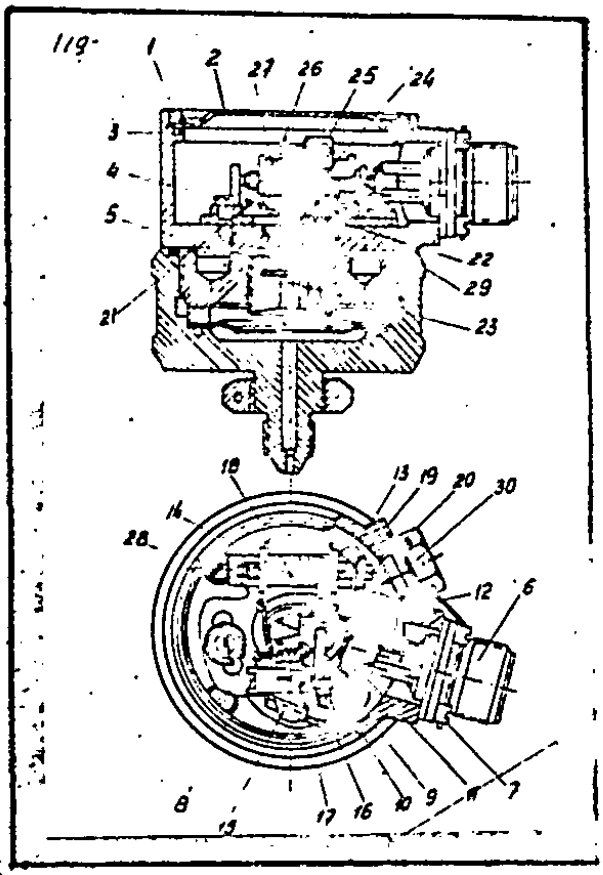


Fig. 119. Fuel Pressure Gauge Pickup.

1-threaded rim, 2-cover, 3-ring, 4-screw, 5-[illegible] nector, 7-screws, 8-spring, 9-screw, 10-limiter, 11-flexible lead, 12-block, 13-brush-holder, 14-brush, 15-weight, 16-lock screw, 17-axle, 18-potentiometer, 19-lock washer, 20-regulating screw, 21-spring, 22-screw, 23-rod, 24-lock screw, 25-axle of rocker, 26-rocker, 27-bush, 28-screw, 29-sealing insertion, 30-plug.

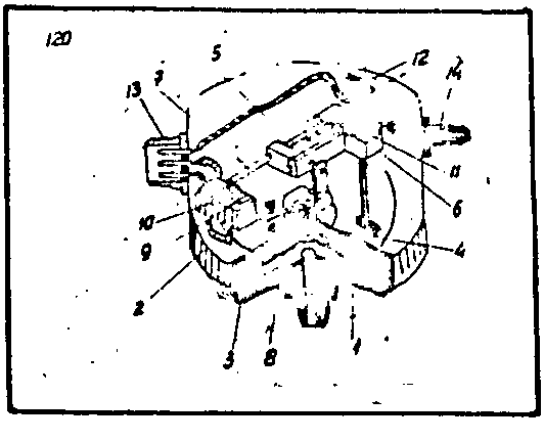


Fig.120. Kinematic System of Oil Pressure Gauge Pickup.

1-membrane, 2-base, 3-cover, 4-rod, 5-rocker, 6-tang, 7-brush holder, 8-regulating stop, 9-brush, 10-rheostat, 11-return spring, 12-flexible lead, 13-male plug, 14-static neck.

Thermometer pickup. The thermometer pickup /fig.122/ has an undismountable design. It consists of the following main parts: temperature detecting element, fittings and electric connector.

The heat pickup element consists of a nickel not insulated wire 1, wound on mica plates 2. In parallel with the nickel winding is connected a spiral 3 made of manganine wire, serving for correction of the thermal factor of the nickel wire. From both sides of the heat pickup element are thin mica insulating plates 4, over which are placed silver heat-conducting spring plates 5. The heat pickup element is connected with the electro-insulating head 6 of the pickup by two hollow rivets. In the head are fastened two pins of electric connector.

The pickup fitting consists of the jacket 7 and of electric connector 8, made of rustfree steel and soldered together by silver alloy.

The heat pickup element with the electro-insulating head

is inserted into a fitting and is fastened by a set screw. The sealing rings 10 and 11 secure tightness of the pickup. The electric connector 8 serves for connection of the pickup to indicating instrument in the cabin.

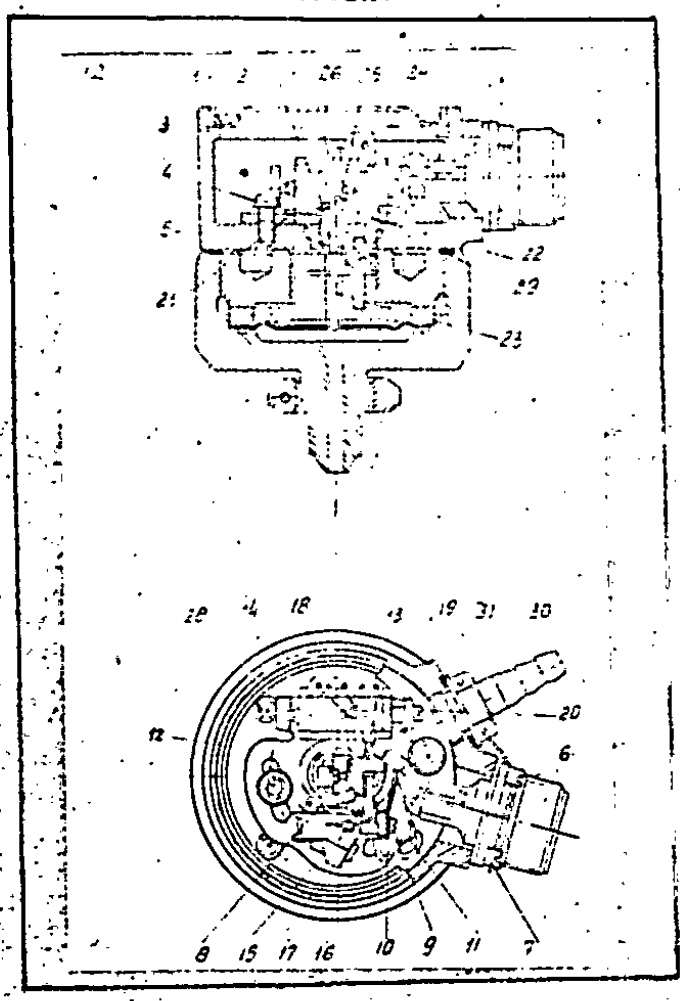


Fig.121. Oil Pressure Gauge Pickup.

1-threaded rim, 2-cover, 3-ring, 4-screw, 5-body, 6-electric connector, 7-screw, 8-spring, 9-screw, 10-limiter, 11-flexible lead, 12-block, 13-brush holder, 14-brush, 15-weight, 16-lock screw, 17-axle, 18-potentiometer, 19-lock washer, 20-regulating screw, 21-spring, 22-screw, 23-rod, 24-lock screw, 25-axle of rocker, 26-rocker, 27-bush, 28-screws, 29-sealing insertion, 30-static neck, 31-sealing insertion.

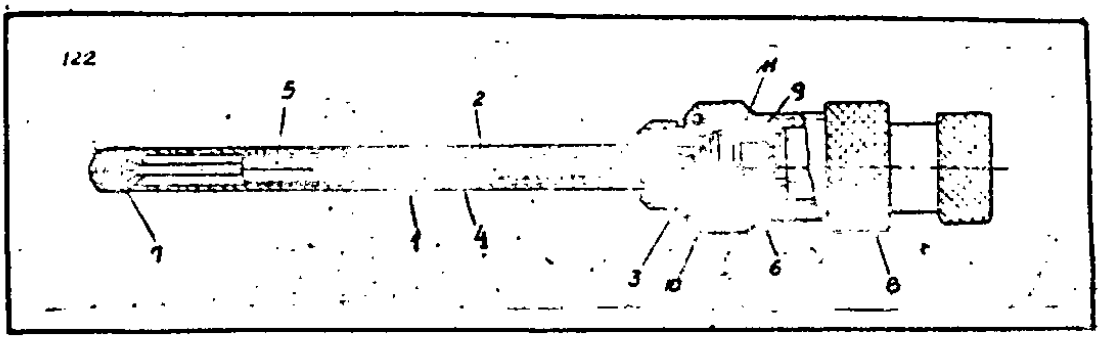


Fig.122. Thermometer Pickup.

1-nickel wire, 2-mica plate, 3-spiral, 4-insulating insertion, 5-elastic plates, 6-head of the pickup, 7-jacket, 8-electric connector, 9-spiral nut, 10 and 11-insertions.

The Electric Remote-control Pressure Gauge EM-100.

The EM-100 fuel pressure gauge is designed for measuring of fuel pressure before the burners of afterburner fuel coolector, when the engine operates with the afterburner.

The EM-100 pressure gauge consists of the indicator UM-47E and fuel pressure pickup I-100. The electric, kinematic and design system of the EM-100 fuel pressure gauge is analogical with the fuel high pressure gauge of the EMI-3E instrument. The logometer of EM-100 pressure gauge is enclosed in a round body, which serves as screen. To the stands, fastened on the base of the logometer, is screwed a dial plate with a round scale.

Main data.

Range of measuring	from 0 to 100 atm.
Working range	from 10 to 90 atm.

Permissible errors of reading of the instrument:

Checked points of scale atm.	Permissible errors at temperatures:			
	+ 20°C	+ 50°C	-45°C	-60°C
10,20,40,60,80,90	± 3	± 5	± 5	± 6
0, 100	± 5	± 8	± 8	±10

The variation of the reading /hysteresis/ at normal temperatue does not exceed 3 atm at points 40,60,80. Current intensity, consumed by the instrument, does not exceed 0,1 atm.

The UP-47K indicator is mounted on the instrument panel of the aircraft.

The pickup P-10C is mounted on a bracket, which is fastened by fastening bolts of the intake nozzle of 5th combustion chamber to the body of the compressor.

Exhaust Gas Thermometer Type TGZ-47.

For measuring of exhaust gas temperature after the engine turbine is used gas thermometer type TGZ-47, which is a thermoelectrical instrument, consisting of a milivoltometer and of two thermocouples, connected in series and measuring the mean exhaust gas temperature in four points.

The TGZ-47 thermometer consists of: pickup /four thermocouples/, indicator /1 piece/, terminal box /1piece/ connecting leads from pickup to terminal box /4 pieces/ and from the terminal box to the indicator /1 piece/.

The thermometer has the following characteristics:

1. Range of measuring 400-900°C
2. The thermometer operates correctly

at ambient air temperature from + 50°C to - 60°C.

3. Error of the instrument within the working range of the scale:

At ambient air temperature °C:	Error in range of readings	
	750 - 500°C	600-450°C
+ 20	± 12	± 16
+ 50	± 17	± 13
- 60	± 24	± 24

On the remaining part of the scale a basic error is permitted of ±20°C.

4. The resistance of the outer circuit /thermocouples and connecting leads/ is 2 Ohms.

5. The thermocouples and indicators are interchangeable within the same group. It is not allowed to connect together the indicator and thermocouples of different groups /graduations/.

The basic electrical diagram of the IGZ-47 thermometer is shown in fig. 123.

The influence of gas flow velocity on the readings of the instrument is eliminated by braking of the gas flow, passing over the hot soldered thermoelectrodes. The materials of the thermocouples are chosen so as to obtain first thermo-electric dynamical power at 300°C. Therefore the temperature of a free end of the thermocouple, varying from -60°C to + 50°C has no practical influence on the value of the thermo-electric dynamical power. Owing to that no compensating leads are necessary.

The value of the thermo-electric dynamicl power is read on a milivoltmeter, connected to the thermocouples and the scale of which is given directly in degrees of Centigrade.

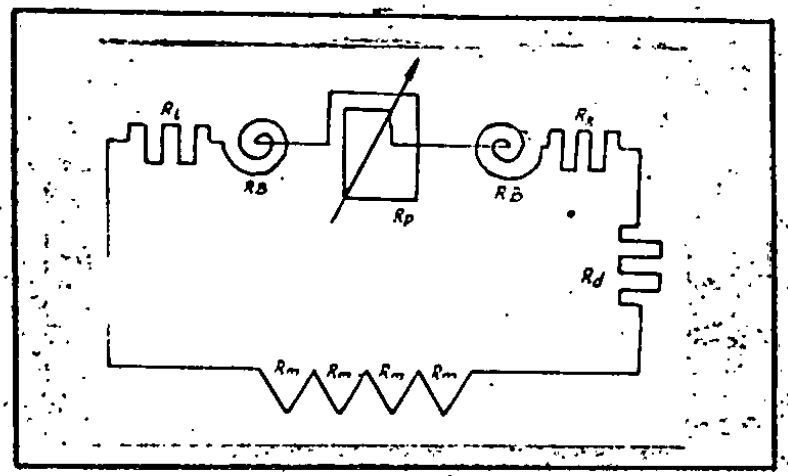


Fig.123. Basic Electrical Diagram of TSZ-47 Thermometer.

Design of the Thermometer.

The thermocouple /fig.124/ is a steel body 15 and tube 19, made of heat resisting steel. In the tube two thermoelectrodes 20 are inserted, forming a hot-soldered connection. The positive is made of nickel-cobaltum alloy and the negative is made of allumel. Inside the tubular fitting of the thermoelectrodes are insulated from each other by a ceramic tube 18. Inside the body the thermoelectrodes are bent in an angle of 90° and are insulated by ceramic bushes 4 and 5. In order to relieve the thermoelectrodes from external tensile strains during assembling and from vibration in the aircraft, the ceramic bushes are fastened through a spring 2 and nut 3 thus they themselves clamp the electrodes.

The gas flow enters the space, surrounding the bimetal through a cutout 21 in the tube 19 and escapes through the opening 22, owing to which the gas flow velocity is considerably reduced.

For protection against mechanical damaging the thermoelectrodes are enclosed into a metal sheat; the latter is enclosed into a metal sleeve 12, which is connected to the body by a union nut 13 and is fastened on the sheath by wedges 14.

The nut 11 fastens by two wedges 10 the sleeve 12 on the metal sheath.

In order to exclude the possibility of a mistake in determing the poles of electrodes, the plus electrode from the nickel-cobaltum alloy is made shorter tha the minus outlet from the alumel electrode.

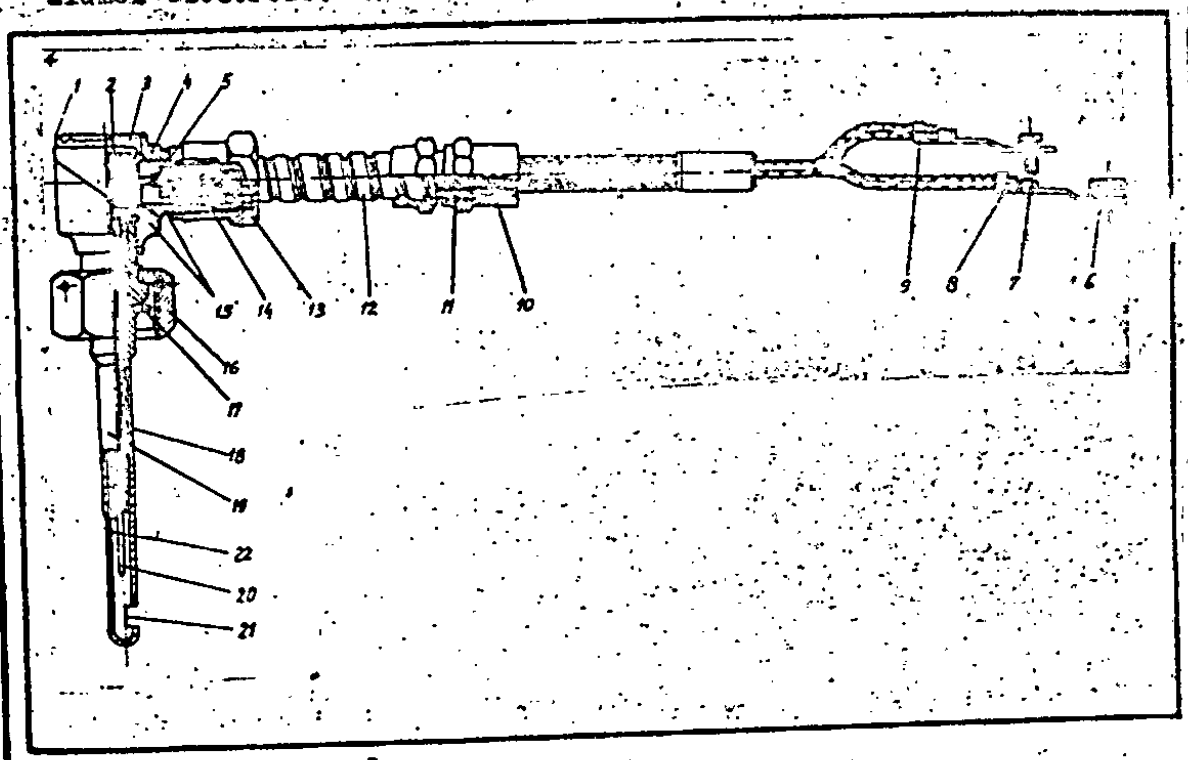


Fig.124. Pickup of TGZ-47 Thermometer.

1-screw, 2-spring, 3-nut, 4-5 - ceramic bush, 6-7-8-9 - special terminal, 10-wedges, 11-nut, 12-metalic sleeve, 13-union nut, 14-wedges 15-body, 16-nut, 17-pin, 18-ceramic tube, 19-tube, 20-two thermoelectrodes, 21-cutout, 22-hole.

The thermocouples are connected to the connecting leads by means of special terminals 7 and 6. The thermocouple on the afterburner is fastened by a nut 16. On this nut is indicated the graduation group fo the thermocouple, No.of the thermocouple and year of delivery.

In the thicker end of the tube 19 is pressed in a peg 17, which at the assembly of the thermocouple must enter the groove of the neck on the afterburner.

The indicator is a vibration-proof magneto-electric milivoltmeter. The design of the indicator is given in fig.125.

The U-shaped magnet 29 by means of the yoke 26 if fastened on the duralumin plate 40. To the same plate are screwed the pole terminals. The mobile system of the milivoltmeter is assembled in a holder 37, which is fastened by two screws on the pole bodies. The frame 34 revolves in a gap between the core and the pole bodies. To the frame on special surfaces the cobalt-tungsten journals 32 are fastened, which lean on the corund bearings 31, which are pressed in into the brass screws 30.

The counter-torque in the apparatus is effected by two counter-springs 33, which serve simultaneously as conductors of current to the frame. For a better damping of the mobile system the holder plate 40 is seated on rubber shock absorbers 23, which are put on screws 24.

From the outer side of the base 36 is placed a silit resistor 41, serving for reducing of thermal errors of the instrument and the coil of adjusting resistor. Thus the resistance of the instrument can be adjusted without removing the body 27.

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On the place where the body touches the collar of the

base, is inserted a rubber sealing ring 42 for a complete tightening. In order to exclude influence of magnetic field of the indicator on ther instruments of aircraft, the instrument is provided by an outer screen 25, inner screem 35 and an iron scale pad. For elimination of incorrect connection the outlets are made in different diameters according to the diameters of holes in the terminals of the connecting lead,

Thus, the plus must be directed to the outlet of the indicator with larger diameter, which has also a mark + at the base.

For arresting of the indicator its outlets are short-circuited by a copper lead. When transported and stored, the indicator must be arrested /gauged/.

The leads, connecting the thermocouples with the terminal box, have on one end terminals for connection to thermocouples and on the other end - the terminals for connection to the terminal box. All terminals, leading to terminal box, are numbered in order to secure a correct connection and are connected according to diagram of connection.

The conductors, leading from the terminal box to the indicator, have terminals: one of them /of larger diameter/ is connected to the plus of the instrument, the other /smaller diameter/ - to the minus. The resistance of the connecting leads should be 0,4 $\pm$ 0,02 Ohms.

The terminal box serves for series connection of four thermocouples, placed on the afterburner, and their connection to the indicator.

The terminal box is made of plastics and has five numbered clamps.

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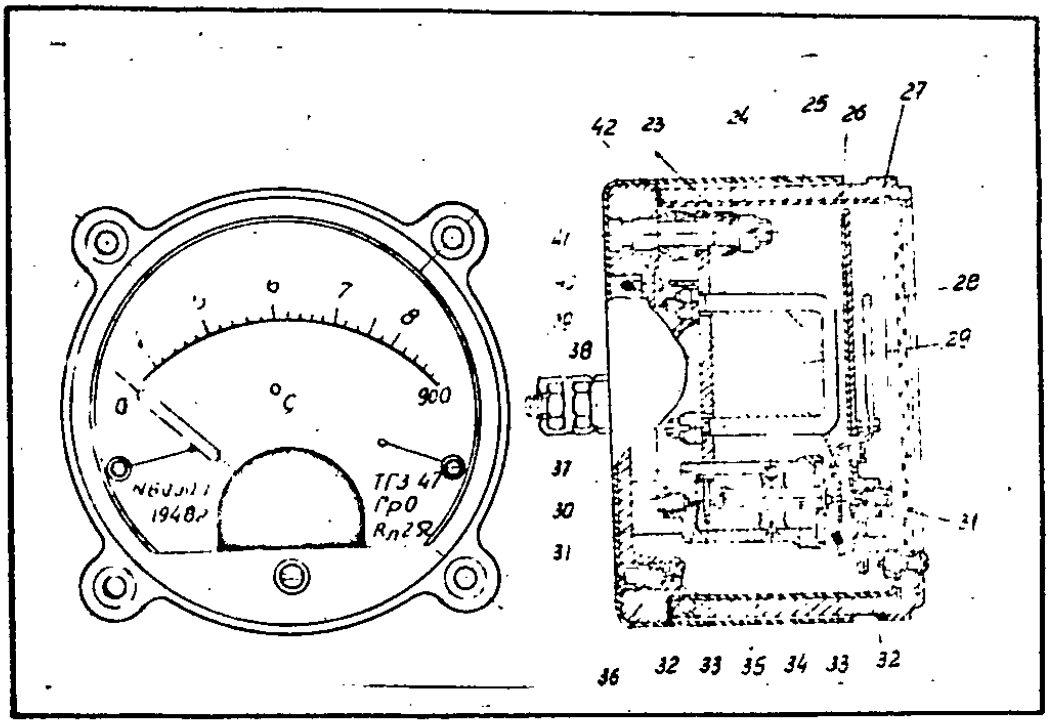
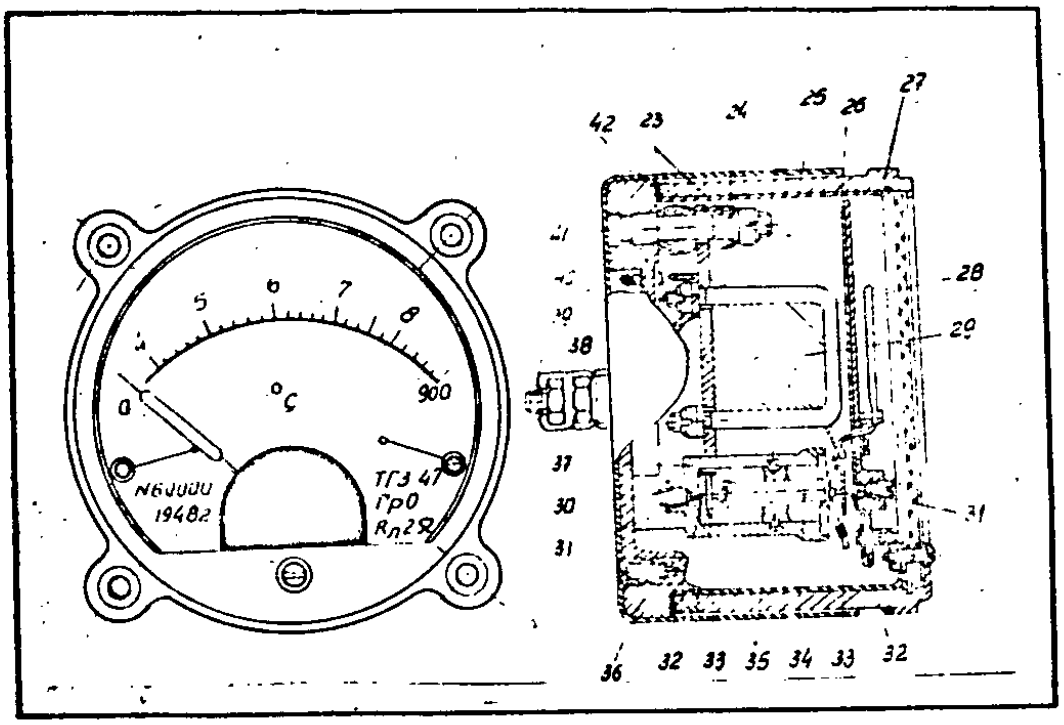


Fig.125, TGZ - 47 Indicator.

23-rubber shock absorbers, 24-screws, 25-outer screen, 26-iron scale pad, 27-body, 28-yoke, 29-J-shaped magnet, 30-brass screws, 31-corund bearings, 32-journals, 33-counter acting springs, 34-frame, 35-inner screen, 36-base, 37-holder, 38-39-outlets, 40-holder plate, 41-silit resistor, 42-rubber rings.

From upside the terminal box is covered by a cover. The pickups for measuring of the exhaust gas temperature are mounted on the afterburner in four specially provided necks and are fastened by four union nuts. While mounting it is necessary to take care that the peg of the thermocouple enters the cutout of the neck, by which a correct position of the cutout in the tube of the thermocouple in relation to direction of gas flow will be secured.

In order to secure the correct and reliable function of the thermocouple, it is necessary to install the free ends of the thermocouple in a zone of "normal aircraft temperatures" and in this zone the connecting leads should be connected.



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When connecting the thermocouples to the connecting leads it is necessary to secure a reliable connection of the terminals of thermocouples with the leads. The connection point of the leads after accomplishing of assembly must be carefully insulated from each other and from the engine body. The indicator is mounted on the instrument panel of the aircraft and is fastened to same by four screws.

By the screw of the corrector the pointer of the indicator is adjusted to the zero mark, after which the lead, short-circuiting the instrument, should be removed and the connecting leads should be connected.

The leads are connected in the terminal box according to the numbering, marked on the terminals of the leads. The leads should be installed in places, protected against direct contact with hot parts of the engine structure.

Correctness of assembly should be tested in the [illegible] manner.

While the engine is running /the thermocouples are warmed up/, mark the readings of the indicator. Remove the cover from the terminal box by a copper lead effect a short-circuiting of each pair of clamps of the terminal box. The readings of the indicator must drop by an equal value.

Fuel Pressure Switch Type SD-3.

The fuel pressure switch serves for warning of fuel pressure drop in the low pressure line of the fuel system below the lower limit.

Characteristic of Function.

The fuel pressure switch switches on the warning lamp at fuel pressure drop below 0,3 atm. The instrument operates in the range of ambient air temperature from + 80°C to - 60°C.

The instrument is calculated for switching on and off of a 5 W warning lamp at tension of 27 V ± 10 per cent.

Error of commutation of the pressure switch at normal temperature and at temperatures from + 50°C to - 60°C does not exceed ± 0,05 atm.

The tightness of the instrument must meet the following requirements:

a/ for pickup part of the presure switch - at air pressure 5 atm. during 10 minutes no drop of pressure on the control pressure gauge must be recorded.

b/ for body of the instrument - when simultaneously into the static and dynamic systems a 300 mm mercury pressure is led, during one minute the pressure drop must not exceed 8 mm mercury.

The instrument holds on overload by dynamic pressure of 5 atm. during 5 minutes.

Resistance of insulation of the instrument at normal temperature and at relative humidity from 30 to 80 per cent minimum 20 M.

Principle of Function.

The principle of function of the pressure switch is based on a functional dependance of elastic deformation of the sen-

sitive element upon the fuel pressure. The principle diagram of the pressure switch see fig 126.

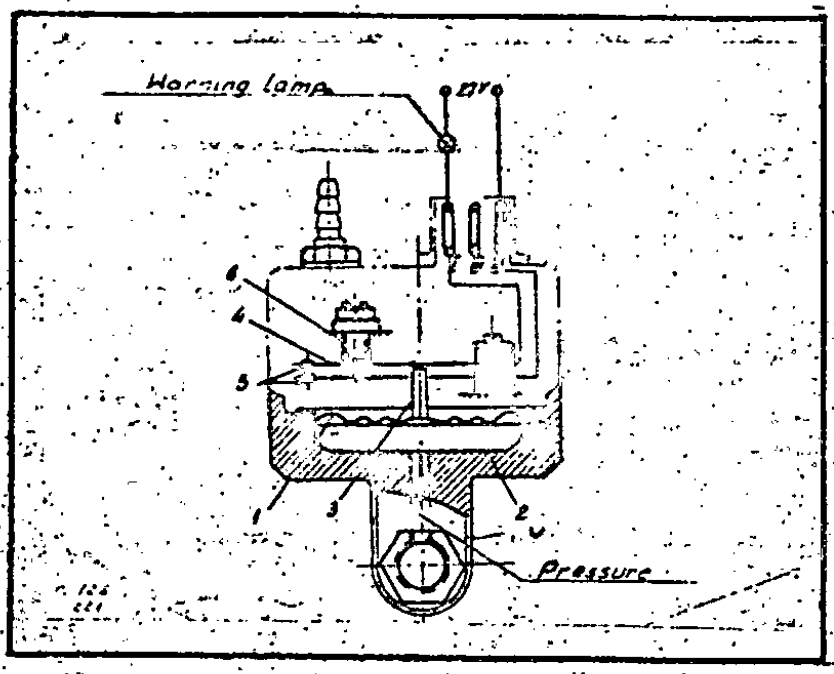

Fig.126. Diagram of Fuel Pressure Switch.

1-membrane, 2-body, 3-rigid pin, 4-upper spring, 5-contacts, 6-regulating screw, I-II-III - clamps for connection of the instrument.

The fuel pressure acts on an elastic membrane 1, fastened in the body 2. When fuel pressure is changed in the low pressure line, the rigid stem 3 is shifted together with the upper contact spring 4 and connects or disconnects the contacts 5. When pressure of fuel in the system is above 0,3 atm., the contacts of the flat springs are disconnected. When pressure drops under 0,3 atm., the contacts are connected, by which the warning lamp is switched on.

The regulating screw 6 serves for regulation of gap between the contacts and for adjustment of the instant, when the commutation is effected.

As to design the pressure switch is made as follows : /fig.127/.

As sensitive element of the instrument serves the elastic corrugated membrane 1 with a corrugation of a trapezoidal profile, securing a sufficient strenght of the membrane. The sensitive element is fastened in a body 2 by means of a ring 3, clamped by a nut 4. The pickup part of the body is separated hermetically from the membrane. The ring 3 secures the necessary clearance between the membrane and the nut. The nut 4 serves simultaneously as a stop for the membrane 1. The fuel pressure is transmitted through an eyelet of the pressure switch body to the membrane. When pressure of fuel in the system is changed the membrane travel is transmitted through the rigid stem 5 with the insulating terminal 6 to the upper flat spring 7., which is in constant touch with the insulating terminal. On the end of the spring is fastened the contact 8.

When the spring is bent, the contact 8 gets connected or disconnected with the contact 9 on the lower flat spring 10. By one end both springs together with the insulating insertions 11 are fastened to the nut 4 by means of two screws 12. Position of the upper flat spring is determined by the insulating terminal 6 of the rigid stem 5.

Position of the lower flat spring is set by the insulating terminal 13 fastened in a regulating screw 14, by which the commutation of the pressure switch is regulated. The screw 14

in screwed in into the plate 15, fastened by two screws 16 and locked by nut 17. To the flat spring 7 and 10 are soldered the conductors 18 and 19, which are connected to the electric male contact 20, fastened by four screws 21 to the cover 22.

In order to avoid unscrewing of the electric contact, the screw 21 is locked by a wire. The cover is fastened to the body 2 by five screws 23, under which are inserted spring washers 24.

The body of the instrument is tightened and provided by a neck 25, which connects by means of a durite hose the inner cavity of the body with the static line og the aircraft, in which the pressure equals the atmospherical pressure.

Tightness of the body in places of connection in secured by sealing inserts 26, 27 and 28.

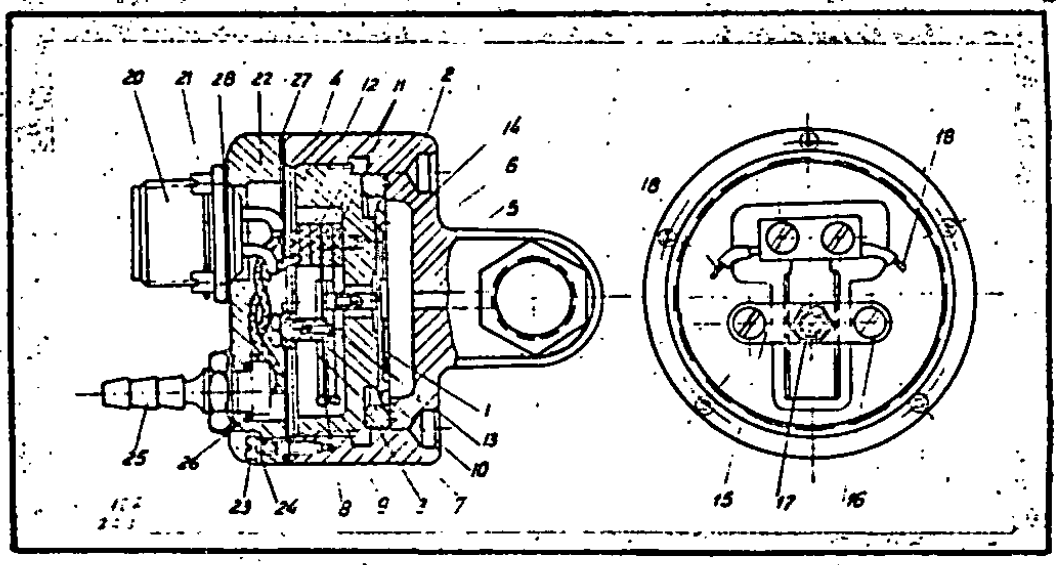

Fig.127. Design of Pressure Switch.

1-membrane, 2-body, 3-ring, 4-nut, 5-rigid stem, 6-terminal, 7-upper spring, 8-9 - contacts, 10-lower spring, 11-insertions, 12-screw, 13-terminal, 14-regulating screw, 15-plate, 16-screw, 17-nut, 18-19-conductors, 20-electric connector, 21-screw, 22--cover, 23-screw, 24-spring washer, 25-neck, 26,27,28-sealings.

Tachometer Type TE - 15.

The tachometer TE-15 is an electric instrument, serving for continous indication of rotational speed of engine rotor.

Technical Data.

a/ The teachometer TE-15 indicates the rotational speed for the engine rotor within the range from 0 to 15000 r.p.m.

b/ The indicator TE-15 hast two scales: the main outer scale from 5000 to 15000 r.p.m. with divisions per 100 r.p.m., on which the rotational speed of engine is checked at the take-off, rated and maximum cruising run of engine, and an auxiliary inner scale from 0 - 5000 r.p.m. with divisions per 1000 r.p.m., on which the rotational speed of rotor during starting is checked. The inner scale is written on the dial so that its marks are placed opposite the marks of the outer scale and therefore at the starting of the engine the rotational speed of the enegine rotor may be checked also on the main scale.

c/ Error of the tachometer set at the ambiet air temperature in indicator space ± 20°C, ± 50°C and - 60°C must not exceed the values, given in the following chart.

Range of measuring in r.p.m.	Error of set of the tachometer in per cents of nominal value of the scale and r.p.m. at temperatures:					
	+ 15-25°C per cent	r.p.m.	+ 45-55°C per cent	r.p.m.	- 55-65°C per cent	r.p.m.
1000 - 11000	±1	±150	± 1,6	±240	±2,6	± 390
1000 - 15000	±0,5	± 75	± 0,8	±120	±1,3	± 195

g/ The indicator works reliably at vibrational overloading of 1,5 kg with frequency from 20 to 80 c/s, the one-side divergence of the pointer of indicator within range from 2000 to 15000 r.p.m. must not exceed 1 mm on the scale, oscillation of pointer must not exceed ± 1 mm.

h/ Variation of readings of the indicator when tipped over by 90° to the left, to the right, or scale upside must not exceed the main error.

i/ Variation of inducations of the indicator during acceleration and deceleration must not exceed a double value of the main error.

j/ The indicator is splash-proof from the side of the glass

k/ The pickup holds good the vibrational overloading 4g with frequency from 20 to 80 c/s.

l/ Voltage on the clamps of the two phases of the loaded pickup at 12000 r.p.m/ according to indicator scale/ should be 18-3 V.

As pickup of the tachometer is used the three-phased a.c. generator type D-10, as indicator is used the magneto-inductance instrument type TE-15.

Principle of Action.

The principle of measuring of the rotational speed by the TE-15 tachometer is based on a synchronous transmission of the engine rotor revolutions and on measuring of angular speed of its revolution by means of magnet inductance indicator.

The shaft 1 of the tachometer pickup /fig.128/ is connected through an elastic clutch 2 to the engine rotor, which

makes revolve the rotor of the pickup 3.

When the rotor revolves, in the stator of the pickup a three-phased electric current is generated, which is transmitted by three conductors to the synchronous measuring motor.

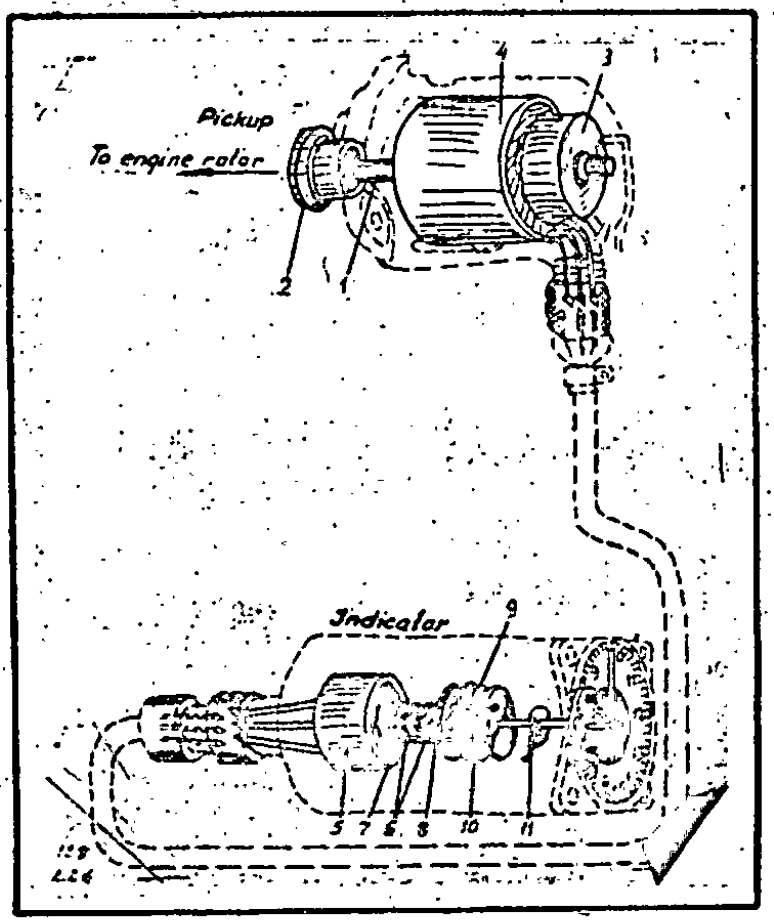

Fig.128. Basic Diagram of the Tachometer.

1-shaft of pickup, 2-elastic clutch, 3-rotor of pickup, 4-stator of pickup, 5-stator of measuring motor, 6-permanent magnets, 7-disk of hysteresis, 8-spring, 9-magnetic assembly, 10-sensitive element, 11-spiral spring.

In the winding of the startor 5 of the synchronous motor of the indicator by action of the current a revolving magnetic field is generated, which makes revolve the rotor of measuring motor, consisting of three permanent magnets 6 and of the hysteresis disc 7, fitted on a common shaft. The rotor revolves synchronously at the speed equal to the speed of the revolving field.

The permanent magnet serves for securing the starting and stabilized torque at low rotational speed, when the values of magnetic field are yet low. The task of the hysteresis disc is to form the starting torque at high speeds, when the power of the magnetic current is high, but when the permanent magnet itself cannot work synchronously. At high speeds /when the indicator is instantaneously engaged / the hysteresis disc makes the rotor shaft to revolve at a speed, approaching the synchronous value and then the permanent magnet accoplishes adjustment into the synchronous operation.

The permanent magnet is fitted freely on the shaft and is connected with it by means of a spring 8, through which it transmits the torque to the shaft of the synchronous motor. The magnet coneffect freely one turn and only after this one turn the shaft is connected. Purpose of this mechanism is to enable the motor to enter the synchonous operation already before accepting any load.

On the end of the shaft of the synchronous motor is fastened the magnet assembly 9, in the air gap of which is the sensitive element 10. When the magnetic assembly revolves, in the sensitive element Foucault currents are generated. In result of coaction of the Foucault currents with the magnetic field of the

Connection of the mounting conductors, running from the indicator to the three-phased stator of the pickup, is performed by means of an electric connector 13 and of a terminal box 14. The latter is mounted in the rear cover and is fastened to it by means of a fastening bush 15.

In order to prevent the terminal box and the bush from turning, a rivet 16 is provided.

Points of soldering of stator leads to the terminal box are protected by insulating tubes. The pickup is mounted on a special drive of the engine auxiliaries drive box.

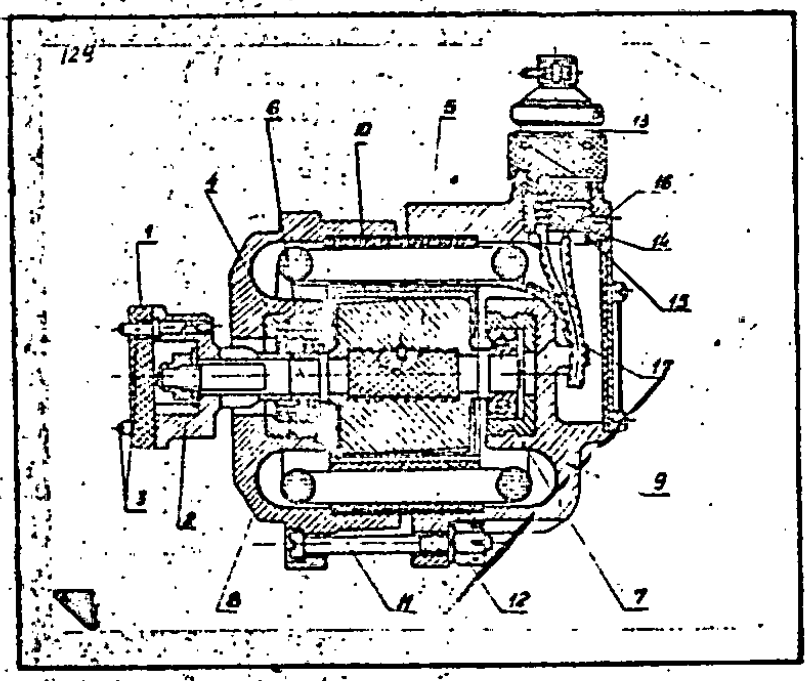

Fig.129. Design of the Transmitter.

1-washer, 2-flange, 3-pegs, 4-rotor shaft, 5-rotor, 6-7-ball bearings, 8-9 covers, 10-stator, 11-screw, 12-nut, 13-electric connector, 14-terminal box, 15-bush, 16-rivet, 17-conductors to the stator.

The design of the tachometer indicator is shown in Fig. 130.

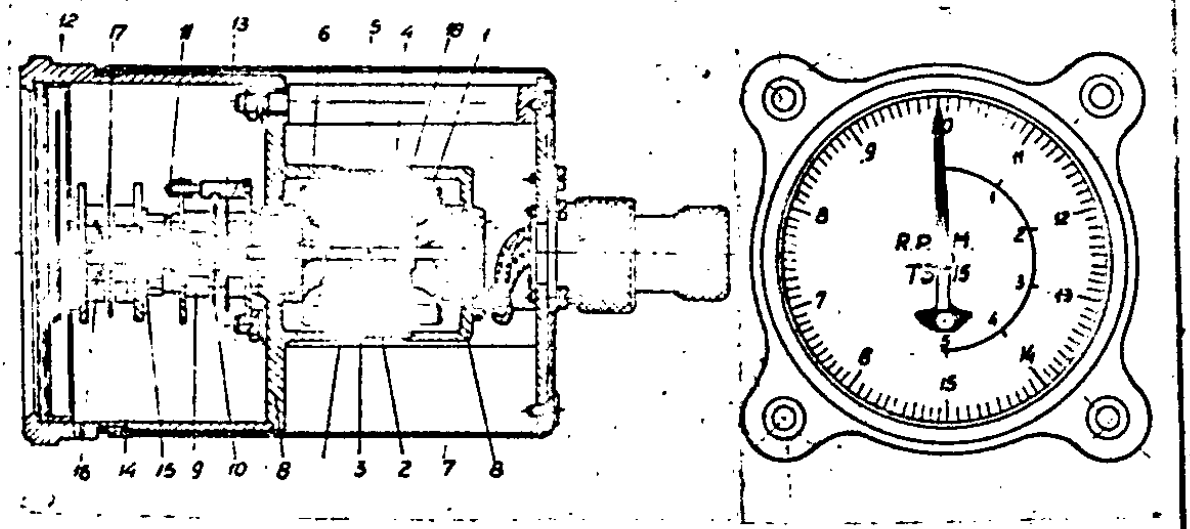

Fig.130. Design of the Tachometer Indicator.

1-starter, 2-rotor, 3-cross-shaped magnets, 4-hysteresis disc, 5-shaft, 6-spring, 7-ball bearings, 8-covers, 9-magnet assembly, 10-sensitive element, 11-axle, 12-pointer of scale, 13-shunt, 14-spiral spring, 15-washer, 16-magnets of damper, 17-disc of damper, 18-additional permanent magnet

The indicator of tachometer consists of the following assemblies, mounted in one body:

a/synchronous motor, b/measuring mechanism.

The synchronous motor consists of the stator 1, being a three-phased winding and rotor 2, made as two cross-like magnets 3. For increasing of the synchronous torque in the measuring motor an additional permanent magnet is provided, fastened on one bush with the hysteresis disc 4.

The magnets 3 and 18 are made of alloy, which has a great remnant inductance and coercitive power because they are subjit-

ted during starting of the engine to an action of a powerful magnetic field.

The rotor is fitted on the shaft freely and the longitudinal travel of it is limited by the hysteresis disc from one side and by the spring 6 from the other side. Through the spring 6 the rotor transmits the torque to the shaft. As suports of the shaft serve the ball bearings 7, inserted inside the motor covers. The covers 8 serve also for assembly of all remaining parts of the motor.

The end of the motor shaft protrudes beyond the front cover and on it the magnet assembly 9 is fitted, which serves as measuring part of the indicator. It consists of two bowl shaped plates with pressed-in cylindric permanent magnets.

The plates in this assembly are placed so that the opposite poles of the magnets are opposed to each other and they con-centrate the magnetic current around the outer edges of the sensitive element /disc/ for obtaining the maximum torque. The mechanism of the indicator has a sensitive element 10, placed in the air gap of the magnet assembly between the faces of the cylindrical magnets.

The pointer 12, fitted on the other end of the axle 11 of the sensitive element, indicates on the scale of the indicator the rotational speed of the synchronous motor and consequently also that of engine shaft.

The material of the sensitive element is an aluminium-manganese alloy, which has a low thermal factor of electric resistance, the variations of temperature causing no substantial errors of the readings on the instrument.

The thermal compensation in the TE-5 instrument is effected in the following manner: on the magnet in one half of the magnet assembly is put a shunt 13, made of a special alloy, the magnetic permeability of which drops with increasing temperature and grows with dropping temperature. When the ambient air temperature is unchanged, the shunt disperses from itself a part of magnetic current and thus it reduces the working process in the gap between the faces of the magnets of the magnet assembly.

When the temperature is increased, the working magnetic current in the gap grows owing to reduced dispersion by the shunt and, vice versa, when temperature drops, the magnetic current in the gap drops, because dispersion of the magnetic current by the shunt grows.

The mentioned changes of working current in the gap are coordinated with changes of the electric resistance of the sensitive element, thus preserving almost a constant value of torque of the mobile system, generated by the magnetic assembly.

Thus, the thermal error of the indicator is reduced to minimu owing to the existence of the thermal compensator.

The scale is evenly distributed through the whole range. Range angle of the scale is 540°.

The counteracting moment in the mechanism of indicator is effected by the spiral spring /hair spring/ 14, fastened by its inner end to the axle, by the outer end to the washer 15 and having a turn angle of 540°. In order to increase the stability of the pointer and for improving of checking the data

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of the instrument a magnetic damping of the mobile system of the indicator is provided.

The damper is a magnetic assembly 3, analogous with the magnet system. Between the faces of six pairs of magnets 16 is placed a disc 17, fastened on the axle of the mobile system of indicator. The magnetic assembly of the damper is fastened rigidly to the bridge of the indicator. When the mobile system of the indicator revolves, the magnetic current of the magnets of damper generates Foucault currents in the aluminium disc. As result of coaction of Foucault currents with the magnetic field of the magnets the mobile system is braked, the stability of the pointer being thus improved.

Connection of the leads from the pickup to the indicator is performed by a three-pin connector.

Fastening of the indicator on the pilot's instrument panel is performed by flange.

NOTICE: There is no special instrument for measuring of pressure in afterburner actuators hydraulic circuit, because measuring of pressure in the aircraft hydraulic system is performed by the pressure gauge, mounted on the pilot's control board.

Collector of Electric Leads.

All electric accessories and pickups of the instruments, mounted on the engine, are connected with the electric connectors SZP-23S /see pos.1/ and SZP-7S /see pos.29/ , braids of conductors, enclosed in the screened collector of leads /see fig.131/.

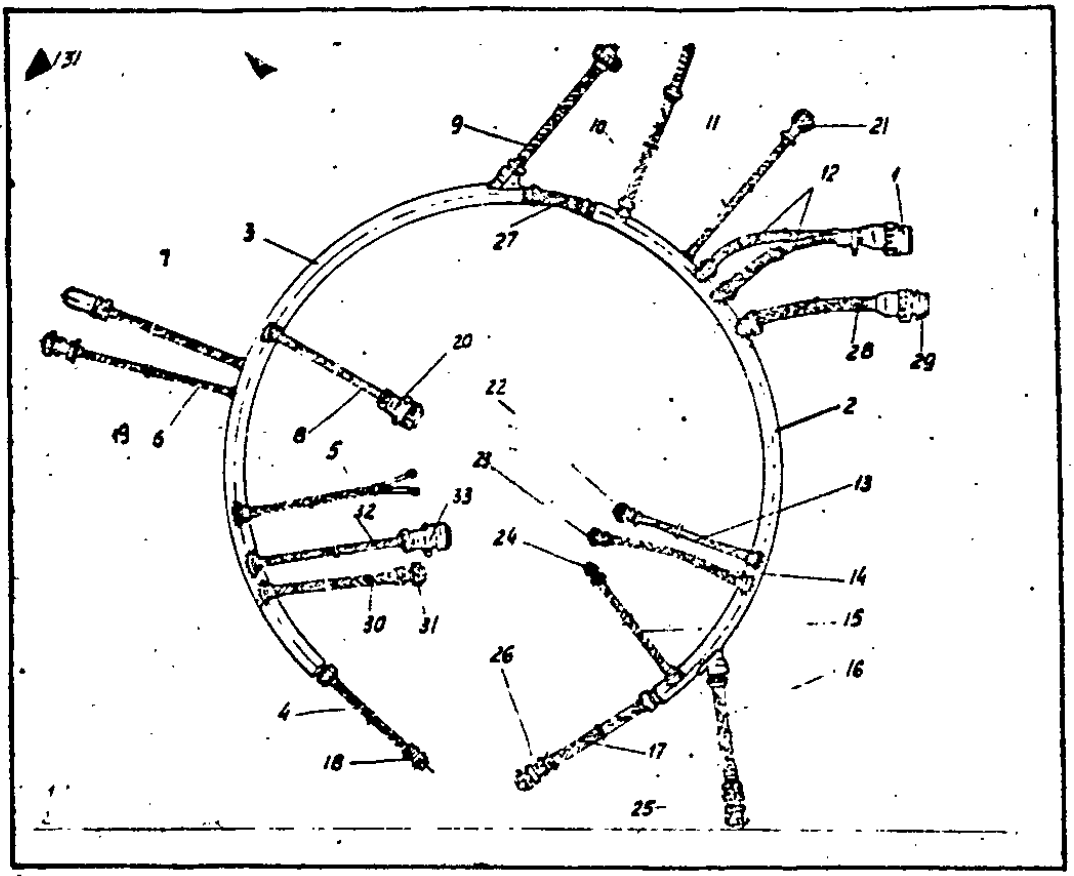

Fig.131. Collector of Electric leads.

1-main electric connector SAR-23S, 2-pipe /half-ring of collector -left/, 3-pipe /half ring of collector - right/, 4-screening sheath of leads to fuel pressure switch, 5-screening sheath of leads to electrimagnet of emergency valve of PN-14A pump, 6-screening sheath of leads to electromagnet of right starting burner, 7-armoured envelope with leads to the right starting plug, 8-screening sheat of leads to motor of startingpump, 9-armoured envelope of leads to ignition coil KR-1, 10-screening sheath of leads to KR-1 ignition coil, 11-screening sheath to the electromagnet of the left starting burner, 12-screening sheaths of leads to main electric connector, 13-screening sheath of leads to tachometer pickup, 14-screening sheath of leads to I-10 pressure pickup, 15-screening sheath of leads to oil thermometer pickup I-1, 16-screening sheath of leads to fuel pressure pickup I-100, 17-screening sheath of leads to EM-100 pressure pickup of afterburner fuel line, 18,19,20,21,22,23,24,25,26,31,33 - electric connectors, 27-screening sheathn of bridge connection of the leads collector halves, 28-screening sheath of leads to electric connector of afterburner, 29-electric connector of afterburner system SAR-7S, 30-screening sheath for afterburner switch, 32-screening sheath to electromechanism MG-2.

The collector of leads consists of two half-rings 2 and 3, made of duralumin tubes, further of screening sheaths 4,5,6,7,8,9,10,11,13,13,14,15,16,17,27,28,30,32, electric connectors 1,18,19,20,21,22,23,24,25,26,31,33 and of leads.

The half-rings made of duralumin tubes and the screening sheaths serve both for protection of leads from mechanical damaging and for protection of the aircraft wireless from radio disturbances.

The electric connectors serve for an easy and rapid electric connection of the accessories and pickups of instruments when they are being assembled on the engine, and also for connection of the electric equipment, mounted on the engine, with electric equipment, mounted in the aircraft framework. The leads collector is fastened by clamps on the stud bolts of the compressor body on the front side of the engine.

NOTICE: Marking of leads [illegible] pickups with their indicators is performed [illegible] the electric diagram of electro-equ[illegible]7.

C O N T E N T S .