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Operating Manual

RD–3M ENGINE

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Chapter I

GENERAL DATA ON THE ENGINE

1. BASIC DATA ON THE ENGINE

The RD-3M jet engine (Figs. 1, 2, 3, and 4) is the most efficient modern engine of Soviet manufacture. In comparison with the AM-3 engine, certain changes have been made in the RD-3M engine, which increased engine thrust and reduced specific fuel consumption.

In designing the RD-3M engine, use was made of experiênce acquired in the designing and refinement of a number of jet engines, particularly those in the AM-3 series. In addition, use was made of operating experience with Soviet-produced, jet-engine aircraft.

The engine's design is based on the normal scheme for a turbo-compressor engine with a eight-stage compressor and a two-stage turbine.

The engine consists of:

-- an eight-stage axial compressor
-- annular combustion chamber with 14 burners
-- a two-stage turbine
-- exhaust tube with nozzle extension
-- an engine accessory drive system and aircraft accessories
-- a gas turbo starter
-- auxiliary systems

Compressor -- is axial, delivers compressed air to the combustion chamber. The compressor consists of rotor and stator [assemblies].

The compressor rotor, which consists of discs, is drum-shaped. This arrangement permits substantial reduction in its weight as compared with rotors of other types. The internal cavities between the individual discs are interconnected by openings in the walls of the discs. Thus the pressure within the rotor cavities is equalized and the axial force against the walls of the discs is eliminated. Air enters the rotor cavities through the openings in the discs of stage V, and proceeds back to the forward relief cavity through the openings in the wall of the forward journal [cone]. Thus, the axial force of the rotor which is held by the center bearing is reduced. In addition, pressures transmitted to the center bearing are equalized by passage of air behind

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stage VIII of the compressor through nozzles which have adjustable orifice plates, by means of which the pressure in the relief cavity is adjusted to 0.3-0.5 atmospheres. In this way the force on the center bearing is relieved.

The front roller bearing of the compressor rotor and the turbo-starter with an aerodynamic cover are located in the forward part of the compressor case. The inlet diffuser is fastened to the forward part of the case; this diffuser together with the starter shield forms the inlet duct through which air enters the compressor. The accessory drive [mechanisms] and the inlet guide vanes of the compressor are located in the forward part of the housing.

The center portion of the compressor case is divided into eight interconnected sections. The case with the stator vanes is divided lengthwise which permits easier assembly and disassembly of the compressor. The stators and the compressor rotor blades are designed so that they may be easily disassembled and replaced in the course of engine dissassembly and assembly.

Combustion chamber -- contains 14 individually installed straight burners; is located between the compressor and the turbine; and is designed for burning fuel and heating air.

Approximately one third of the total quantity of air is mixed in the combustion chamber with the atomized fuel, which enters the burners through the main fuel injectors, and participates in the combustion process. The remaining air is mixed with the products of combustion and reduces their temperature to a level which is permissible for the turbine buckets.

Ignition of the mixture when starting takes place in four burners (Nos 3, 5, 10, and 12) by the so-called igniters which are made of a starting nozzle and a spark igniter plug. The flames flash through the telescoping tubes of these burners to all the other burners.

In the combustion chamber the resulting gases act on the turbine buckets. The turbine uses part of the energy of the escaping gases for driving the compressor rotor and the accessories.

Turbine -- is of a two-stage design made up of two-discs. The turbine discs are rigidly connected to a shaft, thus ensuring good dynamic balance of the turbine rotor. The buckets of the disc of stage II of the turbine may be removed from the disc for inspection purposes with the engine in place.

The compressor rotor is connected to the turbine rotor by a special splined coupling with a ball-joint, mounted on the rear end of the compressor rotor shaft and on the turbine shaft. The compressor rotor and the turbine rotor are seated on three bearings: front, center, and rear, which are located in the front and rear sections of the compressor case and in rear bearing support.

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The front and rear bearings are roller bearings, and in the center there are double ball bearings with four-point bearing contact. All bearings are lubricated and cooled by oil injected by nozzles. To reduce losses of oil, the center and rear bearings are set in a common cavity.

Engine frame -- consists of the forward, center, and rear portions of the compressor, the combustion chamber shield, the rear bearing support, and the turbine shaft housing; these are assembled to form a single unit. The engine is mounted to the aircraft in one of two ways (for details see Chapter VIII, "Mounting the Engine on the Airframe.").

The engine [exhaust] tube has a fixed opening, is removable, and utilizes the energy of the gases remaining behind the turbine, which escape at high velocity into the atmosphere. At the same time the resulting reaction forces of the gas jet is utilized as the motive component of the engine -- the thrust.

The diameter of the nozzle extension ranges from 847.5 to 860 millimeters. The thrust of the engine may be varied by changing the diameter of the nozzle extension. By reducing the diameter of the nozzle extension, the thrust is increased simultaneously with the temperature, and vice versa.

Starter system -- the engine is equipped for independent automatic starting with the S-300 M turbostarter. Starting is fully auomatized and is divided into two phases:

(1). Preparation for starting -- switching on the electrical system and setting the throttle of the engine in the idle position.

(2). Starting -- pushing the starter button. On starting, engine revolutions in the idle mode are set automatically.

The turbostarter, located in the inlet duct, is attached to the forward part of the compressor case and is covered with an easily removable aerodynamic shield.

A valve, which opens automatically only during starting, is mounted in the exhaust gas pipe of the turbostarter. At revolutions higher than idle, this valve closes to prevent autorotation of the turbostarter rotor.

For automatic control of the valve, a PK membrane-type pneumatic contactor is located on the forward portion of the center compressor case. The pneumatic contactor controls the electrical circuit for closing the valve of the turbostarter exhaust.

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The starting system, in addition to the S-300M turbostarter and its accessories includes:

-- a TD-1 tachogenerator which supplies current to the relay box during starting, with the voltage varying in relation to the rpm of the engine.

-- PT-4V relay box, automatically providing "on" and "off" switching of starter system accessories.

The PT-4V box contains all relays of the starter system and is the central [starting] control unit.

Ignition system -- the vibrator-type ignition system is powered by a 18 to 28.6-volt storage battery. It consists of a block of KPNC-2R1 starter coils designed to supply current and four SPN-4 spark igniter plugs.

System for the control of bleeding air from the compressor -- this system includes:

-- RV-40 air reducer, reducing air pressure brought in from the [air] bottle of the aircraft;

-- Electromagnetic air valve, permitting compressed air to reach the pneumatic piston mechanism, for closing off the air bleed valve.

-- CD-3 centrifugal switch for control of the circuit for the electromagnetic air valve at $3,800\pm50$ rpm. Control of bleeding air from the compressor is fully automatized and ensures surge-free operation of the engine within the full range of operational rpms.

Engine drive system -- there are three main accessory drives on the engine:

-- right, left, and lower, set in the front section of the compressor, providing the drive for the engine and aircraft accessories.

Above, at a 30° angle from the perpendicular to the axis of the engine. The right and left main drives are located. The lower drive below, at a 30° angle from the perpendicular to the axis of the engine. The air compressor (assembly AK-50N) is driven by the right lower drive. The drive for the engine accessory group, which is located on the right side of the center portion of the compressor case, connected to the right main drive.

Mounted on the engine accessory housing are:

PN-28B and PN-15B fuel pumps which provide automatic supply of fuel for all engine regimes;

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-- CD-3 Centrifugal switch, controlling air bleeding;
-- Engine oil filter;

Two drives lead from the left main drive for the tachometer pick-up units and the centrifugal oil de-aerator which extracts air from the oil and de-aerates the oil system.

From the left main drive it [the oil de-aerator? makes a turn to the aircraft accessory housing [and] it carries over [appears to be a word missing] located on the left above on the center section of the compressor case.

Located on the aircraft accessory housing are -- two GSR-18000D generators, and two drives, one of which is connected to a 435VF hydraulic pump. The other "free" drive is capped unused on transport airplane?

On the lower drive is an oil pump which has three suction stages and one pressure stage, and a CN-1D-type fuel pump with a pressure regulator.

A PT-4V relay box is mounted on the forward portion of the compressor case (above) between the main drives and between the generators and fuel pumps.

Mounted in the front case of the center compressor case are:

-- left, above -- electromagnetic air [bleed?] valve and an RV-40 air reducer;
-- right, above -- PK pneumatic contactor and SD-24A oil pressure indicator, connected to the starter oil line and to the indicator light circuit.

A drain tank is located in the center sections of the compressor case, under the engine accessory housing.

Located underneath the center section of the case are:

-- PNR 10-3M starting fuel pump;
-- Second block of KPNC-2R1 starter coils;
-- Electromagnetic valve;
-- Drain valve;
-- Drain tank.

The fuel manifold and the manifold for the main fuel [systems] are located on the rear section of the compressor case.

Tubing for venting air from the cavity of the rear portion of the case is mounted on the combustion chamber shield.

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The engine has two firefighting manifolds which are interconnected, and which supply liquids for firefighting to the engine nacelle.

There are four openings at stage VII of the compressor, which deliver air for pressurizing the cabins of the aircraft, and four openings of the rear section of the compressor case for providing air for the aircraft's anti-icing system.

2. BASIC ENGINE SPECIFICATIONS

2.1 General Specifications

Engine designation RD-3M

Type of engine........................Jet

Compressor:

Type ....Axial

No of stages 8

Air compression factor, maximum regime 6.4

Design feature ....Automatically controlled mechanism for bleeding air behind stage III.

Combustion chamber:

Type ....Direct-flow annular type with individual burners

No of burners 14

Location ....Uniformly about the periphery equidistant from the axis of the engine

Numbering ....Counterclockwise, looking from the engine exhaust nozzle and numbering the upper left burner as No 1 [i.e., clockwise facing the exhaust nozzle?].

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Turbine:

Type ....Axial

No of stages 2

Engine exhaust:

Type [exhaust tube] .... Fixed opening

Diameter of Nozzle extension, in mm .... 847 to 860.0

Direction of rotation of the engine rotor .... Left, looking toward the exhaust nozzle. [i.e., clockwise, facing exhaust nozzle?]

Attachment of engine to the engine cradle .... On seven braces

Engine is equipped with:

(a). Anti-icing system which delivers heated air from the compressor: from the cavity of stage VII for heating the aerodynamic cover of the turbostarter and the support struts; from the relief cavity of the forward section of the compressor case for heating the leading edges of the vanes of the inlet guide assembly.

(b). Openings in the compressor case, designed for bleeding air for the aircraft's anti-icing system.

No of openings 4

Location for bleeding air .... From the space of stage VIII of the compressor

Quantity of air withdrawn at a specific regime, kg/hr .... 6,000 ± 50

(c). Openings in the compressor case, designed for bleeding air for pressurization of the cabin of the aircraft:

No of openings 4

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Quantity of air with-, drawn, kg/hr .... 620 ± 20

Note: The indicated quantity of air withdrawn is converted to standard conditions.

2.2 Basic Regimes.

Maximum regime:

No of rotor revolutions, rpm .... 4,700 ± 25

No of rotor revolutions in flight, rpm .... 4,700 ± 50

Temperature of gases behind the turbine (measured and converted) under a steady regime (degrees Centigrade):

-- on the ground .... maximum of 660

-- in flight .... maximum of 720

Period of uninterrupted operation of engine [on the ground?] .... maximum of 8 minutes

Engine rpm with the ambient air lower than -15° Centigrade, at full throttle up to an altitude of 2,000 meters .... 4,700 -40 rpm

Note:
1. In the course of continuous transition of the engine from idle to a maximum regime a brief increase in the temperature of gases behind the turbine up to 690° is permitted, being followed by a decrease (in 1-1.5 minutes) to the temperature level prescribed by technical specifications.
2. The mean temperature of gases behind the turbine is measured according to the data of four thermoelectric cells distributed along the periphery of the exhaust tube.
3. In flight, 4,770 rpm is permitted.

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Nominal regime:

No of rotor revolutions, rpm 4,425

Temperature of gases behind the turbine:

For a steady regime (measured and converted), degrees Centigrade ..... maximum of 590

For operation of engine in flight, degrees Centigrade .... maximum of 610

When bleeding air for de-icing aircraft and engine, degrees Centigrade .... maximum of 620

Period of uninterrupted operation of of engine, on the ground, in hours ... maximum of 2

0.8 norminal thrust regime:

No of rotor revolutions, rpm .... 4,175 ± 25

Temperature of gases behind the turbine, for a steady regime (measured and converted), degrees Centigrade ....maximum of 500

Idle:

No of rotor revolutions rpm ....1,750 ± 50

Temperature of gases behind the turbine (meassured) in degrees Centigrade .... maximum of 500

Period of uninterrupted operation .... unlimited

Run-up of the engine:

(1). From idle (1750 + 50 rpm) to maximum rpm (4,700+25 rpm) at speed of when advancing the throttle at a rate of 1-2 vt[?] in seconds... maximum of 17

(2). Rpm of 1,750 to 3,000, in seconds .... minimum of 7

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In testing acceleration from 1,650±50 rpm, the run-up must still be reasonable.

Note: In making a check of acceleration (from 1,650+50 rpm), the run-up is not specified.

(3). From the beginning of automatic control (3,500 rpm) to 4,700 25 rpm, in seconds ... 12 to 15

Maximum permissible rpm in a test of acceleration (for a brief period) 4,800

Maximum permissible temperature of gases in the tail pipe in acceleration tests, (measured) in degrees Centigrade 720

Note: 1. Basic parameters -- thrust and specific fuel consumption are indicated for a warmed-up engine and apply to standard atmospheric conditions.
2. Permissible fluctuation in the temperature of gases behind the turbine for a maximum regime, $\pm 10^0$ Centigrade.

Time of first general overhaul of engine .. As prescribed

2.3 Fuel System

Type of fuel:

Main .... Fuel LRX-55 TS-1, GOST 7149-54, or T-1, according to GOST 4138-49

Starting .... Aviation gasoline B-70, GOST 1012-54, + one percent (by weight) of oil LT 160KC, MK-8, GOST 6457-53, or transformer oil. GOST 982-56, of any grade (with VTI-1 additive or without additive).

Starting fuel pump:

Type .... PNR10-3M gear pump with an MU-102A electric motor providing independent supply of fuel to the starting nozzles of the engine during starting.

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Number 1

Pressure of starting fuel, kg/cm^2... 1.4 to 1.75

Starting nozzles:

Type .... Centrifugal

Purpose .... Supply atomized fuel for starting of engine.

Number .... Four, located in burners Nos 3, 5, 10, and 12.

Engine fuel pump:

Type .... CN-1D, centrifugal

Purpose .... To supply main fuel to the fuel pumps.

Transmission ratio 1.765

Direction of rotation .... To the right (from the side of the drive).

Number 1

Fuel pumps:

Type .... PN-28B and PN-15B

Purpose .... To supply fuel for starting and operating the engine, control of engine, and maintenance of set rpm at all altitudes levels and at all flight speeds, beginning with automatic regulation of rpm (with position of throttle unchanged), and at the same time controls supply of fuel to the engine during acceleration and maintains the minimal set fuel pressure at all altitudes of flight.

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Note: Maximum output of the fuel pumps is limited to the delivery of $13{,}500^{+500}$ kg/hr, which is regulated by closing the slanted panel of the pumps. As a result of this, at temperatures lower than -15° Centigrade, the engine revolutions are reduced in relation to the elevation and speed of flight to a level not lower than 4,300 rpm.

Transmission 0.95

Direction of rotation .... To the left (from the side of the drive)

Range of automatic regulation, rpm ... 3,500 to 4,700±25

Fuel pressure before entry into PN-15B and PN-28B pumps, kg/cm² ...... 1.8 to 2.4

Fuel pressure in front of main nozzles, kg/cm² .... Maximum of 90

Point of pressure measurement.......... On idle manifold

Main nozzles:

Type .... Duplex, two-stage centrifugal

Purpose .... Supply atomized main fuel to the engine's combustion chamber.

Number 14

2.4 Oil system

Type of oil .... LT160KC, GOST 6457-53 or transformer [oil] GOST 982-56 of any grade (with or without VTI-1 additive.)

Oil consumption, kg/hr .... Maximum of 1.5

For flight operation .... The Normal [level] will be determined from experience in the operation of 20-30 engines.

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Flow of oil through engine for a nominal regime with maximum permissible and recommended oil temperature at entry into engine, liters/minute .... 28±3

Minimum permissible quantity of oil in the tank .... This ~~is~~ depends on the oil system of the aircraft and is indicated in the operating instructions for the aircraft.

Oil pressure in the manifold:

Under maximum, nominal, and 0.8 nominal regime, kg/cm^2 .... 4.0 to 5.0

At idle, kg/cm^2 .... Minimum of two

Location of the oil pressure sensing mechaism .... Extension of oil filter cap

Temperature of oil at entry into engine:

Degrees Centigrade:

Maximum permissible 80

Minimum permissible .... -40

Recommended..................... 40 to 60

Maximum permissible oil temperature at exit from the engine:

Degrees Centigrade 105

Transfer of heat to oil for a nominal regime and maximum per-permissible temperature (kilocalories/minute) .... Maximum 280

Oil pump:

Type .... Gear

Purpose .... To supply and remove oil from the engine.

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No of stages .... Four, in one housing; one pressure stage and three suction stages.

Pressure stage of pump:

Transmission ratio 0.827

Flow for a nominal regime with a counter-pressure of 5 kg/cm^2, liters/ minute .... Minimum of 60

Suction stages of pump:

Transmission ratio 0.827

Flow for a nominal regime with a counterpressure 0.8 kg/cm^2, liters/minute:

1st stage 60

2nd stage 60

3rd stage 60

Centrifugal oil separator:

Type .... Centrifugal

Purpose .... Separation of oil from the air which enters from the engine.

Transmission [ratio] 2.96

2.5 Starting System

Type of starting system .... Independent, automatic; consists of a S-300M turbo-starter with tachogenerator and relay box.

Starter:

Type .... Gas turbine

Purpose .... Provides automatic, independent starting of the engine.

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Range of operational rpm .... 31,000 to 32,500

Output with temperatures of gases at exhaust pipe at a maximum of 680° Centigrade, in hp .... 90 to 100

Fuel consumption and an operational regime, kg/hr .... 85+100

Maximum temperature of gases at the exhaust pipe at operational rpm, degrees Centigrade:

At an ambient temperature of up to 415° Centigrade .... Maximum 680

At an ambient temperature of above +15 degreees Centigrade ....Maximum of 700

At initial turning of starter .... Maximum of 800

Maximum premissible number of revolutions of starter, rpm .... Maximum of 35,000

Period of operation of starter from the instant of depression of starter button, in seconds ...... Maximum 80

Period to general overhaul of turbostarter (No. of starts), maximum 400

No of starts from a 12-SA-55 storage battery (without recharging)........ 15

No of starts with a SAo189B electrical starter .... Maximum of five with 3-minute interval between starts; it is then necessary to allow the electrical starter to cool for 15 minutes.

Tachogenerator:

Type .... Generator with independent TD-1 exciter

Purpose .... During starting it provides current for control elements of the relay box (signalling relay), provides voltage relative to engine revolutions. [?]

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Relay box:

Type PT-4V

Purpose .... Provides automatic "on" and "off" switching of starting equipment

Number 1

Total consumption of fuel per engine start, kg .... Maximum of three

Permissible temperature of gases in exhaust pipe at starting, degrees Centigrade .... Maximum of 690

Time from starting of engine to idle rpm (1,750+50 rpm) from the moment of depression of starter button, seconds .... Maximum of 120

2.6 Ignition System, system of electrical equipment and control

Type of ignition .... Vibrator

Starter coil unit (vibrator type):

Type KPNC-2R1

Purpose .... To supply current to engine spark. Igniter plugs

Number 2

Current voltage .... 18 to 28.6 volts

Starting plugs:

Type SPN-4

Purpose .... Ignite starting fuel when starting engine

Number 4

Valve mechanism for bleeding air from the space of stage III of the compressor:

Type .... Air, piston

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Air pressure in the valve control system, kg/cm^2 .... 40±5

Air reducer RV-40

Number 1

Electromagnetic air Valve:

Purpose .... Controls supply of air into the air bleed valve mechanism

Number 1

Centrifugal regulator for control of valve mechanism for bleeding air from compressor:

Type .... CD-3 single-system centrifugal

Purpose .... At given revolutions of the engine it automatically actuates the electromagnetic air valve in the air bleed valve system.

Transmission ratio 1.33

Number 1

Mechanism for control of starter exhaust pipe (does not belong in the engine assembly):

Type .... MZK-2, electromechanical

Number 1

Air contactor:

Type .... PK, diaphragm-type

Purpose .... Automatically provides linking of mechanism for control of starter exhaust pipe valve.

Number 1

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2.7 Aircraft assemblies

Generators:

Type	GSR-18,000D with differential excitation
Purpose	To supply power to the aircraft cabin [electrical] system
Direction of rotation	To the left
Transmission ratio	1.875
Number	2

Air compressor:

Type	AK-150N
Purpose	To supply compressed air to aircraft's air system
Direction of rotation	To the right
Transmission ratio	0.428
Number	1

Hydraulic pump:

Type	435 VF, piston-type
Purpose	To develop pressure in the aircraft's hydraulic system.
Direction of rotation	To the right
Number	1

3. ENGINE ACCESSORY DRIVES

Torque is transmitted from the shaft of the compressor rotor to the engine accessories in this manner (Fig. 7).

The compressor rotor drives bevel gear (1) of the main drive through the spline shaft which is fitted into this gear.

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Bevel drive gear (1) supported on ball bearings rotates at the same rpm as the compressor rotor. The other end of the shaft of this gear is centered in a blind flange (2) (Fig. 24), which is pressed into the forward journal [cone] of the compressor rotor. The bevel drive gear turns three bevel gears (2, 3, and 4), which rotate the right and left intermediate (vlozeny) drives, as well as the lower drive.

Drive gear (4) supported in two ball bearings, imparts rotation with the aid of a splined, flexible shaft to bevel gear (5) of the lower drive.

Bevel gear (5) supported in two ball bearings, imparts rotation to gear (6), which in turn transmits the torque with the aid of the grooved [shaft] to the CN-1D pressure fuel pump, and through grooved [shaft] coupled with gear (7) to gear (8) of the oil pump.

Bevel gears (2) and (3) of the main drive, which are driven by bevel gear (1) of the main drive, truns bevel gears (9) and 10) of the left and right intermediate drives through splined shafts.

Bevel gear (9) of the intermediate drive, supported in two ball bearings, turns bevel gear (11) which is set in ball and roller bearings; bevel gear (11) transmits the torque to gears (12) and 13) of the aircraft assembly housing and to the two gears (14) and (15) which are attached on the end of the shaft of bevel gear (11) of the intermediate drive.

Gear (15) transmits power through intermediate gears (16) and (17) supported in two ball bearings, to gear (18) attached on the end of the impeller wheel shaft of the centrifugal de-aerator.

Gear (14) transmits the torque through intermediate gears (19) and (20) set in two ball bearings, to the [two] tachometer drive gears (21).

Drive gear (12) for the generators and drive gear (13) for the the hydrualic pump are attached to the drive shaft leading to the aircraft housing; they are supported in two ball bearings, transmit torque simultaneously through two gears (22) of the drive for the generators and to drive gear (2) for the hydraulic pump.

Bevel gear (10) of the intermediate drive is supported in two ball bearings and meshes with bevel gear (32), supported in a roller and bevel bearing. Gear (32), through drive gear (24) which is built as an integral part of its shaft, drives gear (26) for the air compressor. Gear(32) drives engine accessory drive gear (27) which is mounted on the grooved shaft coupled to drive shaft gear (32).

Drive gear (27) splined to the drive shaft, transmits power to gears (28 and 29) for the fuel pumps. Gear (27) is supported in two ball bearings.

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Through gear (30), an integral part of the fuel pump shaft, gear (28) engages gear (31) of the centrifugal transmitter.

In starting the engine, the torque is transmitted from the turbo-starter to the engine rotor though the splined main drive shaft of bevel gear (1), which is coupled with the forward journal of the compressor rotor.

The drive assemblies, with their position in relation to the direction of rotation and transmission rato are indicated in the following table:

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No	Name of Assembly and Drive	Trans-mission Ratio	Direction of Rotation of the Assembly	Position of Assembly
1	AK-150N Air compressor	0.428	Right	Right main drive
2	PN-28B Fuel pump	0.95	Left	Left engine accessory housing
3	PN-15B Fuel pump	0.95	Left	Engine accessory housing
4	CD-3 Centrifugal transmitter	1.33	Left	Engine accessory housing
5	Tachometer transmitter drive	0.5	Right	Left main drive
6	Tachometer transmitter drive	0.5	Left	Left main drive
7	Centrifugal de-aerator	2.94	Right	Left main drive
8	GSR-18000D Generator	1.88	Left	Aircraft accessory housing
9	GSR-1800D Generator	1.88	Left	Aircraft accessory housing
10	435VF Hydraulic pump	0.468	Right	Aircraft accessory housing
11	Reserve drive	0.468	Left	Aircraft accessory housing
12	CN-ID Centrifugal fuel pump	0.82	Right	Lower drive
13	Oil pump	0.82	Right	Lower drive

Note: The rotational direction of the accessory shaft is understood to mean viewing the assembly from the end [which end?] of the shaft [which shaft?]. The rotation direction of the accessory drives is determined [text grammatically garbled for several words] from the side flangs of the assemblies.

S-E-C-R-E-T
No Foreign Dissem

S-E-C-R-E-T
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Chapter II

DESIGN OF ENGINE PARTS

1. FRONT COMPRESSOR HOUSING

The front compressor housing (Fig 8) consists of the following main components:

Main case (1) (Fig. 9), case 9, oil filter 17, reinforcing ring 13, support struts 14, thirty-six guide vanes 4, which constitute the inlet guide assembly, main drive (16), and three drive assemblies 11, 18, and 27 (Fig 10).

The front housing is a casting mode of magnesium alloy ML5, which consists of an inner case, outer case and six hollow struts, cast as a single unit.

In the upper part of the outer case, to the left and to the right at a 30° angle from the vertical axis of the engine, are located two flanges for mounting the housings of the intermediate drives. On each flange there is a centering pin, six stud bolts for fastening the intermediate drive, and dual recesses for draining oil from the intermediate drives.

The left flange has two additional openings for the main drive oil line 12.

In the space between the flanges for fastening the right and left intermediate drives are located four threaded projections 26 (see Fig 10) for mounting housing PT-4V.

In the lower part of the case, to the right at an angle of 30° from the vertical axis of the engine, there is a flange with stud bolts for fastening lower drive 18.

On the upper left side surface of the case is a flange with two threaded holes for fastening fittings 25 (see Fig 10).

Along the horizontal axis on the case are two flanges with stud bolts for mounting angle members 21 and 22.

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On the front flange are 36 bolts for attaching reinforcing ring 13 (see Fig 9), and on the front flange of the inner case there are 18 bolts for attaching main drive 16, twelve threaded holes for fastening the cross brace of the shield and two pins for locking it. On the cast struts of the front housing are 24 bolts for fastening the reinforcing struts 14 and 12 bolts for fastening the turbostarter ducting.

On the front of the flange of the rear wall of the inner case are five bolts for fastening case 9 and oil collector 17; on the rear are ten bolts for fastening the front bearing and nine for draining of oil and for cooling the front bearing.

The rear flange of the front housing has 36 openings for bolts (of which 12 cannot be removed), for attaching this housing to the center compressor case.

In the center opening of the rear wall of the inner case of the front compressor housing is the front bearing of the compressor rotor shaft. Roller bearing 7 (see Fig 9), mounted in housing 8 of the front bearing, is axially secured by cap 6 which is centered on the housing of the front bearing and is fastened to the rear wall of the inner case of the front compressor housing by 10 bolts.

In the inner cavity of the front compressor housing is mounted the main drive 16 -- this is the main drive to the accessories.

On the leading portion of the cast struts of the front housing are bolted six reinforcing struts. The inner cavities of the cast and reinforcing struts are designed to serve as covers for the shafts, for draining oil from the intermediate drives, aircraft accessory housing, engine accessories and centrifugal separator, for supplying oil to the lower drive, for venting of the drives in the front compressor housing and the oil tank, and also for passage of oil, fuel, electrical, and air lines to the S-300M starter.

Shaft 28 (Fig 10) of the right intermediate drive is located in the upper right cast strut. Located in the upper left cast strut is shaft 15 of the left intermediate drive, line 12 (See Fig 9) for supplying oil from the left intermediate drive to the main drive, and tube 41 for connecting [venting?] the front compressor housing to the atmosphere through the centrifugal de-aerator.

On the left end of the left horizontal strut are mounted:

elbow fitting 22 (see Fig 10) for draining oil from the aircraft accessory housing, centrifugal de-aerator, and de-aeration of the oil tank; on the right side is mounted elbow fitting 21 with a tube for draining oil from the engine accessory housing.

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Inside the lower right cast strut is located shaft 24 of the lower drive. Oil from the liner and the inner housing is supplied along it into the lower drive.

Under the upper right reinforcing strut are fastened by means of clips and pins, the bundle of electrical wires 39 (Fig 11), leading to the starter, oil line 40 to the SD-24A pressure indicator, and conductors of the thermoelements for measuring the temperature of the gas in the turbostarter exhaust pipe.

The upper left support strut 37 has in its upper cover an opening for the inlet of hot air through fitting 38 into the strut, and in the lower cover there is an opening to provide hot fuel into the cross brace of the aerodynamic shield.

Air line 30 to the starter and air line 31 to the seal of the turbo-starter [sic] are clamped under the right horizontal reinforcing strut. Starter lines 33, 34, and line 32 for returning oil to the oil tank from the turbostarter while it is in operation are clamped under the right reinforcing strut.

Under the lower left reinforcing strut are clamped line 36 for withdrawing oil from the lower drive of the engine to the turbostarter while it is in operation and line 35 for supply of oil to the turbo-starter from the oil tank.

On the front compressor housing are mounted 36 guide vanes 4 (see Fig 9) which direct the stream of air as it enters the first stage of the compressor. Guide vanes 4 are set at an angle of $80^{0} \pm 30$ relative to the plane perpendicular to the axis of the engine.

The vanes of the guide system are secured at the given angle by hollow round pins 5 (see Fig 9).

Along the periphery of the front compressor housing are 36 radially distributed openings into which are placed sleeves 3 for the upper bolts of the guide vanes.

The bushings are held in place by guide ring 2.

Bearing cover 10 is fastened to the rear wall of the inner case by means of 36 bolts. After fastening cover 10, the lower bolts of the guide vanes may be placed into the 36 openings.

On the inner surface of the bearing cover is a built-up layer of talc which together with the gasket of the forward rotor journal provides a seal.

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Housing 9 is cast from magnesium alloy ML5, is bowl-shaped and serves as an oil collector. It separates the cavity with a large oil content from the cavity of the front compressor housing.

In the cover are:

-- three openings for the lines 23 and 29 (see Fig 10), which are secured by rings. These lines connect the liner cavity with the cavity of the cast struts of the housing.

-- an opening for the line of elbow fitting 21 for return of oil from the engine accessory housing.

-- a lower opening for drainage of oil.

-- five openings for bolts for fastening the liner to the housing

-- fourteen openings for drainage of oil and venting the cavity of the forward bearing and the cavity of the housing.

1.1 Oil collector

The oil collector consists of two parts: the oil collector proper and the cover, which are spot-welded along the outer edge. This weld forms the passage way for the oil.

The oil collector forms a pan in the front bearing of the compressor rotor and prevents the oil from leaking into the inner cavity of the forward compressor case. The oil collector has five openings for bolts for mounting the front compressor housing, three openings for oil drainage, and one opening for the lubrication nozzle of the front roller bearing. In the upper part of the oil collector cap are five openings for connecting the cavity of the liner with the forward compressor case and five openings for oil drainage.

1.2 Inlet Guide Vanes 1 (Fig 12)

The inlet guide vanes 1 are made of AVTI aluminum alloy. The vanes are secured in the front compressor housing by two pins. Along the entire length of the vane is a milled groove which after welding the leading edges of the vane, forms a channel, by means of which hot air for heating the leading edge of the vane passes through opening 2 in the lower [mount] pin.

Air from the vane exists through opening 3 which is located in the upper part of the vane. Steel sleeves 4 and 6 of material 4CH14N14V2M [14Cr14Ni 2W1Mo] are pressed on the lower and upper attach pins of the vanes and are secured against turning by [lock], pins 5 and 7.

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1.3 Main Drive

The main drive (Figs 13 and 14) consists of the housing, bevel gears, roller insert, ball bearings, nozzles, and attachment components.

The housing of main drive 1 (Fig 13) is cast of magnesium alloy ML5 and on the flange has three threaded holes 18 for disassembly, 18 holes for bolts for fastening to the front compressor housing, and channel 29 for supply of oil to the sleeves.

On the front, the housing has flanges with 10 bolts for attaching the turbostarter.

Coupling 26, to which is attached an oil return line from the turbostarter, is under the flange.

On left, above, is return valve 24 for the oil supply to the turbostarter during [?] automatic rotation, and opening 27 for turbostarter venting.

The housing has four openings:

-- central, into which is pressed aluminum sleeve 15 for a ball bearing and which holds the bevel gear of the main drive.

-- openings, located at a 30° angle from the vertical axis of the engine which are used to support the gears of the right and left main drives. Cylindrical sleeve 20, fastened by four pins, is placed in the right opening and aluminum sleeve 6 is pressed into the left opening. One opening is located below, to the right, at a 30° angle from the vertical axis of the engine, and retainer ring 7 for ball bearing 9 is pressed in it. It is a seat for the bevel gear of the lower drive.

In the space between the upper openings on the right side of the upper right opening, the housing has two threaded holes for oil nozzles 25 for lubrication of the bevel gears which turn the right and left center drive. On the front side, the housing has a flange (with an opening and two bolts) to which is attached oil nozzle 16 for the roller bearing of the front compressor rotor bearing.

The threaded holes for nozzles 25 and the hole for nozzle 16 are connected with hole 29 by channels and circular grooves in the upper portions of the ball bearing housings.

The main drive, driven by the compressor rotor via bevel gear 14 turns the bevel gear of the lower drive and two bevel gears of the intermediate drives.

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Bevel gear 14 is pressed on the front end of the shaft, and locked by six pins and a screw. The 30-tooth gear and the shaft are made of 18 CHNVA [Soviet designation: 18 KhNVA] steel.

The shaft of bevel gear 14 is hollow; on the front end it has internal involute grooving for connection with the turbostarter shaft and a retainer ring prevents the gear from falling off. On the rear end, there is involute grooving for connection with the drive shaft of the compressor rotor and the inner centering surface.

Bevel gear 14 and ball bearing 13 are mounted in the center opening and, to prevent shifting forward in the axial direction, it is secured by retainer ring 11.

Bevel gear 5 of the main drive, which turns the left intermediate drive, is made of 18CHNVA steel and has internal involute grooving for connection with the shaft of the left intermediate drive.

The gear rotates on the two radial ball bearings 4 and has a ring with 20 teeth. The sleeve has 16 relief openings.

Bevel gear 5 and ball bearing 4 are mounted in an aluminum sleeve 6 of the left opening and is prevented from shifting on the axle by retainer ring 2.

Bevel gear 19 of the main drive, which turns the right intermediate drive, is made of 18CHNVA steel and has involute grooving for connection to the shaft of the right intermediate drive.

The gear rotates in ball bearings 21 and 30, one of which is radially supported and has a ring with 20 teeth.

Bevel gear 19 and bearings 21 and 30 are mounted in cylindrical sleeve roller insert 20 and prevented from shifting [on the axle] by retainer ring 23. Cylindrical sleeve 20 is in the recess of the right opening of the main drive sleeve and is secured by four pins.

Cylindrical sleeve roller insert 20 of the right transmission is made of 40CHNMA steel and is basically a roller with a tetragonal flange, which has four openings for bolts for attaching insert to the housing. On the side of the insert are two openings, at a 90° angle to one another, for the rings of the drive and gear 5.

Bevel gear 10, which turns the lower drive, is made of 12CH2N4A [Soviet designation: 12Kh2N4A] steel and has internal involute grooving for connection to the shaft of the lower drive. It rotates in two radial ball bearings 9 and has a ring with 20 teeth.

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Bevel gear 10 with ball bearing 9 which is mounted in aluminum sleeve 31 of the main drive housing, is prevented from shifting on the axle by retainer ring 7.

The space between bevel gear 14 and bevel gears 5, 10, and 19 of the main drive is 0.1 - 0.3 millimeters and is set by calibrated washers 12, 3, 8, and 22 mounted between the retainer rings and the ball bearings.

A nozzle is installed in the housing for lubrication of the front bearing of the compressor rotor. The nozzle consists of the case of the nozzle 16, nozzle 17, and connecting bolt 32. The case of nozzle 16 is made of 38CHA [38KhA] steel, has flanges with two openings for fastening the nozzle case to the main drive housing, and an opening for supply of oil and a recess for nozzle 17. The recess and the opening are interconnected by a channel. Nozzle 17 is made of 38CHA steel, and has four openings on its surface, which are covered by a copper screen, a one-millimeter-diameter calibrated opening, a place for mounting the housing of the nozzle and a threaded opening for fastening bolt 32.

The main drive is lubricated as follows: oil under pressure passes through a line from the left intermediate drive to opening 29 of the main drive. From here, the oil goes through the channels to two nozzles 25 for lubrication of bevel gear 14 and to the two bevel gears 5 and 19, and to nozzle 16 for lubrication of the roller bearing of the front compressor rotor bearing. Through return valve 24, the oil passes on to lubricate the turbostarter during autorotation. At its inlet, nozzle 25 and its one-millimeter diameter supply opening has a filter opening a 0.5 millimeter diameter opening. Lubrication of bevel gear 9 and all ball bearings is of the splash type.

The used oil goes through the openings of case 9 (See Sig 9) and the lower right strut of the front compressor housing to the cavity of the lower drive housing.

1.4 Right Intermediate Drive

The right intermediate drive (Figs 15 and 16) powers the AK-50N air compressor and the engine accessories located in the accessory housing.

It is located on the right side of the compressor case and is fastened with six bolts to its flange.

The drive has two housings: the housing of the right intermediate drive 4 and compressor drive housing 7 (Fig 15)

The housing of the right intermediate drive 4 is cast from magnesium alloy ML5 and has two flanges. The lower flange with a recess for cylindrical insert 21 has six openings for bolts for fastening the intermediate drive housing to the front compressor housing, an opening for a lock pin and milled channel F (Fig 16) for oil return.

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The rear flange has a recess for centering compressor drive 7, four openings for bolts; the flange with a recess for cylindrical insert 21 has 6 openings for fastening the intermediate drive housing to the front compressor housing, an opening for the lock pin, and milling F (Fig 16) for oil return.

The rear flange has a recess for the center compressor drive housing 7, four openings for bolts connecting the drive with the compressor drive housing, two bolts 23 and opening 26 for supplying oil to the compressor drive housing (Fig 16) .

The housing of the right intermediate drive has the line connection 25 for supplying oil to the teeth of the bevel gears.

On the inside of the forward wall of the housing there is a threaded hole for nozzle Z (Fig 15) for supply of oil to the grooved connection of the shaft, which transmits power to the drive in the engine accessory housing.

The threaded opening for line connection 25 and nozzles 29 (Fig 16) and Z (Fig 15) are connected by channels in front of annular groove K, in the recess of the intermediate drive housing.

The right intermediate drive is powered by the main drive shaft through gear 18 of the drive.

Gear 18 made of 12CH2N4A steel, has 24 internal involute grooves for coupling to the shaft. On its exterior surface are located two bearings 20 and 22 and bevel gear with 20 teeth.

Bevel gear 18 with ball bearings 20 and 22 is mounted in cylindrical insert 21. Bearing 20 is radial. Cylindrical insert 21 is in the recess of the intermediate drive housing.

Bevel gear 18 is secured in the axial position by retainer ring 17, mounted in the circular groove of the insert.

The insert is made of 38CHA [38KhA] steel, and it is a cylinder with a six-sided flange, on which there are 11 openings: six openings, for bolts for attaching the intermediate drive housing to the front compressor housing; two openings for lock pins; two openings for drainage of oil; and one technical [access?] opening.

On the side surface, opposite the elipsoid openings on the case are located two openings for oil drainage and a cut-out for the ring of the bevel gear 5 of the drive. Bevel gear 5 is made of 12CH2N4A [12Kh2N4A] steel. The forward end of this gear makes contact with roller bearing 3, mounted in aluminum sleeve 2 of drive 4. The bearing rear face of the make contact with the radial ball bbaring mounted in aluminum sleeve 6

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of the compressor drive housing 7. This bevel gear has 30 teeth and two mounting openings for disassembling the ball bearing.

The shaft of the bevel gear has an internal recess which has a blind flange, and in the rear section -- 24 involute internal grooves, a drive gear with 18 teeth and cavity for the ball bearing.

The clearance between the teeth of bevel gear 13 and bevel gear 5 of the intermediate drive is 0.1 - 0.3 millimeters and is set by calibrated washers 19, mounted between the retainer ring and the ball bearing, and also between the ball bearing and the housing 7.

The compressor drive housing 7 (Fig 16) is cast from magnesium alloy ML5 and has four flanges. On the front end of the housing there are: a flange with lug, two openings through which bolts 23 pass, four bolts 28 for fastening the compressor housing to the intermediate drive housing, and further, opening 27 for the oil supply to the AK-150N air compressor. On the rear of the housing are: a flange with an opening and three bolts for mounting the adapter unit of shaft 32 (see Fig 15), a flange with two bolts for fastening cover 33 and also a flange with a recess and four bolts 1 and two holes for bolts for mounting the adapter unit of the compressor 12.

The AK-150N air compressor is driven by gear 15 and intermediate gear 9, which are driven by gear 8 made as a single unit with the drive gear 5. The intermediate gear 9 is made of 12CH2N4A steel and has 30 teeth, and in the inner surface of the sleeve there is a circular groove for retainer ring 10. This gear rotates on the two ball bearings 11. There is a washer between housing 7 and ball bearing 11.

Gear 15 of the compressor drive is made of 12CH2N4A steel and has 42 teeth. The gear is pressed on shaft 16 and three pins and a screw secure it against turning on the shaft.

Shaft 16 is made of 38CHA steel. It is hollow and on the outer surface. it has a centering face with a lug for a ball bearing and external grooving with grooves for the splined coupling 13 which drives the AK-150N air compressor.

Coupling 13 is made of 38CHA steel and has four internal splines and grooving with an annular groove for the retainer ring.

Calibrated washers 30 and 31 are used to prevent overlapping of the face of the teeth of gear 15 with regard to intermediate wheel 9. [There is] a washer between the housing of the compressor drive 7 and the ball bearing, and another [washer] between the adapter unit of the compressor 12 and the ball bearing.

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Adapter unit 12 of the compressor is cast from AL5 alloy in the form of a sleeve with a flange. On the flange are six holes, four of which are for bolts 1 and two for screwing in sleeves 24. These openings are for fastening the adapter unit of compressor 12 to the compressor drive housing 7. On the same flange there are six bolts 14 for mounting the AK-150N air compressor. In addition to this, the adapter unit has four openings for oil return from the air compressor and for connection of the inner cavity of the air compressor to the right immediate drive, and two openings for lubrication of the air compressor, around which are circular grooves for rubber seal rings.

The adapter unit has two recesses inside: for ball bearings and for the projection of the air compressor flange, and also a seating projection for centering the adapter unit of the compressor in compressor drive housing 7.

The intermediate drive joint is sealed by paronite washers. Lubrication of the right intermediate drive and the AK-150N compressor is performed as follows: oil under pressure goes through a line from fitting T of the main line to nozzle 25 of the intermediate drive housing 4. From the housing the oil flows to the milled ring K and by means of channels it is guided to nozzles Z (See Fig 15) and 29 (see Fig 16. For lubrication of the splined coupling of the shaft and the bevel gears, and through openings in the compressor drive housing - it is channed for lubrication of the AK-150N air compressor.

Nozzle Z with a 0.7 millimeter-diameter opening and nozzle 29 with an 0.8 millimeter-opening have 0.5 millimeter openings at the filter inlet. From the compressor and the bevel gear the oil proceeds through the grooves to the compressor drive housing, connected by an opening with the cavity of the intermediate drive housing.

From this housing the oil is released into the forward compressor housing by means of openings in the liner and the milled channels F (Fig 16) and partially also by means of the ball bearing. Lubrication of the gears and all ball bearings is by injection.

1.5 Left Intermediate Drive

The left intermediate drive (Fig 17 and 18) transmits power from the main drive to the centrifugal de-aerator 27 (see Fig 17), to the two tachometers and aircraft accessories located in the aircraft accessory housing.

The drive is located on the left side at an angle of 30° from the vertical axis of the engine and is fastened to it by six bolts. The drive consists of two housings: the left intermediate drive housing 4 and the tachometer drive housing 6.

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The housing of the left intermediate drive 4 is cast from magnesium alloy ML5 and has two flanges. Lower flange 34 (Fig 18) has 6 holes for bolts for fastening the drive housing to the front housing of the compressor; an opening for supply of oil to the main drive; an opening for the retainer pin and two openings 33 for the outflow of oil.

The gear flange has a recess to center the housings of the tachometer drives 6 four holes for bolts; and two pins 32 for fastening the tachometer drive housing to the left intermediate drive housing.

In the front wall of the housing, on the inside, is a threaded hole for nozzle Z (see Fig 17) for supply of oil to the splined coupling of the drive shaft to the aircraft accessory housing.

The housing of the left center drive has nozzle 30 (see Fig 17) for supply of oil to the drive, and nozzle 31 (see Fig 18) for supply of oil to the teeth of the bevel gears. The threaded holes for nozzle 30 and nozzle 31 and Z are connected by channels through annular grooves K (see Fig 17) milled in the intermediate drive housing.

The left intermediate drive is driven by bevel gear 3 of the drive. This gear rotates on the two ball bearings 42 and 16 which are mounted into cylinder insert 14. Ball bearing 16 is radial.

Bevel gear 3 of the intermediate drive is made of 12CH2N4A steel, has 24 internal involute grooves for coupling with the shaft and, on the external surface, two faces with projections [chanfers?] for seating ball bearings, and a ring with 20 teeth. Gear 3 of intermediate drive is secured in the axial direction by retainer ring 15.

The cylindrical insert is made of 38CHA steel and is a cylinder with a hexagonal flange, on which are located 11 openings: six openings for bolts for fastening the housing of the left intermediate drive to the front compressor housing; one opening for the oil line to the main drive; two openings for drainage oil return and two for lock pins. On the side, opposite the openings are two openings for draining oil, and a cut-out for drive gear 5 of the intermediate drive.

Gear 5 of the intermediate drive is made of 12CH2N4A steel and its front end is in roller bearing 2, mounted in aluminium sleeve 1 of housing 4 of the drive. The rear end of the gear is in radial ball bearing 7, mounted in aluminum sleeve 13 of the tachometer drive housing 6. The gear has 30 teeth and two access openings for disassembly of the ball bearing.

The hollow shaft of gear 5 has an inner bore with a built-in blind flange, and in its rear part, 24 internal involute grooves. On its external surface, the gear shaft has a space with two faces for seating the drive gears of the main de-aerator and tachometer, threads for the nut fastening the drive gears, and two lateral slots for fastening the washer.

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The clearance between bevel gear 3 and bevelgear 5 which is [illegible, but probably] 0.1 - 0.3 millimeters, is set by calibrated washers 17, mounted between the retainer ring and the ball bearing, and between the ball bearing and the projection of the tachometer drive housing 6.

Tachometer drive housing 6 is cast of magnesium alloy ML5 and has seven flanges. For the front end, there is a flange with a projection and two openings 39 for bolts for fastening the tachometer drive in the intermediate drive housing, then a tetragonal flange with four bolts 35 (see Fig 18) for fastening adapter unit 29 (see Fig 17) of the tines for venting the forward compressor housing. On the side wall of the housing is a tetragonal flange with four bolts 36 (see Fig 18) for fastening line 26 (see Fig 17) which vents the transmission cavity. On the rear part of the housing are located four flanges, two tetragonal flanges with recesses and four bolts 41 (see fig 18) for mounting the tachometer transmitters; one flange with an opening and three bolts 40 for mounting adapter unit 10 (see Fig 17) of the shaft; and a flange with a recessed area and six bolts 38 (see Fig 18) for fastening the main de-aerator 24 (see Fig 17).

The tachometer drive housing has a recess and collars for seating the ball bearings and rubber packing, lugs with openings for shafts 8 and 28 of the intermediate drives, and a threaded hole for the blind flange.

The connection of the drive gears consists of two rings -- drive gear 11 of the tachometer drive and gear 12 of the centrifugal de-aerator, which are made of 12CH2N4A steel.

Gear 11 of the tachometer drive is pressed on the end of the gear 12 of the centrifugal de-aerator drive, and is secured to the shaft by two pins and a screw.

On the front side of the case of the gear 12 of the drive of the centrifugal de-aerator are two projections which fit into the faces of the shaft of the bevel gear 5 of the intermediate drive. Gear 12 of the centrifugal de-aerator has 27 teeth and the gear 11 of the tachometer drive has 22 teeth.

The connection of the intermediate gear wheels of the centrifugal de-aerator drive, which is set in two ball bearings and pin 28, consists of two cylindriacl [?] rings made of 12CH2N4A steel; the rotations are transmitted from gear 12 and then by gear 23 to gear 25 of the centrifugal de-aerator, which is set on the de-aerator rotor.

Intermediate gear 27 with its 23 teeth is pressed into gear 23 with its 34 teeth and is secured on the shaft by three pins and a screw.

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The intermediate gear of the tachometer drive rotate on the two ball bearings 9 and shaft 8. Through gear 21 the rotation is transmitted from the gear 11 and is then transmitted through intermediate gear 22 to gears 18 of the tachometer drive. Gear 22 has a groove on its inner surface for the retainer ring.

Gear 18 of the tachometer drive is set on shaft 19, which rotates on two ball bearings, mounted in the tachometer drive housing. It is made of 12 CH2N4A steel and has 44 teeth, and on one side of the sleeve are two lobes, which lock it on shaft 19.

Shaft 19 is made of 38CHA steel. The shaft is hollow, on one end it has a blind flange, preventing leakage of oil into the tachometer pick-up mechanism, and on the other end it has a tetragonal opening for the end of the tachometer transmitter. On the outer surface, the shaft has a round projection with two faces for the lobes of gear 18.

To prevent seepage of oil from the housing cavity into the tachometer pick-up mechanism, a special packing 20 with a spring is mounted from the side of flange fastening.

Lubrication of the left intermediate drive is as follows: oil under pressure passes from the line through nozzle 30 into the drive housing.

In the drive housing, oil flows into circular groove K and is run through channels to nozzles 31 (see Fig 18) and Z (see Fig 17) for lubrication of the bevel gears and of the oil groove [sic] of the shaft of the aircraft accessory housing. Nozzle Z with an opening of 0.7 millimeters and nozzle 31 with an opening of 0.8 millimeters have 0.5 millimeters filter recesses at the inlet. The gears and all bearings are spray-lubricated. From the shaft of the bevel gear the oil passes through the grooves into the cavity of the tachometer drive housing, and then through an opening in the housing it proceeds into the cavity of the left intermediate drive housing. From here, the oil passes through the openings in the liner and opening 33 (see Fig 18) in drive housing 4 and partially also through the ball bearing, then through the hollow strut into the front compressor housing.

1.6 Lower Drive

The lower drive (see Figs 19 and 20) powers the CN-1D 16 fuel pumps, and oil pump 1 (see Fig 19).

The drive is located on the right side of the forward portion of the compressor cases, down and to the right at a 30° angle from the vertical axis of the engine and is fastened to the flange of the front compressor housing by six bolts.

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The drive consists of the housing, the bevel gears, the shaft, ball bearings, and the fastening components.

The housing of lower drive 14 is cast of magnesium alloy ML5 and has three flanges. The upper flange has a recess and six openings for bolts for mounting the drive housing to the flange of the front compressor housing. A groove is machined in the flange for retainer ring 13 which holds screen 12. The rear flange with its recess and four bolts 24 (see Fig 20) is adapted for mounting fuel pump 16 (see Fig 19). The forward flange with its recess and eight bolts 23 (see Fig 20) serves for fastening the oil pump 1 (see Fig 19) and has two openings for retaining pins.

The housing has an opening for the inlet of oil for lubricating the fuel pump drive; an opening for the intake of oil from the cavity of the lower drive housing to the cavity of the suction component of the oil pumps; line connection 22 (see Fig 20) for fastening the tube for pumping out oil during engine starting and an engine oil drain oil.

Pressed in the housing are three aluminum sleeve 5, 18, and 3 (see Fig 19) which are bolted in place.

Bevel gear 3 is mounted on the two ball bearings 10, between which there is spacer 7. The ball bearings are in aluminum sleeve 5. Bevel gear 8 is secured axially by retainer ring 6. Gear 8 is made of 12CH2N4A steel and has 19 teeth, and inside [it has?] 24 involute grooves and a groove for retainer ring 9.

Bevel gear 21 is mounted on the two ball bearings 20, between which is located a spacer.

The ball bearings are mounted in aluminum sleeve 18. Gear 21 is secured axially by retainer ring 15 which is inserted in an annular groove in the housing.

Gear 21 is made of 12CH2N4A steel and has 13 teeth, and inside each end [of its fhaft?] are square grooves [splines?] of coupling it on one end with fuel pump 16, and on the other end with oil pump 1. The clearance between the gears is set by calibrated spacers 11 and 17, mounted between the ball bearings, and by retainer rings 6 and 15.

Drive shaft 2 has one end supported by the ball bearing mounted in the housing, and the other end is connected by means of the grooves to bevel gear 21. Gear 2 is secured axially by retaining ring 4 and by a special nut.

Gear 2 is made of 12CH2N4A steel, has 15 teeth, is splined on one end and on the other has a housing for seating the ball bearing and threading for the special nut for fastening the ball bearing.

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The gears and ball bearings of the lower drive are sprayed with oil supplied from the front compressor housing. The lower drive housing is divided into two cavities. Oil is brought into one of these from the liner of the front compressor housing, and the other cavity is enclosed by the same housing and screen. The cavities are interconnected by an opening.

2. COMPRESSOR

The compressor supplies air to the engine's combustion chambers. Heating of the air during compression assists in the rapid combustion of a large quantity of fuel in the small volume of the combustion chembers. The efficiency coefficient is high.

At a rate of flow, along the outer diameter of the compressor disc, of u = 300 meters second, the adiabatic coefficient yad = 0.87

The compressor (see Figs 22 and 22) is axial, eight-stage, with a drum-disc rotor. It is distinguished by its high efficiency, low weight, and small dimensions. The low weight of the compressor is attained as a result of the drum-disc design of the rotor, and the small dimensions are the result of increased axial air speed.

The air duct of the compressor is in essence a narrowing, annular channel, which has a greater intake than discharge area.

The entering stream of air imperceptibly rotates in the direction of the rotation of the compressor rotor, for the purpose of lowering the Mach number.

In order that at operations of up to 3,800 rpm the engine will not pulsate, air is bled from the compressor.

The compressor consists of the rotor, the front housing with the inlet guide vane system, the center and rear case with the stator vane system, the turbine shaft housing; and the shaft shields. The compressor also includes three bearings; front, rear, and rear [rear bearing is actually in combustion chamber-see Fig 4].

2.1 Compressor Rotor

The compressor rotor (Fig 23 and 24) is of drum-disc design and consists of the following components: the front journal assembly [cone] 9, the front journal seal 13, eight compressor discs 29 with blades 19, the rear journal [cone] 23 the rear journal seal 24, the splined drive coupling 25, which is fastened on the rear [sic, center bearing] bearing with nut 26, and spherical bearing cover 28, fastened to the splined drive coupling by 16 bolts 27.

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Torque from the turbine is transmitted by the splined drive coupling 25, connected with the rear [center] bearing in the splines and secured by nut 26.

From the rear [center] bearing, the torque is transmitted by 71 radial pins 22. The torque is also transmitted from disc to disc by radial bolts 18 and 31, located in the grooves of the discs under the blades. Torque is transmitted to the accessory drives from the first disc by radial bolts 14 and eight pins 10 [sic] of the front journal assembly 9 and front journal 4 which has splines 3 on the inner surface into which the shaft of the bevel gear of the main [accessory] drive is coupled.

Internal cavities between the discs are connected with one another by openings 30 in the disc walls, which permit constant pressure to be maintained in the entire cavity of the rotor and thus the axial load on the walls of the discs is eliminated.

[Some] air proceeds from the air duct of the compressor to the rotor cavity through openings 32 (see Fig 23), which are built into the cylindrical surface of the fifth-stage disc, and then through openings 30 in the walls of the discs of the compressor, and, through openings 11 in the cone of the forward journal it proceeds into the front relief cavity, [follows the] shape of the axle equipment, directed aft. Thus the axial load, created by the rotor of the compressor and directed aft is reduced, and thus the load on the center bearing also is reduced.

The portion of the air which proceeds into the front relief cavity is used for heating the leading edges of the inlet guide vanes.

2.1.1 Front Journal Assembly

This serves as the front support of the compressor rotor and takes on the radial load of the rotor and the torque, transmitted to the shaft of the bevel gear of the main [accessory] drive. It consists of the forward journal cone 10, front journal 4, pins 7 and 8, and blind flange 2.

2.1.2 Front Journal Cone

The Front journal cone is cast of aluminum alloy AK-4-1. On the upper flange of the cone, screws 12 fasten seal 13 of the front journal, which is made of aliminum alloy AK4-1 [and] which together with the talc strip of the cover of the front compressor housing constitutes the seal, reducing the escape of air from the front relief cavity into the compressor.

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Front journal 4 is pressed into the center part of cone 10 at the front bearing; the journal, made of 40CHNMA [40KlNMA] steel, is secured by radial pins 8. Pins 8 are prevented from falling out by pins 7. Journal 4 has a small projection on its front part on which roller bearing 5 is mounted.

Seal 6 of the front bearing is mounted on the center part of the journal. This seal is made of aluminum alloy AK4, and together with the talc strip of the front bearing forms a seal, which prevents leakage of oil into the compressor.

Blind flange 2, pressed inside the journal and secured by retainers 1, prevents oil from leaking out of the forward compressor housing into the inner cavity of the compressor rotor.

This flange is made of 38CHMJUA [38KhNMYuA] steel and has a key on which the inside diameter of the shaft of the bevel gear of the main drive is centered.

2.1.3 Compressor Discs

The compressor discs from stage I to stage VI are made of AK4-1 aluminum alloy castings. Discs of stage VII and VIII which operate at a much higher air temperature are made of OCHN3M [OKhN3M] steel.

On the cylindrical portion of the drum of each disc (except the disc of stage VI) there are five Z ridges. The ridges and the talc linings of the semi-circular shapes of the stator assembly make up the seal, which reduces the interflow of air between the compressor stages, and thus increases its efficiency coefficient.

Coupling of the discs of all stages is achieved by the overlapping cylindrical bands and also by radial bolts 18 and 31.

The overlapping is determined according to computations of heat expansion of the connected discs. Expansion of the discs as a result of the effects of the centrifugal force resulting from the blades is also taken into consideration. The overlappings ensure the centering of one disc on another and on the entire compressor rotor during engine operation.

In the discs of the compressor are grooves for attaching the blades; in the discs of stages through VI the grooves are of "dovetail" design, and in discs of stages VII and VIII, of "fir tree" design.

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To reduce the load on the blade from the pressure of the air, the axes of the grooves on all discs are parallel to the axis of the disc. The deflection of the grooves axis is caused by the torque, resulting from the centrifugal force of the blades, which is guided in the direction opposite that of the [sic]. Each disc is statically balanced after machining.

2.1.4 Working Blades

The working blades of the first six stages are made of 7 aluminum alloy VB-17 [VT-17?] as a stampled piece which is further ground and polished; blades of stages VII and VIII, which operate at a higher air temperature, are made of 30CHGSA [30 KhGSA] steel.

Number of blades in the compressor stages: stage I - 27; stage II - 35; stage III - 53; stage IV - 63; stage V and VI - 67 each; and stages VII and VIII - 71 each.

Each blade consists of the blade proper and root. The roots of blades of the first six stages have a "dovetail" shape, and those of stages VII and viii, a "fir tree" shape.

The blades of the first five stages are secured in the axial direction by wedge type retainer 16 at the front, and at the rear by concial pin 17. Blades of stage VI are secured at the front by a metal retainer, and at the rear by projections on the drum of the disc of stage VII. Blades of stages VII and VIII are secured from both directions by lock pins 20.

The metal retainers of the blades for stages I - VI are bent on one end toward the wall of the blades, and their other [end] is fastened in the groove of bolt 15 which is screwed in the cylindrical pins which connect the compressor discs.

2.1.5 Rear [Compressor] Journal 23

Rear journal 23 [cones] supports the radial load of the compressor rotor, the torque, and the axial load of the compressor. It is made of OCHN3M [OKhN3M] steel and is cone chaped with a cylindrical end.

There are three openings and seven rdiges G on the conical portion of the journal. The openings are for the purpose of discharging oil which may have leaked into the compressor rotor cavity.and also to bleed air (behind stage VIII) into the rotor cavity.

The journal ridges together with the ridges of the seal of the rear housing constitute a barrier which reduces leakage of air from the compressor into the rear relief cavity.

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The seal of rear journal 24 is pressed on the end of the front bearing which with the talc lining of the center bearing forms a seal preventing leakage of oil from the center bearing into the rear relief cavity. To improve this seal, air is brought from the compressor rotor cavity through openinds N to the center of the seal. The cylindrical part of the rear journal cone serves as the journal of the rear compressor rotor bearing. Located on it are bearings and other components of the center bearing.

Components of the compressor rotor made of aluminum alloys AK4-1 and VD-17 (discs, blades, seals forward journal cone), are anodized. Components made of OCHN3M and 30CHGSA steel (discs of stages VII and VIII, and rear journal and rotor blades of stages VII and VIII) are plated to prevent corrosion. After assembly, the compressor rotor is dynamically balanced to an accuracy of 40 gcm at each bearing. The balancing is done by relocating the blades of individual discs on stages I, II, VII, and VIII, deepening the openings on the edge of the disc of stage I, screwing in and adjustment of balance weights 21 in the pins of stages VII and VIII, and trimming of screws 15 on stage I.

The front journal 4 and the rear journal 23 serve as supports in balancing the rotor.

2.1.6 Spined Drive Coupling

Splined drive coupling 25 is made of steel and transmits the turbine shaft torque to the compressor. Cover 28 of the ball bearing is fastened to the splined drive coupling by bolts 27. On the flange of the sleeve there are splines which couple with the splined drive coupling on the turbine.

2.2 Center Compressor Case

Joined to the center compressor case (Figs 25 and 26) are the front and rear cases in which the engine bearings are located. This group of cases serves for mounting the stator vane system.

The center housing consists of two circular sections: front 7 (Fig 27) and rear 15. The front and rear sections each have two dividing planes: horizontal -- mounting, and vertical -- technological. In this manner each case consists of four parts which, joined by bolts, constitute the entire housing.

The front section is made of magnesium alloy ML5. The rear section, which operates in much warmer air, is made of aluminum alloy AL5. The individual sections are joined by means of bolts 11 and gudgeons 21, which are secured by the mutual centering of the parts.

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To ensure that the center case is rigid throughout its entire length, the housing walls are progressively strengthened toward the rear housing. In addition, on the exterior there are circular reinforcing ribs.

The center case is joined to the front housing by means of circular flange 23 with bolts of which 12 are tap bolts. Circular flange 23 has a recess hole for the centering projection on the flange of the forward housing.

The front housing of the compressor is connected to the rear case by 48 bolts on rear circular flange 19. 24 of these bolts are tapped in . The center housing has a round recess 16 on the flange which receives a projection on the rear housing flange [for centering?].

In the center housing there are the seven rows of stator vanes 5, they are made of forged aluminum alloy VD17 which have been ground and polished. The stators distribute (equalize) the flow of air and together with the rotor blades of the compressor they convert the motional energy of the air into pressure. On the inner surface of the center case are seven circular recesses. Stator vanes 5 fit into the recesses of the corresponding stages and thus are secured at the required angle, in relation to the center housing.

Number of stator vanes according to stage: stage I, 40 stators; stage II, 48; stages III-VII, 80. Rings 24 stamped from AMcAM aluminum sheet are mounted into groove recesses of the housing between the stator vanes of stages I and II. The cover plates are fastened in the center housing, each with one bolt 25 with a countersunk head.

Number of rings according to stage: stage I, 38 stage II, 46. In the horizontal plane are mounted angle members 1 (see Fig 26), made of D1T material, instead of the rings.

The stator vanes are fastened to the case by bolts 9 and nuts 8 from the outer surface of the center case. To make the center case even more rigid, the bottom fittings 10 of the stator vanes are interlocked by strong, partitioned, semi-circular [elements] 4. Stator vanes of stages I, II, and III are provided with a drop-shaped terminal A at the point of transition from the foot to the pin, thus differing from blades of the other stages. Terminal A is extended in the direction of the intake edge. Fittings 10 of the stator vanes of stages I, II, and III are mounted in the openings of the semi-circular [elements] with an overlap. The semi-circular elements 4 are designed to impart a smooth contour to the air passage of the compressor and for connection of all guide vanes into one element. The purpose of this connection is to reduce vibration of the vanes. Along with the ridges of the compressor discs, the semi-circular elements form the seal, reducing the flow of air within the compressor stages. The inner surfaces of the semi-circular elements are talcum coated to reducing the clearance in the seals.

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The semi-circular elements in stages I-III are made of magnesium alloy ML5. Those in stages IV-VII are made of heat resistant aluminum alloy VD17.

Each semi-circular element consists of a front and a rear semi-circle, which are joined by bolts 14, sleeves 13, and nuts 12. The front and rear semi-circles of stages I, II, and III are joined by three hollow cylindrical pins 26, through which are passed bolts 27 in stages IV, V, VI, and VII [they are joined] by three round pins 28 with retainer rings 29. Connecting bolts 14 and 27 on the semi-circle elements of stages I, II, and III are extended beyond one blade and on stages IV, V, VI, and VII, beyond two blades.

The semi-circular elements are secured by retainer rings 30, placed in recesses on the lower fittings of the blades and in the appropriate openings of the semi-circular elements. The retainer rings are mounted in the peripheral -- viewed from the partition planes -- openings of the semi-circular elements.

In the center part of the case and in contact with a part of the case are located bleed air openings 22 with an over-all area of 930 square centimeters. On each side of the contact are mounted bolts 20 for fastening the stop [and] for withdrawal of the bleed [belt] valve which closes the openings for bleeding air. To attain better contact of the valve and increase its pressure, it is positioned on projections on the center case at the point of flange contact.

At the point of transition of the valve from the center case to the [air] bleed mechanism there are mounted two rails on the same level with projections to prevent escape of air in case the belt is in contact.

Mounted in the rear space are heat-resistant, rubber seal rings 31, to prevent escape of air through the gaps between the stator vane bolts and the openings in the center case.

The round recesses of the six forward stages of the compressor case are talcum coated to reduce the clearance between the compressor rotor blades and the center case, and thus increase the compressor's efficiency.

On the surfaces of the front and rear sections of the case are:

1. Four lugs 2 with blind [?] openings (at mounting connection), for assembly and disassembly of the compressor.

2. On the front case, above and to the left facing forward there are two lugs with collars for fastening the anti-icing tube assembly.

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3. On the upper half of stage IV of the compressor, there are two flanges 3, provided with special blind flanges [sic]

4. In the rear case, above and to the right, there are seven lugs with long pins for attaching the aircraft accessory housing.

5. In the rear space of the case, above and to the left, there are eight lugs with long pins for attaching the aircraft accessory housing.

6. Above stage VII of the compressor there are five flanges. On flange 17 there is an elbow with a valve for bleeding air (see aircraft's anti-icing system).

Air for pressuring the cabins of the aircraft is bled through flange fitting 18. Special blind flanges are mounted on the other three flanges.

Components of the center compressor case, made of magnesium alloy ML5 are provided with eloxal coating (segments of stages I, II, and III and the front part of the center case).

Components made of aluminum alloy VD17, D1T, AMcAM (blades, cover rings, angle members) are spray coated. The rear section of the center case and segments of stages IV, V, VI, and VII have no coating. The exterior surface of the center case has a coat of aluminum paint.

2.3 Rear Compressor Housing

The rear compressor housing (Fig 28 and 29) is one of the main new sections of the engine and has the following functions:

(a) Connects the compressor with the hot section part of the engine, bears the radial and axial load of the center bearing and partially also the radial load of the rear engine bearing.

(b) Takes on the thrust and weight of the engine and transfers this through the engine mount struts.

(c) Is used for fastening the burners of the engine's combustion chamber.

The rear compressor housing is of a strong and light-weight welded construction and consists of the following assemblies and components: the combustion chamber 13, stator vanes 11 of stage VIII, the rear housing seal 4, and the inner liner 20 of the diffuser.

The combustion chamber 13 consists of flange 9 of the rear housing, flange 15 for fastening the combustion chamber case, and outer liner 12.

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Flange 9 of the rear housing is made of 1CH18N9T [1Kh18N9T] steel rolled in the shape of a ring with two ridges.

Shoulder "a" of the flange fits into the recess on the rear wall of the center case. Centering is based on the internal diameter of the shoulder. This connection serves not only to seal, but also to center the rear housing assembly.

On the front ridge of flange 9 are openings for bolts for attaching the rear housing to the center case of the compressor and the engine mount assemblies.

On the rear ridge of flange 9 are 24 openings for bolts, for fastening the engine mount assemblies. The rear and front ridges of flange 9 are made in the form of a crown. On the flat surface of flange 9 are 80 drilled openings for bolts for attaching the vanes.

Flange 15 is made of 1CH18N9T [1Kh18N9T] steel; it is a rolled ring with lugs and is used for fastening the combustion chamber outer liner.

Outer liner 12 is made of 1CH18N9T sheet, 3 millimeters thick. Its inner surface constitutes the outer edge of the flow channel behind the compressor. This liner is welded at the front to flange 9, and at the rear, to flange 15.

The following are welded to outer lines 12 on the exterior:

-- 14 flanges 25 (see Fig 29) for fastening the fuel nozzles;

-- 14 flanges 20, of which four are for attaching the igniters. The other 10 flanges are closed off with retainer blind flanges, which secure the burners in an axial direction;

-- four tetragonal section flanges 14 (see Fig 28) for mounting equipment for bleeding air for the aircraft's anti-icing equipment;

-- a large triangular section flange for mounting lines for exhausting air from tubes; the transmission [drive shaft assembly];

-- two triangular section flanges for fastening oil return lines from the center and rear engine bearings;

-- one triangular section flange for fastening oil inlet lines to the center and rear engine bearing;

-- four threaded couplings for attachment of lines for bleeding air from behind stages VIII into the automatic starter system, the turbostarter, oil tank, and acceleration equipment;

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-- a small elongated flanged fitting for bleeding air for the aircraft cabin from behind stage VIII of the compressor;

-- two lugs with threads for fastening contactor bands [?].

Stator vanes 11, of stage VIII of the compressor, with outer and "b" and shaped section [vane proper] "s", has the pin "e" with a threaded end, by means of which the vanes are fastened to the inner ring with nuts 5. The nuts are secured in pairs by lock-washers 6 made of 1CH18N9T steel, which also secure pins 7 for attaching seal 4.

Forty of these vanes are made of 4CH14N14V2M [4Kh14N14V2M] steel and serve to reinforce the connection between the inner ring and the flange. The remainder, which are not of the reinforcing tupe, are made of aluminum alloy VD17. These two types of vanes are installed in alternate sequence, The ends of the reinforcing stator vanes fit into the flange with a 0.05-+ 0.3 millimeter overlap and the others with a clearance. Each blade is attached to the flange with a radial pin 10.

The rear housing seal 4 is made of OCHN3M steel and, together [meshed] with the ridges of the seal of the rear journal of the compressor rotor, forms a barrier, restricting the passage of air from the compressor into the relief cavity. The seal assembly is attached by 40 pins 7 on the inner ring of the rear housing with a radial clearance of 1.2 $\pm$ 0.2 millimeters.

The inner liner 16 of the diffuser consists of inner ring 8 of the rear housing, inner liner of the diffuser 20, flanges 17, 10 struts 1, and 10 brackets 3.

The inner ring of the rear housing, the inner liner of the diffuser, the center bearing cone, and the flanges are made of steel 1CH18N9T. These form the air channel behind the compressor and also serves to transmit forces from the center bearing to the reinforcing vanes of stage VIII.

Stator vanes of stage VIII of the compressor are mounted and secured in the 80 openings in the inner ring of the rear housing. In addition there are 40 openings for pins for attaching the seal.

On the flange of the inner ring of the rear housing are 20 openings for bolting brackets 3.

Liner 20 of the diffuser forms, by its outer surface, the inner edge of the flow channel of the engine, and, together with flanges 17 it serves to reinforce the support of the center bearing of the engine.

Struts (1) welded from 1CH18N9T steel connect the center bearing cone and the inner ring of the rear housing. This forms a power triangle,

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transmitting to the reinforcing blades the radial stresses and the difference in axial stresses caused by the compressor rotor and the turbines.

The center bearing cone 19 consists of flange 21, for securing the center bearing; flange 22 for securing the turbine shaft housing and case wall 23. On flange 21 there are 10 eyes for bolts for attaching the struts. Case 23 of the center bearing cone has eight openings 18, which provide for bleeding air which penetrates the rear housing seal. For increased strength, the wall has eight corrugations.

Struts 1 are hollow tubes with eyes 24 welded onto it. Brackets 3 are made of E1481 steel and are fastened to the inner liner of the diffuser by two bolts 2.

2.4 Turbine Shaft Housing

Turbine shaft housing 19 (Fig 30) contains the power train between the rear bearing of the engine and the rear section of the compressor housing. The outer surface of the turbine shaft housing forms the inner boundary of the flow channel of the engine's combustion chamber.

The turbine shaft housing is circular in cross section, is made of [CH18N9T [1Kh18N9T] steel sheet, and has flanges welded on its ends. By means of front flange 16 the housing is attached to the rear flange of the inner liner the diffuser, and by means of rear flange 22, to the case of the rear bearing through the flange of frame 23 of the guide assembly of stage I of the turbine. To make the assembly stronger, reinforcing rings 21 made of steel sheet are welded to the inner surface of the housing.

On the outer surface of the turbine shaft housing there are the following flanges and openings:

-- three accesses covered by plates 17 for assembly and disassembly of the compressor and turbine shaft coupling;

-- five flanges 32 (Fig 31) for fastening air bleeder tubes 33 for bleeding air from the relief cavity into the atmosphere;

-- one opening with sleeve 34 (Fig 32), for a telescoping tube fitting for venting the cavities of the shaft housing;

-- two openings with sleeves 35 (Fig 32), for the telescoping tube fitting 3 (see Fig 30) for removal of oil from the cavity of the center bearing and tube 1 for removal of oil from the cavity of the rear bearing of the engine;

-- one opening with sleeve 24 (see Fig 30) for the telescoping fitting of oil line 25 to the center and rear engine bearings.

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2.5 Shaft Case

The cavity of the turbine shaft is divided by into two large cavities: the relief cavity between the body of the turbine shaft and the inner housing, and the oil cavity.

The relief cavity is connected by means of openings 18 (See Fig 28) in the center bearing cone to the space behind the stage VIII seal and serves for venting into the atmosphere air which has penetrated the seal.

On the turbine shaft housing are fastened five tubes 33 (see Fig 31 which pass between the combustion chambers and bleed air from the relief cavity into the atmosphere. In the relief cavity a pressure of 1.3 1.5 kg/cm^2 is maintained. This is accomplished at the plant by adjusting the diameter of the openings for the passage of air from the relief cavity into the atmosphere.

The oil space connects the oil spaces of the center and rear bearings of the engine so as to simplify the system of sealing the bearings, and lowering the oil temperature.

The inner cavity of the case is connected with the atmosphere by means of a tube and with the centrifugal separator, mounted on the left intermediate drive.

The inner [shaft] case consists of three assemblies: the front 13, center 6, and rear 2 (see Fig 30). The case are made of welded of 1CH1089T [1Kh10N9T] steel sheet.

Front case 13 (see Fig 30) is fastened by its front flange to the housing of the center bearing and by its rear flange it is connected to the center case at the point of coupling with the engine. On the front case is oil collector 7 with trap 8 to which oil flows from line 3. Inside the front case, case 12 is positioned, with flanged sections 15 which reduce spraying and prevent formation of a large quantity of foam. In the lower part of this case are five openings 11 and fiften openings 9, for return of oil from the cavity of the front and center cases. On the oil collector inlet is mounted screen -- the foam filter [literally defoamer].

On center shaft case 6 is support 14, fastening the oil inlet line to the center bearing of the engine.

Fastened to the housing of the rear bearing of the engine is rear case 2 which has oil collector 30 near the rear bearing.

Within the rear case is case 26 which has cross-sections with bent elements 18. In the lower portion of the case are openings 27 for oil drainage and a spacer 20 is fastened here; this spacer improves oil

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drainage. In addition, the ring flange of the case has openings 28 for oil drainage from the front cavity of the rear case. At the point where the oil feeds into the oil tank there is the screen type foam filter 29. On the lower part of the oil tank is mounted trap 31, from which oil is pumped through line 1.

Cases 10 and 29 are made of sheet metal and have a number of openings for drainage of oil. These openings are distributed in checkerboard fashion.

There are three flanges on the rear case for fastening the oil line to the rear bearing, the oil return line from the cavity of the rear bearing; and the de-aerator tube.

Center shaft case 6 and rear shaft case 2 are connected telescopically so that during assembly the center case may be shifted to the side of the rear engine bearing. Graphite asbestos packing 5 and tightened nut 4 seal the telescoping joint.

2.6 Combustion Chamber Case

The combustion chamber case connects the turbine and the compressor, and transmits stresses from the turbine to the compressor housing.

Simultaneously, from the outer side it [the case] forms a space in which the burners are located. The combustion chamber case (Fig 33 and 34) consists of the case proper 2 butt welded from four sections into the shape of a cylinders, and of two flanges 1 and 4, which are also butt welded to this wall.

Flange 1 joins with the rear compressor housing flange by means of 56 bolts, 14 of which are tap bolts. The case is fastened by flange 4 to the front flange of the extension of stage I. On this flange are two left or two right engine mounts. To reduce the weight of the flanges, both are machined milled along the edges between the attachment openings.

On the sides of the case proper are welded five flanges 3 for couplings, connecting the relief cavity of the turbine shaft housing to the atmosphere, and one lug 6 for fastening the drain line.

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In addition there are four fittings 5 with threads for fastening the oil lines. To prevent leakage of fuel a half asbestos gasket and a screw cap is mounted to the lower fitting, where they are fastened to eye 8, welded to the outer surface of the fitting.

Two flanges 7, to which tubes are attached, are welded to the lower case of the combustion chamber for draining off fuel [in the starting process].

All components of the combustion chamber case are made of type 1CH18N9T [1KHN9T] stainless steel.

The construction of the combustion chamber case and the attached fixtures is such that an inspection may be carried out and burners may be replaced without disassembling the engine. The casing can be disconnected at both flanges and pushed to the rear. This makes the burners accessable.

2.7 Engine bearings

The compressor rotor rests in the front and center bearing, the turbine rotor in the rear bearing and the ball joint, attached where the splined case of the compressor rotor and turbine are connected.

The roller bearing of the front bearing (Fig. 35 and 36) is located in the central opening of the back wall of the inner front compressor housing, which makes up the bearing support. The forward bearing receives the radial load of the compressor rotor and it consists of the following components: Housing 10 of front bearing, thrust roller bearing, cover 11 of front bearing, oil nozzles 7 (Fig. 36), and oil seal packing.

The housing of front bearing 10 is made of type 12CH2N4A [12Kh2N4A] steel and consists of a ring with a flange which has 10 openings for fastening the front bearing to the front chamber of the compressor with the help of pins. On the other wall of the ring is a boss which serves as a support surface for the outer ring of roller bearing 9. On flange "a" between the openings for the pins there are three equally spaced openings "b" which serve to release the oil from the area of the cover 11 of the front bearing into the cavity of the front compressor housing.

The roller bearing with separator 8 and rollers 6 is inserted into the housing 10 of the front bearing. Outer ring 9 of the roller bearing is equipped with two bosses "2" which secure the rollers 6 and 8. Inner ring 2 of the roller bearing (without bosses) is set on the front journal 3 and tightened by nut 4.

The inner sleeve of the roller bearing enables the compressor rotor to rotate around a fixed bushing during operation of the engine as well as during its assembly.

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The roller bearing packing consists of rotary [labyrinth] seal 1 and the load surface of the fixed cover of the front bearing, with a minimum clearance between them. The teeth of the seal dig into the talc layer "e" of the cover, which prevents it from moving and assures the dependable performance of the engine.

Cover 11 of the front bearing is made of aluminum alloy type AL5 and it is held in place by 10 bolt, screwed into the front housing of the compressor. The cover is centered by a boss "?" in housing 10 of the front bearing. Annular cavity "1" and three pockets "K" serve to collect the oil and to discharge it into the area of the front housing through 9 openings in the housing of the roller bearing and on the flange of the front compressor housing.

Oil for the lubrication and cooling the front roller bearning is piped under pressure is sprayed by nozzle 7 with a diameter of 1 millimeter, which is mounted on the housing of the main drive.

The center bearing (Fig. 37 and 38) is fastened to the flange of the cone and it rests against the radial ball bearings, which secures the compressor rotor and the turbine rotor in an axial direction.

It receives the radial load component of the compressor rotor and the difference in the axial weight of the compressor rotor and the turbine rotor.

The central bearing consists of the following main joints and components: housing 11 of the central bearing, front oil collector ring 5, two radial support ball bearings 4, two spacer rings 12, two spacer rings 3, oil nozzle 13, cover 9 of the center bearing.

The assembly of the central bearing (Fig. 39) consists of housing 8 of the center bearing and adapter 10, which are joined together by 16 radial pins 3. Radial pins 3 are locked by pins 2 to prevent them from dropping out of the housing of the center bearing. Radial pins 3 enable the adapter to move in relation to the housing of the bearing when the engine is in operation and they compensate for the difference in the coefficient of the linear expension of the rear component which is made of type 12CH2N4A [12Kh2N4A] steel.

Housing 8 of the center bearing is as a hallow tube of type 12CH2N4A steel one face surface of which terminates in a flange with threaded openings 12, to which the front housing is fastened.

Threaded openings 6 are used for fastening cover 9 of the center bearing with bolts (see Fig. 38).

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Two ring grooves 7, 90 longitudinal channels 5 and longitudinal openings 9 permit intensive circulation of the oil and the removal of heat from the center bearing by means of the oil. Opening 11 is used for the attachment of the oil nozzle. Openings 14, covered from the face side by blind flange 13, carry oil to the oil nozzle.

Adapter 10 of the center bearing is made as a bushing with a flange of type 1CH18N9T [1KH18N9T] steel. The flange contains threaded openings 4 for fastening the center bearing to the flange of the cone of the center bearing.

The radial support of the ball bearing 4 (see Fig. 38) is assembled in a special way to assure the simultaneous contact of the balls and ball races at four points and so that the axle pressure is distributed equally as both ball bearings rotate. This condition is secured by using adjustment rings 3 and two grooved rings 2 and 1 of varying dimensions. The four point contact of the balls offers the possibility for increasing the load being carried by the ball bearings. Cover 9 of the center bearing (see Fig. 38) is made of type 12CHN3A [12KhN3A] steel and has a "15" recess on its outer circumference and a support flange "16" with 16 holes for the bolts with which to secure the cover. The cover has 45 openings, 6 for carrying off the oil from the ball bearing housing to the case. The inner surface of the cover is built up with a layer of talc 8, which together with the ridges of [labyrinth] seal 7 of the rear journal comprises the seal, preventing oil from the central bearing from entering the relief cavity.

Oil is supplied to the ball bearings under pressure through nozzle 13 with two calibrated openings, which regulate the flow of oil to the ball bearings. The necessary oil passes through openings in the cover and the bearing housing and passes into the front housing and its oil collector from where it is pumped through the outlet lines.

Copper gasket seal 10 is placed in the joint between cover 9 and bushing 11 of the center bearing, assuring a tight assembly. To achieve the same objective, a "peronite" packing is placed in the joint between the bushing 11 of the center bearing and the flange of the front housing.

The rear bearing (Fig. 40) consists of the following components: bush 11 of the rear bearing, roller bearing, two oil nozzles 2 and 8, outer cover of rear bearing 15, inner cover 13.

The assembly of the rear bearing (Fig. 41) consists of case 4 of the rear bearing and housing 3, which are joined together by 16 radial pins 2. To prevent the radial pins from dropping out, threaded stops are located here which, when adjusted, will assure (centering) at three points. The joint between the housing of the rear bearing and the case of the rear bearing is packed with a silk packing cord impregnated with siloxane to make the joint tight.

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Case 4 of the rear bearing made of type OCHN3M [OKhN3M] steel in the form of a cone, the front face of which terminates in flange "a", which serves to fasten the rear bearing to the shaft of the ru4bine and the stator assembly. The tapered surfaces of the case contain "15" [opening?] for attaching air bleed lines.

In the center of the case is a round opening into which is mounted the housing 3 of the rear bearing. 30 passage openings "d" and a line coupling serve to center and hold the rear cover. A "peronite" packing is placed in the joint between the rear cover and the case of the rear bearing.

The housing of the rear bearing (Fig. 42) is made of type 12CH2N4A [12Kh2N4A] steel. The front case contains the support of the rear bearing and a rolled flange 5 which serves as a supporting surface for the outer ring of the ball bearing. In the rear part of the component is centering band 6 and supporting flange 2 for centering and fastening the inside and outside covers.

The annualar channel 1 of the component has recess 4,100 axial channels 10 and side openings 3, used for cooling the outer ring of the roller bearing and for carrying off the oil to the rear inner area of the housing. One opening 9 and two openings 8 with threads are used for mounting and securing the oil nozzle. Outer sleeve 10 (see Fig. 40) of the roller bearing together with separater 3 and rollers 4 are installed in the housing of the rear bearing. Outer ring 10 of the roller bearing is made with two lugs "a", which hold rollers 4 in a longitudinal position.

Inner ring 5 of the roller bearing is placed on shaft flange 6 of the turbine and fastened by special nut 7. Inner ring 5 of the roller bearing does not have a setting which makes possible the shifting of the turbine rotors in an axial direction during the operation of the engine.

For better removal of heat, the roller bearing is bathed from both sides with oil, supplied by nozzles 2 and 8. On the turbine side is located a two stage [labyrinth] seal. The ridges of the seal of the turbine shaft revolve around the talc layer 1 of the outer 15 and inner 13 covers. Between the tops of the ridges and the talc layer there is a minimum clearance. This prevents oil from passing from the rear bearing into the turbine and also prevents hot air from getting into the roller bearing cavity of the rear bearing.

Outer cover 15 of the rear bearing is made of type 38CHA [38KhA] steel. It is mounted on housing 11 of the rear bearing with 16 screws. Rear lid cover 13 is also made of type 38CHA steel. It is fastened to the housing of the rear bearing with screws together with the outer lid.

The outer roller ring contains 16 milled openings 12 for releasing oil from the roller bearing into the circular track of the rear bearing

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component. Copper gaskets are placed between the joints of the lids.

Oil passes under pressure to the roller bearing from the oil system by means of a line. Screen oil filter 16 is mounted on the line behind the nozzle. The oil flows through an opening in the inner cover into the rear inner case, from where it is sucked out by a gear pump..

2.8. Compressor air bleed.

Air is bled from the compressor into the atmosphere to prevent [compressor] surging during a low RPM and to reduce the necessary power for starting the engine.

With engines which have high pressure compressors the stages of which are designed for maximum effectiveness at rated RPM, all stages operate, during the starting RPMs, in an unsuitable regime. Also, for intermediate RPMs, they operate in an unstable manner and the power needed to turn the rotor increases sharply.

The first stages of the compressors are designed for an air flow of 164 kilograms per second at rated RPM. At starting RPM they use a significantly smaller amount of air, as a result of which the axial speed of the air drops. At the same time the axial speed in relation to the circumferential speed of the air is such, that the air reaches the first stage under a more favorable angle of entry.

In the final stages of the compressors, which are set for a steady flow of air, heated and compressed in the preceeding stages, the relation between the axial speed and the circumferential speed of the air at low RPM increases in comparison with the uniform relation of speed of the systems under consideration [?]. The stages thus work with a great negative angle of entry, which leads to an increase of power needed to turn the rotor of the compressor.

When the air is released from the intermediate stages of the compressors (at low RPM) the air pressure falls as a result of the release of a part of the air into the atmosphere and the first stages begin to move a greater amount of air.

The increased flow of air in the first stages results in an increased axial speed and the relation of this pseed to the circumferential speed approaches that which is expected.

As a result of this, the angle of entry also approaches that which is expected and the stages of the compressors require a smaller amount of power. During the last stages, in this case, there is a drop in the relation of the axle and circumferential speed of the air as a result of the reduced flow of air passing through these stages and released into the atmosphere. This leads to the approach of the angle of entry to that which is anticipated and to the fact that these stages require less power.

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[redacted]

Bleeding of air is accomplished by means of a row of openings located on the circumferential surface where the front and rear components of the center case are located, i.e., behine stage III.

From the outer side of the center case these openings are covered by a steel band 1 (Fig. 43), on the ends of which are eyes 2 for fastening to levers 11 of the automatic bleed mechanism.

One lever (right) is lengthened to bring the band bleed valve closer to the center of the housing.

The [compressor] bleed mechanism (Fig. 43) is fastened to the center case of the compressor by two supporting frames, 8 and consists of two cylinders 4, two pistons 6 with piston rods 3, springs 7 and levers 11. Springs 7 shift the piston rods outward, increasing the distance between them. In this way the band bleed valve moves over the center case and openings are uncevered through which the air passes.

The escape openings are closed by the band valve which is actuated by air pressure on piston 6, in cylinder 4 of the mechanism. As pistons 6 move together, they compress the spring 7 and band bleed valve 1 is drawn tightly against the seal collar of the center case, thus preventing escape of air from the compressor into the atmosphere.

The pistons of the mechanism are equipped with rubber gaskets 5, which prevent the escape of high pressure air which is entered from the tank to cylinder 4. In order that the circular opening between the band bleed valve and those in the center case be distant when the valve is in an open position, and in order to prevent the vibration of the belt on the seal flange of the center compressor case, retainers 10 and 12 are affixed here which prevent movement of the belt in the axial as well as radial directions. 2.9. System for controling the air release belt on the compressors.

The air bleed valve on the compressors is controlled automatically, i.e., depending on the automatic control setting according to engine RPM. A diagram of the automatic control system of the value is shown in Fig. 44.

The system consists of the following components:

compressor piston 1 (AK-150N), compressed air tank 2, which is mounted on the aircraft, centrifugal transducer 5 (CD-3), electromegnetic air valve 4, air pressure reducing valve 3 (RV-40) compressor bleed mechanism 17, band bleed valve 12.

Automatic control of the system for bleeding air from the compressor during starting of the engine is carried out by centrifugal transducer CD-3.

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At 3800^{+50} RPM, the centrifugal transducer automatically closes the air bleed openings in the compressor by means of the band bleed valve. At these RPMs of shaft 11 (Fig. 45), the centrifugal weights are displaced overcoming the tension of spring 17. Slide valve 24 is shifted upward, connecting the diaphram cavity of the mechanism with the oil inlet from the engine lines through its circular recess. Under the pressure of the oil, diaphram 5 overcomes the tension of spring 6. It moves, and, together with the slide valve, it cuts in terminal switch 2, which cuts in the circuit of electromagnetic air valve 4 (see Fig. 44). Electrical current from the aircraft cabin circuit passes through circuit breaker 10 (AZS-5) and the terminal switch of centrifugal transducer CD-3 into the electromagnetic air valve. This valve opens and air from tank 2 under a pressure of up to 150 kilograms per square centimeter passes into pressure reduction valve 3 where the pressure is reduced to 40 kilograms per square centimeter. Under this pressure the air passes into the housing of the [compressor] bleed mechanism and acts on pistons 15. The pistons shift, compress spring 14, and as they move together, pull in the band bleed valve encompassing compressor case 11, thus covering openings 16 in the compressor case.

From the instant of starting to 3800^{50} RPM the bleed openings are uncovered and at higher RPM, increased RPMs, closed. The openings are closed automatically by the band bleed valve as soon as the rotor achieves the afore mentioned RPM. With a decrease in the RPM the band automatically uncovers the openings.

At reduced RPM the slide valve of the centrifugal transducer closes off the intake of oil into the amplifier and the contacts of the microswitch are broken in this case as a result of the spring action. Contact between the terminal switch of the centrifugal transducer and the electromagnetic valve of the transducer is broken and electromagnetic valve 4 prevents passage of air into compressor bleed mechanism 17. The action of spring 14 on the pistons 15 forces the air through the exhaust valve and it returns to the outlet area. Air bleed band 12 moves away and uncovers bleed openings 16. This position assures normal operation of the engine up to 3800 RPM with an increased consumption of fuel. The band bleed valve may be found in an open position, that is with the bleed openings uncovered, if the electric or air system is not working.

The special push button 6, for closing the air bleed band at idle engine RPM, is connected in parallel with the terminal switch of centrifugal transducer CD-3. The push button is located on the motor at compressor bleed mechanism 17. If it is necessary to close band bleed valve push button 6 is depressed and then the wing nut on compressor bleed mechanism 17 and the band remains closed. To open, the push button 6 is again depressed, the wing nut is again unscrewed and the bleed valve opens.

At an engine RPM of less than 3800, the valve of the compressor mechanism is open and the outer surface of the motor is intensively bathed. In the event of fire this would greatly contribute to its

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intensification. To reduce the danger of fire, the compressor bleed system has a built-in electrically-controlled closing system with a fire indicator. In addition, the engine has terminal switch VK2-140B-1 (p. 7), which is mechanically connected with the engine throttle and electrically connected in series with the aircraft fire indicator 8, found in the engine area.

The electrical circuit of the transducer remains broken until such a time as the fire indicator (fire alarm) begins to operate. In a normal situation the terminal switch is not connected electrically with the electromagnetic valve and the band bleed valve on the engine is open at RPMs below 3800. As soon as the temperature of the air flow reaches 155 170° C (which is possible in the event of a fire), it sets off one or a number of fire indicators, the circuit of the aircraft's fire sensing system cuts in, and current is carried to terminal switch 7. At the same time the warning light goes on.

Moving the engine throttle to the "STOP" position closes off entry of fuel to the fuel manifold and simultaneously closes the contacts of the terminal switch. Current from fire indicators 8 passes through terminal switch 7 on to the armature of relay 9 of the aircraft. Relay RP-2 closes the contacts through which the current from the cabin circuit passes to the armature of electromagnetic air valve 4. The valve opens and the band bleed valve of the compressor closes and at the same time assures air tightness of engine areas.

Relay RP-2 is connected to the aircraft's electrical system in such a way that during normal operation it is cut off from the engine circuit.

The centrifugal transducer (see Fig. 45) controls the band bleed valve for release of air from the compressor. Centrifugal transducer CD-3 is rigidly connected through a drive with the shaft of the engine and controls the system according to engine RPM. The transducer cuts in and breaks the electric current of the electromagnetic valve.

The assembly consists of the following elements:
Housing 23; rotor 11 with centrifugal weights 19, which rotate in bronze bushing 8; spring 17; adjustment nut 14; and an amplifying diaphragm with terminal switch 2. Bushing 8, pressed into the housing 23, serves as a bearing for rotor 11 and the oil distribution equipment. The shaft is secured in its axial position by a retainer ring 27, which is connected to housing 23, through the seat 28, stamped spacer 25, and lock ring 26.

Pressed into the bottom part of the shaft is a square opening for the drive of the assembly. Mounted on ball bearing 21, at the upper part of the shaft are the centrifugal weights. The centrifugal weights react on disc 12 which is located on the outer ring of ball bearing 20 and is attached together with cupped disc 18, on the terminal end of slide valve 24. Spring 17, whose tension is set by nut 14 screwed into cap 13 of the transducer housing thrusts against cupped disc 18. The tension of the spring may be changed by screwing in adjustment bolt 16

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and locking with nut 15.

The diaphragm amplifier consists of housing 1, diaphragm 5 with slide shaft 7, spring 6, terminal switch 2, enclosed in the housing and by cover 3, and the slide connection 9. The diaphragm amplifier is fastened to the transmitter housing by stud bolts. Oil from coupling 29 is carried to the central recess of bushing 8 and openings of rotor 11 and proceeds into the recess of the slide valve under its barrel. The illustration shows the position of the slide valve at which its barrel prevents the passage of oil into cavity 4 of the diaphragm amplifier. Spring 6 of the diaphragm amplifier forces out diaphragm 5 and oil from cavity 4 is released into the lid of the chamber of the transmitter through opening 10. From the lid of the transducer housing the oil is carried by channel 22 into the channel of the transducer drive. In a forced-off position of the diaphragm, slide shaft 7 cuts out the micro-switch, which corresponds engine operation with the band bleed valve open.

At increased engine RPM, the action increased centrifugal force on the weights overcomes the tension of the spring and the slide valve lifts and begins to uncover the opening for the intake of oil into the cavity of the diaphragm amplifier. The pressure of the oil in cavity 4 increases and at speeds of 3800 RPM it achieves a force sufficient to lift the diaphragm.

From the instant that the contact between the disc of the diaphragm and the seat is broken, the effective surface of the diaphragm increases, spring 6 is compressed and the microswitch cuts in. From this instant the electromagnet of the air valve is activated and the band bleed valve is closed. At lower RPM the centrifugal force acting on the weights is reduced and the slide valve barrel begins to cover the oil intake opening to cavity 4. Oil pressure in the cavity drops and pressure on the diaphragm decreases.

However, as a result of the fact that the effective surface of the diaphragm is greater in this case than during an increase of RPM, the micro-switch cuts out a lower pressure in cavity 4 (than before), even with a reduced opening of the oil intakes, reduced centrifugal force on the weights and a reduced number of RPMs. The micro-switch cuts out during reduced speeds at about 3800 50 RPM.

This method of changing the effective surface of the diaphragm and the number of RPMs necessary for the opening and closing the compressor bleed valve prevents irregular operation during the transition to over 3800 RPM.

The electromagnetic air valve (Fig. 46) consists of two main components: the valve and electromagnet, which are joined together by screws 6. The valve consists of housing 9, two valves 7, lifter 8, springs 10, and line coupling 12.

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The housing of the valve, which is made of brass, has a flange for fastening it to the electromagnet, threads for a fitting, compressed air inlet coupling, a coupling nut for connecting the valve with the compressor bleed mechanism and an air outlet coupling.

Inside the housing, on both sides of the openings, which connect the valve with the compressor bleed mechanism, are two milled seats.

The valves are located inside of the housing against the seats and are held down by a copper lifter 8. When the electromagnet is cut out the valve located on the side with fitting 11, is pressed into the seat by spring 10 and it prevents the entry of compressed air into the compressor bleed mechanism. At this time the other valve is raised off from its seat by the lifter so that the compressor bleed mechanism is connected with the atmosphere. Simultaneously compressed air is released from the compressor bleed mechanism into the atmosphere. Through the action of the spring of the compressor bleed mechanism the band bleed valve begins to open. When the electromagnet is cut in, its movable core 2 draws in and contact 5 presses the upper valve into its seat while the lower one is raised from its seat, the compressor bleed mechanism is connected with the compressed air lines and the band bleed valve is closed.

Adjustment screw is used to obtain the desired setting between the movable and the stationary core of the electromagnet. The valve is equipped with connector 1 for hooking up the assembly to the electrical system of the engine. The electromagnet is designed for long term operation.

2.10 Air pressure reduction valve RV—40

This valve reduces the pressure of air from the tank (pressure 150 kilograms per square centimeter), to a pressure of 40 kilograms per square centimeter.

This valve is of a spring type, is leverless, and has a safety valve.

It has two areas: high pressure area A (Fig. 47) and low pressure area B. The high pressure area is connected directly with the tank and receives constant pressure from it. The high pressure is measured by a manometer. The low pressure area is connected through the automatic electromagnetic air valve with the compressor bleed mechanism. Safety valve 2, held in a fixed position by a lock nut, protects the low pressure area from a possible excessive increase of pressure.

Area B has a slide valve 3 which, with the help of the spring 4, tightly closes the opening at the seat which hoins both areas of the reducer, if the air in the low pressure area has not been expended. The low pressure area is tightly closed by a metal diaphragm 5. Inside, between diaphragm 5 and slide valve 3, is piston 6 with pushrod 7. On

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the outer side of diaphragm 5 is outer washer 8, spring 9 and adjustment screw 10. When the reducer is in a monoperating position the low pressure area has a constant pressure of 40 kilograms per square centimeter, which is created by the mechanism of the reducer which is set for this pressure.

In an operating position the presssure in the low pressure area drops, and as a result of this spring 9 presses against washer 8, and moves diaphragm 5; this shifts piston 6 against push rod 7 and pushes slide valve 3 from its seat. This permits the passage of air to diaphragm 5.

If the consumption of air corresponds to that passing into the reducer, the pressure in the low pressure area remains constant and diaphragm 5 is moved. Thus through piston 6 and push rod 7 it holds slide valve 3 in an open position. As soon as the release of air is cut off, the pressure in the low pressure area increases, diaphragm 5 recovers and the slide valve closes the opening.

When diaphragm 5 operates in this way, piston 6 together with push rod 7 and slide valve 3 are in equalibrium, i.e. the total force which acts to open the slide valve is equal to the total force which acts to close it.

3 COMBUSTION CHAMBER

The combustion chamber operates at the highest temperatures and is the most important part of a gas turbine. Dependable and accurate functioning of the combustion chamber is dependent on the reliability and economy of engine operation.

The basic purpose of the combustion chamber is to produce the greatest amount of heat energy through continuous combustion of the fuel in heated air.

Therefore, the combustion chamber should experience only a minimum loss of fuel when in operation. It should have the greatest possible heat per volume in which the combustion takes place; the combustion system should have low hydraulic resistance, because loss of pressure in the combustion chamber reduces the economical operation of the engine; the length of the flame should be as short as possible, and there should be an equal field of heat in the gas stream coming from the combustion chamber.

In addition, the combustion chamber must meet the following specifications; good sensitivity and dependable combustion (there must be no failures, flame-outs, pulsations, or flaring of the flame under all engine operating conditions, at any set speed and altitude of flight, and during changes from one mode of operation to another); dependable combustion of fuel during start of the engine on the ground and in flight adequate life under various atmospheric conditions.

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The physic-o-chemical processes which occur in the combustion chamber can be divided into the following stages:

injection of fuel;
mixing of fuel and fuel vapor with air;
heating the fuel-vapor mixture and vaporizing the fuel;
ignition and combustion of the fuel
mixing of the combustion gasses with air and creation of a homogeneous gas-air mixture.

Fuel injection is a pre-calculated process and the quality of atomization of the fuel and its mixture with the air depends, to a great extent on the rate and completeness of combustion.

The gas turbine differs from piston engines in that the combustion process in the combustion chamber proceeds simultaneously with the mixing and vaporization of the fuel.

Combustion of fuel requires an excess of air, which is used to mix with the heated gases passing into the turbine. With such a great excess of air the combustion process in the gas stream may be unstable without special precautions, since an excess of air leads to a reduction in the rate of propagation of the flame. If the spreading of the flame is slower than the speed of the air stream, trouble occurs in the burners and the flame goes out.

In view of this fact, the burner is divided into the following two sections (from the standpoint of construction): the primary mixing section and the secondary dilution section. The primary mixing section receives primary air and a small amount of secondary air. The quantity of air in theprimary mixing section amounts to 30 percent of the total flow. This amount of air assures great rapidity in spreading the flame. Air is forced into the ignition center of the flame in the primary mixing section in an amount sufficient for complete combustion. The surplus of air coefficient in the primary mixing section is 1:1. In this area combustion achieves maximum temperatures.

In the secondary dilution section the combustion gases mix with the secondary air, which comes in through special openings.

In the secondary dilution section of the burners the secondary air reduces the temperature of the gases to a temperature permissible for the turbine buckets and equalizes the temperature field of the gas stream. The combustion chamber of the engine is an annualar type with 14 burners parallel to the axis of the engine in the annular area between outer case 5 (which is common for all the burners), and turbine shaft housing 10 (Fig. 48) constitutes the burner clusters.

Air coming from the compressor, passes through diffuser 1 where its speed is reduced. The front part of every burner has a fuel nozzle 7 passing through the lining of vortex generator 8 and at the opposite

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end fits telescopically into the hollow opening in the frame of the stator vane assembly of turbine stage 1.

The burners are numbered counterclockwise from the top as viewed from the exhaust nozzle, i.e., the upper left burner is No 1.

Igniters 2, for igniting the mixture when the engine is started, are located in burners 3, 5, 10, and 12.

A flame tube (Fig. 49) consists of the following primary components: vortex generator injector 1, flame tube dome 2, cylinder 4, rear section 5, terminal section 6. The flame tube is argon-arc welded to cylinder 4. The vortex generators are spot welded to the dome.

Vortex generator 1 has 10 vanes each of which is spot welded to the outer surface of the [nozzle] sleeve insert and on to the inner edge to dome.

The exit angle of the blades varies from the axis of the burner: where they come against the [nozzle] sleeve they form an angle of 80 degrees and at their outer ends an angle of 73 degrees.

Component 4 is shaped like a cylinder which terminates in dome 2. Cylinder 4 is located in the area of the highest temperatures. In order to give it sufficient strength and so that it may dissipate heat, 114 ridges have been milled longitudinally on it to a depth of 3.5 millimeters into an overall wall thickness of 6 millimeters. On the surface are six rows of openings of various diameters.

Agron-arc welded to the surface of four flame tubes are igniter sleeves 4 (Fig. 48) for mounting the igniter itself. In burners which have no igniters, sleeve 1 of a smaller diameter is welded on for a fastener. The lining of the fastener has two openings used for blowing air through the fastener. Both sleeves are made of type E1437A material. Crossover tube 3 (Fig. 49), spot welded to the surface of the flame tube is used in the engine starting process for conducting the flame to the burners which do not have igniters.

Each flame tube has two crossover tubes, one of a smaller and the other of a larger diameter. The crossover tube with the smaller diameter fits telescopically into the crossover tube with the larger diameter on the adjacent burner.

The rear section 5 is a cylinder, which passes from a circular configuration to an irregular shape corresponding to the shape of the opening in the intake of the turbine stator vane equipment [burner nozzle guide vanes].

On the surface of the burners are four rows of openings with a diameter of 32 millimeters and two rows of openings with diameters of 3 and 4 millimeters for the passage of secondary air. The openings with

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a diameter of 3 millimeters are clustered in four groups in checker board pattern on the bottom and side of the burners and the openings with a diameter of 4 millimeters are located under the irregular section of the flame tube.

Component 6 is hydrogen-arc welded to the flame tube to help strengthen it and also to facilitate telescopic coupling with the stator vane assembly. The cross section of component 6 fits the irregular shape of the opening of the stator vane assembly. The terminal component is coated with copper so that it will not wear excessively or burn off.

The rear section of the flame tube is electric arc welded to the cylindrical section. All components of the flame tube are made of type E1602 sheet; only the domes and terminal section is made of type CH20N80T [Khz0N80T] material.

The flame tube is secured in an axial position by attach member 3, fitting with its round surface of 38 millimeters in diameter into sleeve 4 (see Fig. 48), which is welded to the surface of the cylinder section.

Those burners which do not have igniters are fastened by locking component 12. The tapered locking component has a flange on one end with two holes for attachment and on the other end a round surface 14 millimeters in diameter. The ball sphere of the locking component is nitrided to prevent wear.

Upon heating the flame tube can expand freely in the direction of the stator vane assembly of the turbine. At the same time the flame tube nozzle can move into the opening of the stator vane assembly to a distance of up to 11 millimeters. Fuel accumulated in the combustion chamber during a starting failure, is removed by two drain lines which are fastened to the lower part of the case of the combustion chamber.

4. TURBINE

The gas turbine is axial and serves to power the compressor and the engine and aircraft accessories.

The gas expansion factor (5) of the turbine is 3.4. For more efficient utilization of the energy of the gases, distribution of the gases is divided [equally] between two stages of the turbine. Each stage has a stator vane unit and turbine wheel. Both discs of the turbine wheels are on the same shaft.

The hot gases pass from the combustion chamber into the stator vane assembly of turbine state I. On entering this assembly the gases have a maximum pressure P of 6.16 kilograms per square centimeter temperature

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T_2 of 810° C and speed C of 155 meters per second (Fig. 50).

In the shaped channels between the stator vanes the pressure of the gases is reduced to P = 4.31 kilograms per square centimeter and as a result of this drop in pressure the absolute speed of the gases increases to C_1 = 473 meters per second. The gases leave the stator vane assembly at an angle of 26 degrees to the face of the revolving rotor of the turbine. The temperature of the gases drops, in the meantime, to t_1 = 722° C.

The gases strike the revolving buckets of turbine wheel I at a speed of w_1 = 255.6 meters per second; the magnitude and direction of this speed is determined by the magnitude and direction of the absolute speed c_1 and the perripheral speed, i.e., the radial speed of the buckets u_1.

A further reduction in the temperature of the gases, e. e., is when the pressure drops from p to p = 3.4 kilograms per square centimeters at stage I of the turbine, occurs in the channels between the buckets of the turbine, as a result of which the mean speed of the gases between them increases from w_1 to w_2 = 422.6 meters per second, and the temperature drops to t_2 = 675° C.

Simultaneously the absolute speed of the gases drops to C_2 = 247 meters per second, because a part of the kinetic energy gained by the gas in the channels of the stator vane assembly is transferred to the buckets of the turbine.

The turning buckets are subjected to forces resulting from changes in the direction and speed of the gases as they pass over the passing buckets, (active work of the flow). In addition to this, as a result of the increase in the speed of the gas flow during its movement through the channels between the revolving buckets (due to the special shape of the revolving buckets), the jet force increases, acting on the revolving buckets (the reactive action of the flow). The peripheral components of these forces creates a rotating movement on the wheel of the turbine. The temperature of the gases drops further in the stator vane assembly and the revolving buckets of the stage II. At the same time the gas parameters change in a manner analogous to the process described for stage I of the turbine.

Diagrams of the flow section of both stages of the turbine, a graph of the changes of gas parameters, and the velocity triangels [vectors] at the inlet sections are presented in Fig. 50.

From the turbine the gases proceed into the exhaust nozzle of the engine at an absolute speed of C_2 = 317 meters per second, which time the gas stream is insignificantly twisted (angle d_2 = 83° 9).

All components of the turvine, operating at high temperatures made of heat-resistant steel. These include the vanes of the stator assembly,

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buckets of the turbine wheels, rims, the discs of the turbine and other components.

The turbine consists of shaft 2 (Fig. 51) and stator vane assemblies 3 and 4 of turbine stages I and II, respectively, which make up the fixed portion of the turbine. The rear bearing of the rotor is a roller bearing which supports the radial load of the shaft.

Axial forces of the turbine rotors are carried by the ball bearings of the compressor rotors and this helps to relieve the load on the ball bearings of the center bearing of the engine. The ball bearing compensates for a possible misalignment of the shafts of the compressor and turbine.

The rotating motion of the turbine rotor is transmitted to the rotors of the compressor by means of splined coupling.

4.1 Turbine rotor

The turbine rotor (Fig. 52 and 53) consists of disc 7 of stage I disc 12 of stage II, buckets 8 and 10, cross braces 9 which connect the discs, flanges 11, turbine shaft 3, ball coupling 1 of the shaft, labyrinth 6, inner ring 4 of the rolle bearing, splined drive sleeve 2 and other small components.

Discs 7 and 12 of the turbine are made of forged E1481 type steel. There are 86 broached grooves of fir-tree design in stage I for attaching the buckets, in stage II there are 68. The grooves are cut at an angle of 10° to the axis in both disks.

The following rings are attached to the disc of stage I;

a smaller front collar which serves to connect it to the shaft of the turbine;
the rear one, of a larger diameter for joining the discs with the the spacer ring.

The disc of the stage II also has two ring collars:

a front one for connecting with the cross brace and the rear technological collar, used for fastening the rotors of the turbine when the turbine is assembled and disassembled.

Both discs have openings for bringing in cooling air.connections of the disc between the cross brace and shaft have close tolerances.

In order to prevent the pins from falling out as a result of centrifugal force, the blind flanges are screwed in and secured against falling out by metal screw locks. [?]

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The buckets of stages I and II of the turbine are forged of stainless E1437A steel and subjected to additional machining. The bucket has a root.

The profile of the bucket is varied along its length, it is characterized by painted flanging, changing into a straight line on its trailing edge. The root of each blade has a fir tree shape corresponding to the fir tree track in the disc of the turbine. The fir tree locks on both stages are the same. The geometric pattern of the fir tree locks takes into account equal distribution of stresses on the root of the bucket. In order to reduce vibration stresses in the locks where the blade joins the disc, the fir tree locks are designed to have a tolerance when the engine is cold, which enables the buckets to adjust under the influence of the centrifugal and aerodynamic forces when the engine is in operation.

The buckets in the I stage 1 (see Fig. 54) have two projections which together with the projections on the disc of the rotor make up the [labyrinth] seal. An analogous seal is in the front part of the roots of the buckets in stage II, while the [labyrinth] seal of the wheel of the III [sic] stage consists simply of projections from the buckets.

The buckets of the stage I are projected from a displacement in an axial direction by a metal lock pin, which fits into a track of the bucket, and the ends are bent toward the face sides of the discs.

The buckets of the stage II are protected from displacement by metal safety lock pins, the round parts of which fit in the tracks of the discs, and the ends are bent toward the face side of the buckets from both sides. The construction of the locks prevents the possibility of the buckets from touching the flange and this also prevents any damage to it by the vanes.

The outer edge of an unmounted turbine wheel is ground to an average tolerance as indicated in the sketch. The difference in the weights of diametrically opposed vanes must not exceed 2 grams. The assembled rotor of the turbine with its splined coupling (Fig. 55) is balanced dynamically to a precision of 40 gcm.

Balancing is accomplished by reworking the buckets, by drilling openings in the blind flanges of the pins joining the discs with the separator and the disc of stage I with the shaft of the turbine and by shaving material off the border of the splined lining in the places marked with the letter "D" (see Fig. 55).

Separator 9 (see Fig. 53) serves to strengthen the connection of the discs of stages I and II of the turbine rotor. It has the shape of a truncated cone with two rounded ends.

The forward smaller rounded end serves to fasten the disc of stage I, and the rear rounded component, for the disc of stage II. To assure

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the necessary seating depth for the separator on the discs, the support seats are machined to a fixed depts.

In order to guarantee the centering of the discs and the transfer of the turning motion (in a heated state) each end 30 has openings for pins. The openings for the pins are made when the unit is assembled.

To make the separator lighter, the face sides and the internal surfaces of the rounded edges are machined. It is made as a forging out of stainless E1481 type steel.

The flange [II] has the shape of a truncated cone with a flared base for the purpose of joining it with the disc of stage II. The flange is fastened by long pins, which also serve for fastening the disc of turbine stage II to the separator.

The flange serves to:

a) direct the cooling air into the locks, holding the buckets of the stage II.
b) protect the periphery of the discs and the locks holding the buckets against the effect of hot gases.

The flange base is milled in order to reduce the weight.
The flange is drop forged of stainless E1481 type steel.

The flange of shaft 3 serves to transfer the turning motion from the rotor of the turbine to the compressor. The shaft is hollow and at the rear it has a flange, facing the disc, are circular grooves whose task is to reduce the transfer of heat from the disc to the shaft. The shaft is fastened to the disc by radial pins. In order to reduce the weight, the flange of the shaft is machined down.

In order to increase the strength of the rotor the disc of stage I is shrink fitted on the shaft on a specially prepared seating on the shaft flange. This flange contains openings, and it fills the space between the shaft and the disc [?]. Along the outer periphery of the front end of the shaft [assembly] are involute grooves for transmitting the torque of the compressor rotor by means of this coupling. The grooves have two planes which serve to center the couplings. [sic] The rear plane has a recess for securing the couplings in an axial direction by means of a locking collar.

One of the teeth of the grooves is adapted along its entire length for locating the locking coupling, which aligns the couplings with regard to the shaft in a uniform position for all movements of the motor. This safeguard permits the maintenance of rotor balance. Also located here is a threaded countersunk opening for securing the rotor shaft.

Inside of the shaft is a thread and two precision cylindrical surfaces for centering and securing the shaft.

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On the rear of the shaft, on its outer surface, are two precision cylindrical surfaces for centering the collar of the turbine shaft.

The shaft of the turbine is made of type 40CHNMA [40KhNMA] steel. Ball coupling 1 of the turbine shaft serves to transfer the axial forces of the turbine rotor on to the rotor of the compressor, and also for compensating misalignment of the rotors of the compressor and turbine. The axial force of the turbine rotor is received by the surface of the large ball of the coupling through the cover of the bearing, which is fastened by bolts to the splined collar of the compressor rotor.

The rear part of the ball coupling has a small ball for transferring the axial forces acting to the rear.

The ball coupling is screwed into the shaft of the turbine with a precisely determined torque, and then it is secured on the shaft by a special stop dog for which an opening has been milled on the ball coupling.

The stop prevents the ball coupling from unscrewing during engine operation, and provides for proper setting under the engine is reassembled, i.e., it assures the maintenance of turbine rotor balance and the proper functioning of the grooves.

The ball coupling is centered on the shaft of the turbine on two cylindrical surfaces, which together with the grooves are copper coated. Between the small centering area and the grooves are found cutouts to reduce the weight of the coupling.

On the outer [?] surface of the ball coupling are involute grooves, used for screwing into the shaft of the turbine. This coupling is made of type 12CH2N4A [12Kh2N4A] alloy steel and, in addition the surfaces of both the small and large ball, is carburized.

Seal sleeve 5 of the turbine shaft serves to accommodate components, fastening the inner ring of the roller bearing and for sealing the oil area of the bearing. The sleeve is set on the shaft beside a centering pin and it is secured to it by four cylindrical pins.

In order to reduce the transfer of heat from the shaft to the [bearing inner] ring, the inner surface of the sleeve has 60 splines. On the outer surface is a precision rolled area for the placement of the bearing ring, and also the [labyrinth] seal grooves.

The inner ring of the bearing rests with its rear face against space ring 13, and on the other side it is fastened to the nut 16 of the rear bearing. The nut is screwed on the threaded end of the sleeve on its three equally spaced grooves and in one groove is a metal lock pin 15 bent into the opening of the nut. The lock pin is secured in an axle direction in a recess of the ring 14, which is set in place between the ring of the bearing and the nut. In order to prevent the ring 14 from turning while screwing on the nut, it has two bits [?], fitting into the

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proper grooves of the sleeve of the turbine shaft.

The sleeve of the shaft is made of type 30CHGSA [30KhGSA].

The [labyrinth] seal of turbine shaft 6 serves to seal the oil area of the rolle bearing, it is a cylindrical ring on whose outer surface ridges have been machined.

Through a precision cylindrical surface the labyrinth is pressed on the corresponding surface of the sleeve of the turbine shaft and is secured by four set screws. It is made of type 30CHGSA [30KhGSA] steel.

The splined coupling sleeve (see Fig. 55) consists of splined drive sleeve 1, centering ring 2, and spring locks 3.

Splined sleeve 1 is made of type 40CHNMA [40KhNMA] alloy steel. It has internal splines for joining with the shaft of the turbine. On the outer surface are annular recesses and short splines for seating the retaining collar. The front part of the collar has short internal splines with which it connects with the [front] splined coupling (see Fig. 51).

On the outer perimeter of the front part of the collar are annular recesses making up the distribution level up to which it is possible disassemble the components of the collar during its balancing [?].

The centering surfaces of the collar, with regard to the shaft of the turbine, consists of the internal surface which specially pressed into the sleeve of ring center 2 and the cylindrical surface under the oblong grooves C (B) [sic].

The center ring is secured, with regard to the collar, by a threaded stop B (Z), whose projecting end is seated in the groove of the truncated tooth of the turbine shaft. This assures the precise mutual spacing of both components when assembling the engine.

On the tapered surface of the collar are 3 openings A, serving to bring the oil to the engine. In one tooth of the oblong grooves of the collar is an inset ring, which contains a spring fastener 3. This safety component consists of bolts 4, springs 5, and a safety sleeves 6. The splined drive sleeve is secured in an axial position by a locking collar.

Locking collar 5 (see Fig. 51) is a ring with grooves on its inner surface: the front side has oblong grooves, the back side -- involute grooves. Among the grooves are ring recesses. Through these grooves the collar is centered according to the oblong grooves of the outer surface of the splined drive sleeve. In the center of the annular recess is an opening into which falls a locking pin for securing the collar. The opening is spaced in such a way so that the teeth of the grooves of all three connected components (splined drive sleeve, locking collar and shaft of the turbine) are placed in mutual opposition to each other.

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In this position the locking collar is tightened by the spring lock nut 3 (see Fig. 55).

2. Stator assembly of stage I

The stator assembly of stage I (Figs. 56, 57, and 58) consists of outer casing 4, inner casing 1, stator assembly frame 2, cover 3, upper and lower supports 6, stator vanes 5, flanges 7 and fastening components.

The outer case is made of type 1CH18N9T [Kh18N9T] steel. The front flange is connected with the frame and the case of the combustion chamber by 56 bolt, a number of which are screwed in, and 16 are [for engine mounts] extended to accomodate the aircraft mounts. Aside from this, the frame and flange are joined by 11 "technological" bolts 8.

Labyrinth [seal] ring grooves are machined into the outer periphery of the front flange to reduce escape of air from the combustion chamber. Machined diagonally into the front side of the flange are grooves for bringing cooling air into cavities obstructed by the outer case and the upper supports.

The rear flange is connected to the case of the stator vane assembly of turbine stage II. It has been machined along the periphery between the openings in order to reduce weight. This recess also serves to facilitate assembly and disassembly of the casing of the combustion chamber. On the wall of the lower part of the case is a level surface with an opening for draining fuel in the event of a cold or an unsuccessful start.

The inner case is made of type 1CH18N9T [1Kh18N9T] steel. It has two flanges. The front flange is joined to the frame by bolts, a number of which are stud type. The front side of the flange has a semicircular recess with diagonal openings, serving to bring cooling air to the area between the case and the lower support.

Flange 7 of the stator vane assembly is fastened with bolts to the rear flange of case 14 [sic].

In order to reduce the weight, both flanges are machined down between the fastening openings.

Frame 2 of the stator vane assembly serves to achieve a strong connection between the inner case of the assembly and its outer case, and also for transferring the torque and forces acting on the case of the combustion chamber and the housings of the rear bearing. The frame of the stator vane assembly unit is centered on the pivots of the turbine shaft and the center housing of the rear bearing by an inner flange.

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The frame consists of an outer ring, an inner ring and 14 equally spaced strute along the periphery, as well as fastening components. The outer and inner rings are made up of 14 segments into which the flame tubes fit. The outer ring of the frame is made of type 1CH18N9T [1Kh18N9t] steel.

Recesses to reduce the weight are found between the fastening openings and they also serve to bring cooling air to the diagonal grooves on the front flange of the outer sleeve of the stator vane of assembly.

On the rear side of the rings is a rolled recess for centering the ring of the outer frame with regard to the outer case. The recess is milled in places. This recess together with the lightening holes assure the entry of air into the areas between the outer case and the upper supports.

Support strut 2 (Fig. 59) firmly joins the inner with the outer rings of the stator vane assemblies. The strut is connected to the outer ring with bolts, at the other end the strut has threaded pin. This pin fits into an opening of the inner ring and is fastened to it by a nut, which is prevented from unscrewing by a lock pin.

The strut is installed in special grooves in the inner rings of the frame. The outer side of the strut is round [?] and with its projection is set into the outer ring. The strut has a T-shape and it is forged of type 4CH14N14V2M [4Kh14N14Vam].steel.

The side surfaces of the strut, bordering the openings of the flame tubes are nitrided.

Along the axis of the strut are two openings for screws which are used to fasten the streamlined covering, while the upper opening is milled in such a way that the covering may freely expand when heated during operation. The strut has 5 openings of a smaller diameter serving to bring air into the streamlined covering.

The inner ring of the frame is made of type CH23N18 [Kh23N18] steel. It has 112 openings located in pairs in 56 places -- for bringing cooling air into the areas between the inner ring of the stator vane assembly and the supports, and also 14 openings for bringing in air for cooling the turbine rotor in the area obstructed by the flange of the stator vane assembly.

Streamlined coverings 1 (see Fig. 59) are used for smooth passage of gases from the flame tubes to the stator vane assembly. The covering is made of a sheet metal material of welded construction. The covering consists of two walls: side and front.

Welded to the front wall are two pins with threads so that the covering can be screwed fastened to the strut of the frame. The covering

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is forged of heat-resistant CH20N80T [Kh20N80T] type steel.

The lower mounts 1 and upper mounts 2 (Fig. 60) for the outer and inner rings of the stator vane assembly are fastened at 56 locations, forming, when assembled with the vanes, passage section of the turbine. In an assembled state, the vanes are located in the areas between the areas.

The areas formed between the mounts are precision cast from heat-resistant type CH23N18 [Kh23N18] type steel and some of the surfaces are machined. Every mount has three threaded lugs used for fastening the mounts to the frame of the stator vane assembly. One of the bolts is of a stud type.

The mounts are of a casing type. Cooling air passes into the space created between the mount and the frame which considerably reduces the temperature of the frame of the stator vane assembly so that even with the considerable dimensions of the engine, minimum radial clearances of the turbine are maintained at all operating regimes. In addition, such construction makes possible the easier changing of the vanes.

Vanes of the stator assembly of turbine stage I (Fig. 61) are precision cast of heat-resistant type ZS6 [ZhS6] steel and also undergo machining.

The profile of the vanes is constant. In order to achieve the necessary exhaust angle for the gases, the vanes are bent. Along its passage portion the vane decreases in thickness giving the leading edge a greater thickness, thus strengthening it and [helping to] preventing cracking.

The vanes can be moved in a radial direction, permitting them to expand when the engine is in operation.

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They are set between the mounts with a clearance for the vanes to prevent them [the vanes] from wedging during operation. To reduce the transfer of heat from the blades to the casing, the face surfaces have a rest projection.

After being assembled, the minimal passage area between the vanes of the stator assembly is checked. F 2225 to 2245 square centimeters, the prescribed area, is achieved by proper vane selection.

Flangs 7 (see Fig. 58) together with the inner frame of the stator vane assembly and the ring of the frame makes up the annualar area through which air passes, through special openings, for cooling the disc turbine state I and the housing of the rear bearing.

The flange is made up of the flange wall and two additional flanges welded to it. One of the flanges is fastened to the inner frame of the stator vane assembly, and the other is set over the outer section of the flange on the housing of the rear bearing. Both flanges and the wall of flange 7 are made of type 1CHi8N9T [iKh18N9T] steel.

4.3. Stator Vane Assembly of Stage II

The stator vane assembly of Stage II (Figs. 62 and 63) consists of housing, stator vanes 2 (56 pieces), outer and inner rings of the stator vane assembly 4 (56 pieces), supports 5 (56 pieces), serving to reduce the transfer of heat from the rings to the housing, mounts 3 (28 pieces) and fastening components.

On the front flange of the housing is a cylindrical projection, which is used to align the stator assembly with the outer case of the stator vane assembly of stage I, and is fastened to it by 56 bolts of which 7 are stud bolts. Fastened to the rear flange of the housing with 56 bolts is the engine nozzle.

After assembly the passage area between the blades of the distribution unit is checked. This area must equal 3390 to 3460 square centimeters.

The housing 1 of the stator vane assembly consists of a case, weleded of sheet steel, two flanges, electric welded to the case and used for fastening the stator assembly to the engine. The flanges are machined out between the fastening openings to reduce the weight. The flanges are also used for attachment to the combustion chamber case [i.e. through stator assembly of stage I].

The case has four lines of openings for fastening the blades and also the outer and inner rings of the stator vane assembly. On the lower part of the wall is a small surface with an opening through which fuel

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which had gathered in the passage part during a cold or an unsuccessful start is drained.

All components of the housing are made of type 1CH18N9T [1KhNi8N9] stainless steel.

Vanes of the stator assembly of turbine stage II (Fig. 61) are forged of Ei437A type heat-resistant steel. The vane is of an equal height and is curved to create the necessary exhaust angle for the gas, leaving the stator assembly.

The upper part of the vane evolves into an area with two openings for receiving the counter sunk screws for fastening the vane to stator assembly of turbine stage II.

For reducing transmission of heat from the vane to the housing of the stator assembly, the outer end [of the vane is machined to reduce the area of contact with the housing and to permit passage of cooling air.

The bottom part of the blade terminates in a pin with threads to which is fastened a mount (one mount for two blades).

The mount is fastened to the blade by a nut locked by a metal pin.

The outer and inner ring elements [mounts] of the stator vane assembly (Fig. 65) are made of forged 1CH18N9T [KhNi8N9T] type steel. On the outer surface of the ring is a machined area to which cooling air passes through two special grooves in the face of the front wall from the stator vane assembly stage I. The back face of the wall has two similar grooves for bringing in air.

In the center of the ring [mount element] is a hole into which fits the outer end of stator vane unit. On the inner surface of the mount element are two countersunk openings for bolts which hold the moun t to the housing of the stator assembly. The openings [for the vane] are oval and expand with temperature.

The sides of the mount elements have longitudinal ribs serving to reduce the passage of air from the cooling area to the passage part, and for assuring the necessary strength of the elements. The assembled mount elements make up the outer passage wall of the turbine channels. The mounts (Fib. 66), when assembled, make up the inner wall of the passage part of the stator vane assembly. The mounts have two counter-sunk openings for seating the threaded pins of the blades [two]. On both face surfaces of the mounts are found two concentric projections [when assembled] which, when assembled, make up the [labyrinth] seal into which fall the appropriate projections of the buckets of the turbine. This seal between the mounts and the buckets of the turbine, prevents the

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passage of gases from the flow channel to the area between the rotor and the mounts.

In a cold state there is a certain amount of clearance between the mounts, which is needed for thermal expansion and when the engine is operating.

The mounts are made of type CH23N18 [Kh23N18] steel.

4. Radial and Axial Clearances in the Turbine

The amount of clearance between the moving and fixed parts of the turbine is determined, to a great extent, by engine operating modes. Large clearances lead to a lower economy of operation because a part of the power of the gases is lost to the turning buckets. Small clearances could lead to abraison of components against stationary parts due to distortions caused by high temperatures. Therefore, during the assembly of the engine, special attention is given to setting and checking the radial and axial clearances (see Fig. 51).

Radial Clearances	Cold	Operating (approx. data)
S - Between the rim and the rotating buckets of the wheel of stage I	4.5-5.9	0.6-2.0
S - Between the rim and the rotating buckets of the wheel of stage II	4.5-5.9	0.8-2.2
G - Between the labyrinth seals on the disc of stage I and the mounts of the stator vane assembly of stage II	4.62-5.55	0.9-1.8
D - Between the labyrinth seals on the rotating buckets of stage II and the mounts of the stator vane assembly of stage II	4.57-3.9	0.8-2.1
V - Between the rear areas on the disc of stage I and the mounts of the stator vane assembly of stage II	3.96-6.5	clearance increases
E - Between the rear surfaces on the rotating buckets of stage II and on the mounts of stator vane assembly of stage II	4.04-7.06	clearance decreases

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Axial Clearance	Cold	Operating (approx. data)
K - Between the face surfaces of the inner mounts of the stator vane assembly of stage I and the face surfaces of the shoes of the rotating buckets of stage I (support 6 is set up)	14-15	10-11
L - Between the face surfaces of the mounts of the rotating buckets of stage I and the face walls of the mounts of the stator vane assembly of stage II	5.4-7.4	8.7-10.7
V - Between the face surfaces of the mounts of the stator vane assembly of stage II	10.5-14.17	7.2-10.9
Between the face surfaces of the mounts of the rotating buckets and the face surface of the exhaust nozzle [housing]	8.63-12.65	11-15

4.5 Cooling of the Turbine

The components of the turbine which work under high temperatures, are cooled by flowing air which is withdrawn from the areas between the burners.

Thus the possibility arises for significant reduction of the temperature of the components and the use of inferior types of special steel on some components.

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Components of the turbine which are cooled are the discs of stages I and II, roots of the working blades of both stages, the outer case of the stator vane assemblies, coverings of the struts, mounts of the stator vane assemblies, inner case of the stator vane assembly stage I, and other components.

The air cooling the outer case of the stator vane assembly progresses from cavity "a" (Fig. 67) between the flame tubes, by special channels in the outer case of the stator vane assembly of stage I and also by the flanges of the frame to area "b", bounded by the mounts and cases.

A part of the air passes through the clearances of mounts and also through the mounts and the stator vane assembly, passing into the working channel of the turbine. A large part of the air passes via the milled grooves into the vent holes "c-b" [?] between the segments of the rings and casings of the stator vane assembly of stage II, thus cooling them. It further passes on into the working channel behind stage II of the turbine.

The air cooling the coverings of the struts progresses through openings in the struts, it bathes the coverings from the outer side and cools them. A portion of this air passes through a special flange in the front wall of the covering into the inner cavity "d-2" [?] passing out through two openings on the face sides of the case and mixing with the gases.

The inner case of the stator vane assembly of stage I with the lower mount is cooled by air brought in through special openings in the frame and the diagonal openings of the inner case into area "d," bounded by the mounts and cases. A part of the air passes through the clearances between the mounts and the blades and passes on into the working channel, the other part of the air is directed for cooling the face sides of the discs of stage II via special grooves on the rear wall face of the inner mount [ring].

Air is taken from the cavity between the flame tubes through 14 openings of the inner ring of the frame for cooling the discs of the turbine rotors and it progresses into the ring area "f-e". This area is created by the flange, the inner case of the stator vane assembly of stage I and the casing of the frame. From there the air passes via an opening in the flange toward the disc of stage I and the housing of the roller bearing, and it fills up area "g-?" ahead of the first rotating wheel; it also cools the locks of the rotating blades of stage I through special openings, and cools the periphery of the discs.

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Through the openings in the discs of stage I the air passes on to:

a) the "h-3" areas, bounded by the discs of stages I and II, and the separation; all of these components are cooled by it;

b) into the cavity "i", bounded by the mounts of the stator vane assembly stage II, the rotor disc and the separator.

From the "h-3" areas between the discs of the rotors and the separator the air passes through openings in the disc of stage II into area "k" bounded by the disc and flange, and it cools the locks of the rotating buckets of stage II. A part of the air from the area between the discs of the rotor passes through a drilled opening in the disc of stage II and into area 1 between the disc and flange of the exhaust nozzle.

All of the air brought in to cool the rotors of the turbine is further mixed with the gas stream. The amount of air used for cooling the turbine equals about 2.5 percent of the total amount of air taken in to cool the engine.

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5. EXHAUST NOZZLE

The working gases deliver a large part of the energy which they possess to the turbine, however on progressing into the exhaust nozzle they still have significant pressure. Here in the exhaust nozzle the potential energy of the gas stream is converted into kinetic energy as pressure is reduced, the temperature falls, and the speed increases significantly. The speed of exit of the gases from the exhaust nozzle of the engine determines the thrust of the engine.

The exhaust nozzle of the engine (Fig. 68) is made in the form of a tapering channel, but is not of an adjustable type. The exhaust area of the nozzle extension is determined according to individual engine performance.

Exhaust nozzle (Fig. 69) consists of the inner case 18, nozzle cone case 36, turbine exhaust stouts 5, front closure 1, nozzle extension 28, heat insulation 19, and outer case 20 serves to protect components of the engine from overheating. (Heat insulation is modified).

The exhaust nozzle extension (see Fig. 74) serves to further protect components of the aircraft from overheating, as does the protective case of the stator vane or assembly of stage II and the exhaust nozzle (up to the extension) and the opening [scoup] for the passage of the cooling air.

The exhaust nozzle is fastened by front flange 7 to the rear flange of the stator vane case or of stage II.

The exhaust nozzle has 4 lugs with supports 16 for case welded to the outer location of the TVG-11 thermocouples which serve to measure the temperature of the gases behind the turbine. The lugs for the thermocouples 15 are used also for fastening the outer case 20 by means of the cupped inserts and anchor nut 14.

The inner case of the nozzle and the exhaust cone are connected to each other by six turbine exhaust struts to form the exhaust channel of the nozzle.

Each strut is rigidly joined to the exhaust cone by electric welding and also by four bolts 32. The bolts are tightened down by castellated nuts 33, under each of which two mouting plates 34 are placed.

Each strut is connected to the inner case of the nozzle by radial screws 11, the threaded part is screwed into the bosses 10; these screws are welded to support 9 and the cylindrical part fits telescopically into projection 8, welded to the casing. Such a connection permits the inner case of the nozzle to freely expand in a radial direction with regard to the outer case when it is heated.

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To eliminate possible distortion of the exhaust struts and to take the pressure off screws 11, caused by the radial pressure of the gas flow, the outer case is further connected to each strut by screws 23. Screw 23 is screwed into cover plate 25, welded to retainer plate 12, and the part falls into the opening of insert 26, which moves freely in an axial direction along a groove of the centering bushing 24.

The insert is secured from falling out by ring 22, welded to centering bushing 24.

The centering bushing is welded to the upper wall of the exhaust strut 21. This connection permits the outer case to expand in an axial direction with regard to the blades when heated, and it is secured by radial screws 11.

The outer case of the nozzle is made of steel sheet 1.5 millimeters thick and butt welded, at most, from six parts. In order to strengthen the weld joints, four reinforcing plates 3 millimeters thick are welded to each of them on the outer case.

Two flanges 7 and 27, milled about the periphery between the fastening openings in order to reduce the weight, are welded to the face surfaces of the inner case. On flange 7 this milling is also necessary for carrying out the assembly and dismanteling of the combustion chamber case.

The flanges have 56 openings; on front flange 7 the openings are in the form of radial sections in order to permit the flange, when heated, to expand in a radial direction (with regard to the case of the stator or vane unit of stage II). Three rows of rings 17 are electrically welded to the outer surface of the inner case for the support of the outer case. In each row there are 27 ring segments. The rings have eyes for fastening the heat insulation springs.

In the front part of the inner case between the first and second row of rings are welded supports 9 and case cover plates in [groups?] sixes in a single row.

All components of the nozzle inner case are made of type 1CH18N9T [1Kh18NGT] steel.

Nozzle cone case 36 is located inside the nozzle.

It is argon-arc welded of two truncated cones 4 and 13, made of steel sheet 2 millimeters and 1.5 millimeters in thickness.

Cone tip element 29 is welded to the apex of the cone and flange 3 to the base of the cone. To the inner flange 3, which has 24 threaded openings, is front closure 1 with screws 2.

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Five circular rings 30 are spot welded inside the cone for reinforcement.

All components of the cone are made of type 1CH18N9T [1KL18N9T] steel.

Turbine exhaust strut 5 serve to connect the outer case and cone. The strut consists of the strut proper 5, the upper faces 21 of the strut, reinforcement 6, aft edge 35, lugs [?] and centering bushing 24. It is made of steel sheet 2 millimeters thick and is streamlined in design.

The face sides have flanges. To the upper flanges are welded the top of strut 21, and the bottom, is welded to the cone case.

In order to increase the support surface, aft edge 35, with its four openings for screws to secure the strut to the inner wall, is argon-arc welded to the cone and the lower terminal part of the strut.

Reinforcement 6 is welded inside the strut to give it greater strength. Projection 8 and the centering bushing are argon-arc welded to the top of the strut. Components of the casing are made of type 1CH18N9T [1Kh18N9T] steel.

The closure (Fig. 70) reduces transfer of heat from the cone of the nozzle to the disc of the turbine. It has three rows of openings with flanging for equalizing the pressure in the inner areas of the case in the event of a rapid drop of pressure.

The closure consists of the case 2, made of steel sheet 1 millimeter thick, and flange 1, spot welded to the case of the closure proper. Along its periphery this flange has 24 radial holes for screws fastening the closure to the flange of the cone. The closure is made of type 1CH18N9T [1KL18N9T] steel sheet.

The nozzle outer case (Fig. 71) serves to protect components of the aircraft from the excessive heat of the exhaust nozzle.

The case proper, made of a sheet metal material 1 millimeter thick, has a conical shape.

For strengthening purposes three ring (frames 2) are electrically welded to the inside of the case. In the places where the ring stiffeners 2 are welded, the covering has "wavy" rings in the skin which also increase its rigidity.

The covering has four circular openings. A with flanging used for fastening it to the inner case of the turbine and for leading out the thermocoupling conductors.

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Every opening is bordered with a welded support 1, which strengthens the construction in this place.

The outer case has six protrusions C (B), located on the outer surface of the exhaust nozzle over the strut components. The bottom extrusion has an opening B for the release of fuel, which may enter the case during a cold start of the motor.

In the lower part of the case back-up plates 3 are riveted in two places to reinforcements 4. The back-up plates have a strengthening function here and the drain line is fastened to the bosses with screws and couplings.

Material of the bosses -- steel 45. All of the other components of the outcase are made of aluminium alloy AMgAM.

Heat insulation 19 (Fig. 67) consists of one layer of asbestos strip on the inner case of the nozzle and five layers of aluminium foil.

Between the second and third layers of the foil is a mesh with 48 longitudinal and four transverse wire springs. The spring mesh holds the inner sheets and creates an air space between the foil sheets.

The longitudinal springs are secured to the eyes of the rings. The ends of the transverse springs are joined together.

The nozzle extension (Fig. 72) consists of a flange 1, with milled out areas for the purpose of reducing its weight, the case proper of the extension and ring 4.

The nozzle extension is of tapered design and is butt welded to flange 1. Ring 4 is welded to the opposite end of the case to give it greater strength. On the edge of the ring are two eyes 5 for securing the blind transfer flange [?]. Spot welded to the base of the flange are eight anchor nuts 3, to which the discharge pipes are fastened by screws and couplings. The face of the front nozzle extension flange butts with the rear flange of the [main] nozzle inner case and fastened to it with 56 bolts.

The exhaust diameter of the nozzle extension, which determines the operational temperature and thrust of the engine, is selected when the engine is tested at the test station of the production plant. The most efficient extensions selected range in diameter from 847.5 to 860 millimeters.

All parts of the nozzle extension are made of type 1CH18N9T [1Kh18N9T] steel.

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The nozzle shroud (Fig. 73) serves as a protective component for the aircraft against overheating. Shroud 4 (Fig. 74) is made of aluminum alloy AMgAM 1.5 millimeters in thickness and it is butt welded from a maximum of 6 parts.

A small section of the front face side of the shroud is curved outward to collect air. On the center of the shroud are 6 lugs A opposite the lugs on the nozzle [proper] outer case [?].

For strengthening purposes, four aluminium rings 6 are spot welded to the inner surface. For the same reason an aluminium air scoop 2 is welded to the front part of the shroud. The air scoop and three additional rings in the lower part have stamped out sections for the free passage of drain lines.

Riveted to the air scoop are 15 attach members made of 65G steel strip. In order to dependably strengthen the attach members, 28 steel plates 3 are placed under the rivets. The support 1 with special brackets and screws holds the nozzle shroud to the front flange of the stator vane assembly of stage II of the turbine.

The shroud contains four flanged openings 5 for attaching the thermocouples. From the inner side these openings are strengthened by welding on back-up plates 8. Attached to the outer surface of the shroud are 13 clamps 7, and one clamp 9, for fastening the thermocouple conductors. Five clamps 10 serving this purpose, are fastened symmetrically by screws 11 from the right or the left side of the shroud during its attachment on either the left or the right engine.

ACCESSORY HOUSING

Housing of the engine accessories assemblies.

The housing of the motor assemblies (Figs. 75 and 76) contains fuel pumps PN-15B and PN-28B and centrifugal transducer CD-3. It is located on the upper right wall of the center compressor case at a 30° angle to the vertical axis of the engine, fastened by seven bolts. It consists of the housing proper 35 (see Fig. 76), gears, shafts, ball bearings and the reduction drive shaft of the centrifugal transducer.

Housing 35 of engine accessories is cast of magnesium alloy ML5 and has four flanges. Fastened by bolts to the two rear flanges of the housing are pumps PN-15B and PN-28B, while the intermediate mounting member 9 of the centrifugal transducer is fastened by screws 36 to the two front flanges, and filter 2 is fastened to pivot stud bolt 38 (see Fig. 75). Paronite gaskets are placed over the flat surfaces of the flanges of the engine accessory housing.

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Engine accessory housing 35 has three rows of recesses for bearings, seven brackets with openings for screws with which to fasten the accessory housing to the center [compressor] case, two oil line couplings 31 for bringing oil from the oil filter to the oil distributer and an oil outlet coupling 11 for carrying off the oil from accessory housing 35, two openings 37 for carrying off oil from the drive of the centrifugal transducer, and two threaded openings for nozzles 22 and 42 for bringing oil to the splined joint of the shaft and to the gears of the PN-28B drive.

Oil inlet opening 39 on the flange holding the oil filter is connected with threaded line coupling 31 (see Fig. 75) bringing oil to the oil distributor. The threaded couplings for the lines and nozzles are connected by channels and an annutar groove located in a recess of the engine accessory housing.

The drives located in the engine accessory housing are powered by the right intermediate drive through a shaft connected on one end by splines with the drive shaft of the bevel gear of the intermediate drive, and on the other end -- with drive shaft 20. All three housings have their shafts mounted on ball bearings pressed into the recesses in flanges made of an aluminium alloy. The bearings are secured by screw stops.

Drive shaft 20 of the engine accessory housing turns on two ball bearings and transfers the turning motion through gear 17 to the drives of fuel pumps PN-15B and PN-28B and to the drive of the centrifugal transducer. Drive shaft 20 is hallow and is made of type 18CHNVA [18 KhNVA] steel. On its inner surface the shaft has 24 involute grooves and the three ring grooves (two grooves for retainer rings) securing the shaft of the drive against axial displacement and the third, for the blind flange, assures a certain level for oil brought in by nozzle 22 for lubrication of the grooves of the drive shaft, and the oil affected by the centrifugal forces. On the outer surface the shaft has 38 involute grooves and on the face surface -- an assembly section for installing and removing the retainer ring. The drive shaft with its ball bearing and gear are secured in an axial position by retainer ring 44.

The gear is made of type 12CH2N4A [12Kh2N4A] steel and has 38 inner involute grooves; on the rim of the gear are 38 teeth and openings to reduce weight. Bevel gears 12 and 24 receive their power from gear 17 and they transmit it to the shafts of fuel pumps PN-15B and PN-28B. Gear 12 also drives the centrifugal transducer.

Gear 24 of fuel pump PN-28B is mounted in two ball bearings. Ball bearings 29 are held in the flange by retainer rings 26 and 30, and gear 24 with its bearings is fastened by nut 27, secured by lock washer 28.

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Separator bushing 23 is made of type 12CH2N4A [12Kh2N4A] steel. Its rim has 40 teeth and the inner part of the end section has 14 involute grooves.

Gear 12 of the fuel pump PN-15B drive and the centrifugal transducer drive are mounted on splined shaft 16, which turns on two ball bearings 15. The ball bearings are fixed in the flange by retainer rings 14. Gear 12 is made of type 12CH2N4A [12Kh2N4A] steel and has 38 involute grooves inside its head, and 40 teeth and lightening holes on its rim.

Shaft 16 of the fuel pump drive is hallow and is made of type 12CH2N4A [12Kh2N4A] steel. The shaft has 38 outer involute grooves for engaging gear 12 and a gear with 21 teeth of the centrifugal transducer drive, two areas for positioning the ball bearings, and 14 inner involute grooves for engaging the shaft of the PN-15B fuel pump.

The drive of the centrifugal transducer serves to transmit power from the drive shaft of the fuel pump to the centrifugal transducer.

Intermediate mounting member 9 of the centrifugal transducer is cast of magnesium alloy ML5. The member has two flanges: one flange with a lug and four openings for securing the bolts of the intermediate housing of the engine accessory drives, and the other -- square flanges with four bolts for securing the centrifugal transducer.

Member 9 has two recesses for ball bearings and positioning the centrifugal transducer, nine openings for draining the oil from the centrifugal transducer and two annular grooves -- one for a retainer ring and the other for a rubber seal ring.

Gear 8 turns on two ball bearings, which are pressed into the front of the housing. Retainer rings 5, set into the annular groove of the adapter flange, and also retainer ring 6, set into the annular groove of the shaft of the drive gear, prevent axial displacement. Gear 8 is made of type 12CH2N4A [KhZNYA] steel and its rim has 15 teeth, a groove for a retainer ring, and on the end of the shaft -- a square flange for connecting with the coupling of the centrifugal transducer.

Oil for lubricating the housings of the aircraft accessories progresses through oil inlet opening 39 (see Fig. 76), from the engine oil filter. The connection between the flanges of the oil filter and the engine accessory housing is sealed by bushing 33 (see Fig. 75), rubber seal ring 32, and parcnite washer 84.

From the channels milled inside the housing the oil is led to nozzle 42 (see Fig. 76) for lubricating gears 17 and 24 (see Fig. 75), and in the places where they are connected to nozzle 22, for lubricating the shaft of the drive. Drive 22 with a calibrated opening of 0.7

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millimeters in diameter and hozzle 42 with a calibrated opening of 0.8 millimeters, have filter openings 0.5 millimeters in diameter at the outlets. All of the other gears and ball bearings spray are lubricated.

Oil is carried, from the housing of the engine accessories by a line connecting coupling 11 with the line passing along the right horizontal arm of the compressor case.

The housing of the aircraft accessories (Figs. 77 and 78) serves for the positioning transfer of power to one hydraulic pump and two generators. The housing is located on the left upper side of the center compressor case at an angle of 30° to the vertical axis of the engine and is fastened by eight stud bolts. The housing consists of component 1 (Fig. 77), gears, shafts, ball bearings and two rubber washers.

The housing is cast of magnesium alloy ML5 and has four-flanges. The two front flanges with four stud bolts 28 (see Fig. 78) are used for attaching the hydraulic pumps, the two rear flanges with four threaded openings for fastening the adapter components of the generators 6 [sic.] (see Fig. 75). In addition to this, the bottom wall of the housing has an opening with a flange and nine stud bolts 31 (see Fig 1.78) for fastening the cover. Through this opening the gears can be installed in the housing.

In the lower part of the housing are two line couplings: line coupling 32 for bringing in oil and line coupling 30 for discharging oil. The housing has eight openings 29 for bolts for attaching the engine accessory housing to the center case of the compressor.

The drive of the accessory is powered from the left intermediate drive through a shaft joined one end by splines with the shaft of bevel gear 5 (see Fig. 15) of the intermediate drive and on the other end with drive shaft 24 of the accessory (see Fig. 77).

Drive shaft 24 transmits power through drive gears 10 and 25 to the drives of the hydraulic pumps and generators.

All of the shafts of the components move on ball bearings mounted in flanges made of aluminium alloy D1. The flanges are pressed into recesses in the housing and secured by screw stops.

Drive shaft 24 is hallow and is made of type 18CHNVA [18KhNVA] steel. It has 24 inner involute grooves and two annular grooves for retainer rings to prevent misalignment.

Blind flange 7 serves to maintain a certain level of oil brought in by nozzle 8 for the lubrication of the drive shaft and of the oil thrown from the shaft by the centrifugal forces. The shaft has 38 outer involute grooves and a recess on the face end for inserting and removing the retainer rings during assembly.

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On drive shaft 24 are assembled the following:

-- generator drive gear 10;

-- hydraulic pump drive gear 25;

-- spacer bushing 22 and two ball bearings 23.

Axial alignment of the drive shaft is maintained by ring 26.

Generator drive gear 14 is mounted on splined shaft 12, which is mounted on two ball bearings 11 and transfers motion via the grooves to the shaft of the generator.

Drive gear 14 and shaft 12 is secured against axial displacement by retainer ring 18 from one side and packing box 4 on the other. Gear 14 is made of type 12CH2N4A [12KhZNYA] steel and has 23 teeth along its rim and 34 involute grooves in the flange.

Drive shaft 12 is made of type 38CHA [38KhA] steel and has 34 outer and 16 inner involute grooves. Blind flange 16 prevents oil from seeping into the generator.

Hydraulic pump drive gear 17 is mounted on a splined shaft which turns on the two ball bearings 19. Gear 17 transmits power through the splined shaft of the hydraulic pump. Retainer rings 21 and retainer rings 18 safeguard gear 17, shaft 20, and ball bearings 19 against axial displacement. Gear 17 is made of type 12CH2N4A [12Kh2N4A] steel and its rim has 43 teeth and lightening holes; in the bushing are 38 involute grooves.

Driven shaft 20 is made of type 38CHA [38KhA] has 38 external involute grooves, and inner [word illegible], and also an opening for lubricating the ball bearings.

The attach member for fastening generator 6 is made of aluminium alloy AL5 and it has a square shape. The flange has two openings for stud bolt and two threaded openings for screws 2 for fastening [word missing] to the housing. In addition to this, the flange has 6 openings for bolts 9 for fastening the generator.

Lubrication of the engine accessories is carried out as follows: [word missing] from the oil distributor is carried to oil inlet coupling and the channels in the body of the housing is forced into the ring recesses under the aluminium sleeves of the ball bearings. It is further carried through milled areas in the sleeves to the ball bearings. Lubricated in this manner are four bearings of the generator dive and two bearings of the hydraulic pump.

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[redacted]

The two end bearings 19 of the hydraulic pump drive are lubricated through openings in shaft 20. The spaces occupied by the bearings and the hydraulic pump are always partially filled with oil, because the oil outlet is found above the lower level. Gears 10 and 14 of the generator drive are lubricated through grooves of annular grooves 5 of the center bearings. In the above mentioned oil channels, carrying oil for lubricating purposes, are filters, which consists of lines and filter openings of 0.5 millimeters in diameter.

The grooves of the shaft of the engine accessory drive are lubricated by nozzles 8, which have a calibrated opening of 0.7 millimeters in diameter and an opening of 0.5 millimeters in diameter at the inlet filter. Gears 25 and 17 of the hydraulic pump drive and the bearings of the drive shaft are lubricated by nozzles.

In order to prevent oil from reaching the generator cavity, the component uses rubber packing 4. Release of the oil from the packing cavities is carried out by a tube with a nozzle, attached to the lower edge of the intermediate attach member 6.

Oil from the cacity of the housing flows off to the front case of the compressor by a line connecting nozzle 15 with the line passing along the left arm of the front compressor case.

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Chapter III. Lubrication System

DATA

The lubricating system (Fig. 79) maintains a constant delivery of oil to the working parts of the engine when it is in operation in order to reduce friction and carry off the heat developed between the moving surfaces.

In addition, oil which circulates in the engine baths the small metal parts of the working surfaces.

The following components make up the lubricating system: Oil tank 1,
Oil-fuel cooler 2,
Oil pump 36,
Oil filters 6,9,20,22,
Centrifugal separator 32,
Lines and channels of the oil system and the nozzles for the delivery of oil to the parts being lubricated.

OPERATION OF THE LUBRICATING SYSTEM

Oil is taken from oil tank 1 mounted on the aircraft to oil pump 36, which consists of delivery stage 38, three pumping stages 39, 40, and 41, and a two stage reduction valve 37.

Oil from the delivery stage of oil pump 36 flows to filter 6. Through the return valve located in the body of the filter, and the milled part in the body of the engine accessory housing, the oil progresses [word missing] drives of the aircraft assembly case 11 and it goes on to the oil flow divider 26 [?].

From this flow divider the oil is distributed through lines as follows: 1) through further filters 20 and 22 on to lubrication of center bearing 16 and rear bearing 23 of the engine, to lubrication of the right intermediate drive 4, then on to lubrication of the left intermediate drive 30 and from the channel in which [word missing], located in the upper left casting of the front compressor case the oil passes on to lubricate front bearing 34 and the bevel gears, then on through the check valve 35 to lubricate the bearings of the disengaged turbostarter during its autorotation when the engine is running; 2) to lubricate the drive 28 of the aircraft accessories; 3) through auxillary filter 9 to lubrication of the centrifugal transducer 10 and hydraulic operation of the diaphragm of its electric microswitch.

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[redacted]

Reduction valve 37 of the delivery pump maintains back pressure in feed lines to the desired amount (4-5 kilograms per cubic centimeter). The second stage of the reduction valve, with a partial release of oil from the feed lines to the vacuum lines, assures a reduction of pressure in the feed lines during the various stages of the idling of the engine. A drop of pressure in these stages is a warning of oil leakage from the center and rear bearings of the engine through the [labyrinth] seals.

The pressure of the oil in the feed lines is measured by remote electrical pressure gauge EMI-3R7, the sensor of which is fastened by a screw joint on cover of oil filter 6.

The temperature of the oil entering the engine is measured by electrical thermometer EMI-3R, sensor 29 is located in the oil flow divider 26.

All of the used oil from the housing of the aircraft and engine accessories as well as the right intermediate drive drains, by gravity, into the housing of the lower drive. Oil from the main drive and the front bearing is also collected here. The oil used in the center and rear bearing of the motor is carried off through the foam filters 18, 21 and two oil collectors 17 and 25, from which it is carried off by lines 39 and 40 to the oil pump.

From the lower drive the oil is pumped off by stage 41 of the oil pump. The discharge lines of pump-off stages 39, 40 and 41 are joined into one channel, from which the oil is led through oil-fuel cooler 2, located on the aircraft, into oil tank 1.

During starting and the operation of the turbostarter the oil, which has passed through the starter, is carried off to the front housing of the motor and then to the housing of the lower drive. Pumping of this oil back into the oil tank is carried out by the oil pump of the turbostarter, which, in addition to the main delivery stage, of the appropriate oil system of the starter, also has an additional pumping stage. The pumping stage pumps off the oil from the lower drive during the operation of the turbostarter and delivers it to the lines leading to the oil tank.

Check valves 8.35 and 48 prevent flow of oil from the oil tank to the engine when the engine is not running. In addition, valve 48 prevents the escape of oil, during the operation of the turbostarter, from its engine's oil system.

The engine has three oil discharge components: drain 47 on the lower drive and two threaded line couplings 45 and 46 on the lines which carry off oil from the oil collectors of the inner housings.

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3. OIL SYSTEM VENTING

To assure the normal operation of the oil system the inner cavity of the front compressor housing, the area of the shaft casing and the oil tank is connected with the atmosphere through centrifugal separator 32, fastened to the housing of the tachometer drive of left intermediate drive 30.

Venting on the engine is carried out as follows: The shaft casing is connected by a steel tube and an angle member with the housing of the tachometer drive. The rotor of the front compressor housing is also connected with the drive housing of the tachometer by a steel tube in the left cast upper strut and the outer vent tube. The oil, tank is connected by a steel tube with the front compressor housing through the left horizontal strut. The air and oil gases from all of the abovementioned areas pass through the housing of the tachometer drive into centrifugal separator 32, in which air is separated from the oil. The air is conducted from the motor via a steel tube connected to the nozzle of the centrifugal de-aerator by a flexible synthetic [durain] tube.

The oil is released via a line coupling on the housing of the centrifugal separator into [word missing] compressor case through the left horizontal strut.

ASSEMBLIES OF THE OIL SYSTEM

Oil pump of the engine

The oil pump of the engine (Fig. 80) interconnects four oil pumps of gear type; it supplies oil under pressure to locations being lubricated and pumps the oil out of the engine.

The oil pump is fastened to the housing of the lower drive to which it is attached by four screws. It consists of housing 1, delivery stage 22, stage 18 which pumps the oil out of the center bearing, stage 17 which pumps oil out of the lower drive, shaft 16 of the drive gears, shaft 15, ball bearings 14, gear 13, and a two-stage reduction valve.

The following components are screwed to housing 1, which is made of type ML5 magnesium alloy: line coupling 3 for bringing oil from the oil tank 2nd adapter 2 for bringing the oil to the oil pump of the turbostarter;

coupling 25 for bringing the oil from the center bearings;

coupling 23 for bringing the oil from the rear bearing;

coupling 12 for carrying oil via the pumping stage of the oil pump of the turbostarter into the oil tank;

coupling 11 for carrying oil from the oil pump to the oil tank.

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Each stage of the oil pump consists of one pair of gears, housing, and cover. All of the stages are joined into one unit which is fastened to housing 1 by two screws 26.

Rubber packing 24 and seal rings 20 and 21 prevent the leakage of oil from the delivery stage into the vacuum stage.

Oil from delivery stage 22 is brought by lines into the cavity of shaft 16, which is sealed at both ends by blind flanges. Oil is brought in via the check valve 48 (see Fig. 79), which is mounted in the housing of the delivery stage.

The oil passes through radial openings in shaft 16 to lubricate the bronze bushings of the drive gears.

The two-stage reduction valve, which consists of line coupling 6, valve 9, slide valve 10, nut 5, adjustment screw 4, and two springs 7 and 8, maintains a fixed oil pressure for all modes of engines operations. Operation of the two-stage reduction valve is based on the principle of releasing the oil from the feed lines to the vacuum lines. The amount of oil released depends on the pressure in the feed lines. This pressure increases with and increase of engine RPM.

If the pressure in the feed lines is changed, slide valve 10 and valve 9 are shifted by springs 7 and 8 to the right of the end position and oil does not flow through the valve. With increase of engine RPM, the output of the pump increases, the pressure in the feed lines increases, and it overcomes the tension of spring 8, shifts slide valve 10 to the left and this slide valve opens the release opening in valve 9.

The slide valve spring characteristic is selected in such a way that at idle engine RPM a reduced oil pressure is maintained in the feed lines, and at engine RPMs above idle slide valve 10, as a result of the increasing pressure of the oil, shifts to the left of the end position and closes the release opening in the valve.

The flow of oil through the slide valve is interrupted and the pressure in the feed lines rapidly increases. During basic types of operation valve 9 comes into play, maintaining the oil pressure in the feed lines of the oil system of the engine at 4 + 5 kilograms per square centimeter. Adjustment screw 4 is used to set the pressure.

The oil filter (Figs. 81 and 82) is fastened to the aircraft accessory housing by eight screws and consists of housing 1, cover 3, and 12 discs 2 of the filter element, which are set on a shaft and tightened by screw 6. Each disc of the filter is made of corrugated plates, two screens, two fine screens, and outer and inner sleeves.

Oil passes from coupling 12 to the cavity of filter housing 11 and moves through the corrugated plates of the filters. It goes on to the

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area of cover 7 from where it passes through check valve 9 and cavity 10 before moving on to the drainage outlet which is found on the flange of the filter housing.

Check valve 9, of a disc type, prevents leakage of oil from the tank into the engine when it is not running. The filter is equipped with safety valve 4, through which oil passes to the engine in the event of filter clogging, thus bypassing the filter. The housing and cover of the oil filter are made of magnesium alloy ML5, and the screens, of brass wire.

The cover has coupling 8 to which is fastened the sensor for measuring the oil [pressure] in the delivery tubes. The cover is fastened to the housing by seven bolts 13.

Centrifugal separator (Figs. 83 and 84) separates the air from the oil-air mixture, which is formed inside the housing, and the front housing of the compressor as a result of the oil thrown about by the rotating components.

The centrifugal separator is fastened to the housing of the tachometer drive by six screws. It consists of housing 1, rotor 2, and housing 14. The housing is made of magnesium alloy ML5, and fastened to it by eight screws is a steel housing of welded construction and a rotor.

The rotor consists of the cover 12, drums 6, drive gear 4, two ball bearings, packing components, and securing components. The clearance between the rotor and the housing is fixed by means of calibrated washer 21.

The drum is made of steel, it is machined and has 12 equally spaced blades in the unit with the head [work missing] and rear wall.

To prevent leakage of oil through the ball bearings from the area of the drum into the atmosphere, the bearing is sealed from both sides. On its rear side, the side from the bearing, the drum has 24 equally spaced grooves 22 which have a centrifugal function with regard to discharging oil from the bearing. From the other side of the bearing is a packing consisting of rings 13, bushing 18, bronze rings 17 and a rubber gasket 19. The insert and rings are steel. The insert has a flange with eight openings for screws 20, fastening [word missing] lid and a groove for the rubber packing.

The inside diameter of the insert serves as a sealing surface on which act two bronze seal inserts mounted in a groove on the outer section of the rings. The level surfaces of the flanges of the centrifugal [separator] are sealed with washers 10 made of cloth.

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The centrifugal separator is powered by the left intermediate drive through gear 4. The gear is connected by splines with the moving wheel and it is fastened with screw 5.

Air, saturated with oil vapors, passes out through four openings 3 from the side of the flange which secures the centrifugal separator to the moving wheel. The oil, as a result of the effect of the centrifugal force, is separated on the inside [word missing] of the housing which has a collection channel 9; oil flows via this channel into cavity 7. From the cavity the oil passes through discharge coupling 8 on to the housing of the centrifugal separator through the discharge line into the cavity of the insert of the front compressor housing.

Air separated from the oil passes through openings 16 in the head of the turning wheel into housing 14, from which it is carried off by line 15 outside of aircraft.

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Chapter IV.

THE FUEL SYSTEM

1. GENERAL DATA

The basic fuel for RD-3M engine is grade T-1 petroleum product according to GOST 4138 - 49, or grade TS-1 according to GOST 7149 - 54. Aircraft gasoline B-70, according to GOST 1012-54, is used as the starting fuel, together with an additive of 1 percent by weight of MK-8 oil according to GOST 6457-53, or transformer oil according to GOST 982-56 of any grade (with an admixture of VT-1 or without an admixture).

The fuel system serves to supply fuel to the engine in the quantity necessary to run it in any operating mode, and it operates on the principle of direct injection of the fuel by nozzles to the burners of the engine.

The quantity of fuel required by the engine depends on the speed of rotation of the engine and the altitude and speed of flight. The highest consumption of fuel, during maximum engine rpm of low temperature, and maximum speed of flight at sea level, is approximately 11 times greater than the minimum fuel consumption of the engine. This fact places definite requirements upon the system of fuel supply and engine control.

The control of the RD-3M engine is achieved by changing the consumption of fuel through automatic control and manual throttling.

The following units make up the fuel system:

Pump CN-1...1
Plunger pumps PN-28B and PN-15B.......................1 set
Fuel manifold...1 set
Discharge valve.......................................1
Main nozzles..14
Starter pump (PNR-10 - 3M)............................1
Filter for starter fuel...............................1
Electromagnetic fuel valve............................1
Starter nozzles.......................................4
Connecting hose.......................................1 set

2. OPERATION OF THE FUEL SYSTEM

The fuel assembly consists of three individual systems, designated for different functions:

- the main fuel system
- the starter fuel system
- the main fuel waste system

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MAIN FUEL SYSTEM

In the engine fuel supply system (Fig. 85) the fuel units are distributed according to the following schematic:

From fuel tanks 106, the fuel is admitted to centrifugal pump 107, mounted on the aircraft, and also through fire valve 108, to the second pump 109, mounted on the engine. The fuel passes by flow meter 100, oil-fuel cooler 111, and filter 112 to plunger pumps PN-28B and PN-15B.

During rotation of rotor 46A and 63, plungers 65, resting on the conical surface of the thrust bearing, acquires linear reciprocal movement due to the slanting position of the thrust bearing.

In its linear movement for about half a revolution of rotor, the plunger sucks in the fuel through opening 66 in the slide valve, and during the following half-revolution the plunger displaces the fuel to the high-pressure channel through an opening in slide valve 58.

The extent of the plunger displacement and consequently the feed of the pump increases in proportion to the increase of the angle of inclination of the thrust bearing. The delivery of the pump also increases with increase of the rotor speed and increase of the work stroke of the plunger.

An increase in the back pressure of the pump leads to a certain decrease in the fuel delivery under constant pump speed and the angle of inclination of the bearing due to the lack of tightness in the slide valve and the clearance of the plunger in the rotor.

By decreasing the inclination of the thrust bearing to 0°, the pump output is decreased to zero; and in the further changing of the angle of inclination, the pump changes from a displacement pump to a suction pump, because now, during the suction stroke of the plunger, the discharge slide valve will be opened, and during the displacement stroke, the suction slide valve will be opened.

The possibility of pumping out part of the fuel at negative angles of inclination of the bearing, is utilized by the PN-28B and PN-15B systems for lowering the total capacity of the two pumps during flight at high altitudes. In this case, part of the fuel supplied by pump PN-15B is pumped back by pump 28B.

Fuel under high pressure passes from both pumps (By channel 52 from fuel pump 15B and by channel 38 from fuel pump PN-28B) to throttle valve 32, located in fuel pump PN-28B.

Throttle valve 32 changes the passageway depending on the position of the control lever and, together with distribution valve 54, performs the functions of a stop valve. During a failure of the automatic fuel control system, the fuel is supplied with the aid of manual emergency control.

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The fuel which passed through the throttle valve is carried by duct 26 to distribution valve 54, which is opened by fuel pressure and admits the fuel to the nozzle.

At relatively low pressures, when the distribution valve begins to operate, only part of the passageway of duct 55 is opened, which feeds the fuel to the idling duct of the main fuel nozzle. The passageway gradually increases with rise of fuel pressure. With further increase in pressure, the passageway of duct 56 opens, whereby the fuel passes to the main duct of the nozzles.

2.1.1. Automatic fuel supply system

The control of the engine at all stages and also its shut off is achieved by a single lever 34.

The fuel pressure at the pump outlet must vary within wide limits to satisfy all conditions of operation. In order to eliminate the effect of pressure changes on the performance of the automatic equipment, constant-pressure valves 46 and 78 (Fig. 85) have been mounted on units PN-28B and PN-15B which maintain at the entrance to the automatic devices a constant pressure (on PN-28B 11.5 - 1.0 kg/cm^2, and on PN-15B 20 - 3 kg/cm^2).

The principle of operation of the constant-pressure valve is based on the throttling of fuel admitted to the valve. If the fuel pressure rises in front of the valve, the tension of the spring becomes inadequate to hold the valve in balance and the valve moves closing the admission opening until the fuel pressure drops to the desired value for given setting of the spring). If the fuel pressure drops below desired valve, then a reverse process takes place which is accompanied by an enlargement of the admission opening, thus increasing the pressure in front of the valve to the desired value.

The change of the fuel supply to the engine is effected only through the change in the angle of inclination of the thrust bearing of the pump. All the automatic equipment exerts an influence on the thrust bearing through one servocontrol. While one of the automatic devices is in action other equipment automatically cease to influence the operation of the servo-control.

The speed ranges are maintained by the pilot in the following manner:

a. in the range from idling to n = 3,400 rpm, in the so-called manual control range - with the aid of the throttle valve and the valve for maintaining a constant fuel overpressure at the duct of the cock.

b. in the range from n = 3,400 rpm to maximum rpm (in the so-called automatic control range) with the aid of the centrifugal governor goes into action (n = 3,400 rpm on the engine shaft) is called the beginning of automatic operation.

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2.1.2. Manual range of control.

As has already been mentioned, control of the engine is carried out by the lever alone. The shaft of the control lever is moved with the aid of gear link moving at the same time the throttle valve and the bushing which directs the bias of the spring of the centrifugal governor. However, in the range of manual control moving of the bushing does not change the bias of the spring, because there is an adjustment clearance between bushing 45 and bushing 29 (see Fig. 85).

As a result of this, the governor in the manual range is adjusted to constant rpm, corresponding to rpm at the beginning of automatic operation, which is higher than the actual rpm of the engine, and for this reason the governor is cut off.

In order to ensure the proper control of fuel supply in the manual range, valve 39 is used which maintains constant pressure at the throttle valve of the unit (that is, the difference between the fuel pressure in front of the throttle valve and behind it).

From the left side only the pressure on the throttle valve exerts pushing on slide valve 39; while from the right side both the pressure behind the throttle valve and the tension of spring 36 exert pushing on the valve. The extent of tension in the spring determines the over-pressure, under which the slide valve begins to move to the right. If the over pressure on the throttle valve exceeds the required value, the slide valve moves to the right and opens the outlet from inter-piston chamber 2 by duct 40 and the high-pressure feed under piston 1 by duct 41.

As a result of the pressure drop in the enter-piston chamber and the pressure rise under piston 1, the piston moves to the right and changes the thrust bearing (which is often called a plate) inclination by a smaller angle. The delivery of the pump now falls, the over pressure decreases to the required value, and the slide valve covers the openings leading to channels 40 and 41. This state is maintained as long as the pressures necessary to hold the washers in the required position is ensured.

If the over pressure at the throttle valve is lower than is required, then the entire process recurrs in the reverse order. In this case, the slide valve is moved by spring 36 to the left, as a result of which the pressure in the inter-piston space begins to increase, and the pressure under piston 1 of the thrust bearing falls. With such change in pressure piston 1 moves to the left and changes the inclination of the thrust bearing through large angle. The delivery of the pump increases and the over pressure rises to the desired value.

In order to maintain constant over pressure on the valve and to change the quantity of fuel feed to the engine, it is necessary only to change the passage diameter of the throttle valve. This is accomplished by moving the valve with the aid of control lever 34.

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By moving throttle valve 32, the passage diameter between the opening of the guide bushing of the valve and the shaped portion of the valve is changed. When the throttle valve is moved to the left, i.e., the side of opening, the passageway of the throttle valve and the quantity of fuel supplied to the engine increase, and when the valve is moved to the right, i.e., the side of closing, they decrease.

When the engine is an idling mode, the throttle valve assumes such a position that the exit of fuel from it is blocked. The fuel in this case passes to the engine through the by-pass valve, whose diameter is regulated by idling screw 33. This permits regulation of fuel consumption for idling only by the changing of the setting of screw 33, without changing the position of the throttle valve.

The shaped part of the throttle valve is made in such a way that in moving it to any position corresponding to the angle of turn of the lever from 8 to 14 degrees, the passage opening, and with it the delivery of fuel, virtually do not change; thus, the so-called "idling range" is obtained.

The limits of the "idling range" are marked on the dial of the pump by two lines and the center of the range by the center line.

Because the fuel supply remains constant throughout the entire idling range, shifting of the throttle lever to any idling position between the lines does not result in an undesired change of the idling speed.

If further shifting of the throttle valve toward the opening, the fuel begins to pass to the engine also through the main section of the valve.

At all speeds of the engine which are higher than the beginning of automatic operation, the over pressure on the throttle valve is lower than the pressure exerted by spring 36, and for this reason, valve 39, under the spring tension moves to the last stopping device and is thus switched off.

When the engine is stopped while its shaft and pumps still continue to rotate for a certain time due to inertia with the throttle valve closed, fuel pressure may rise in the pump which exceed allowable levels. In order to avoid such a pressure build-up, safety valve 44 has been installed here.

The fuel enters the lower part of the valve in front of the entrance to the throttle valve, and then to the upper part through the outlet of the throttle valve. Spring 43 of the valve maintains a pressure on the valve which is considerably higher than the over pressure on the throttle valve. In this way, the possibility of engagement of the safety valve during all stages of operation of the engine is avoided.

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When the throttle valve is fully closed (position "STOP"), the pressure behind it falls, the valve opens and admits the fuel fed by the pump to the suction pipe. The over pressure needed to open valve is 20 25 kg/cm^2.

For continued operation of the engine with shut-off fuel feed (during the stages of "auto-rotation"), the fuel pressure behind the throttle valve must rise in proportion to the leakage through the clearance between the cock and its bushing. Under the influence of this pressure the distribution valve opens, which results in excessive flow of the fuel through the nozzles and the smoking of the engine.

In order to prevent this, an opening is provided on the throttle valve which connects the exit duct (behind the throttle cock) with the discharge area of the regulator when the cock of the stopping device is in position "STOP".

2.1.3. The automatic range of control.

When the engine reaches the speed for the beginning of automatic control, the centrifugal governor goes into action. With further advancement of the throttle lever, the bushing begins, through the hydraulic delay action (see below) to change the tension of the spring, which in turn changes the speed of the engine.

The basic parts of the speed governor are centrifugal weights 48, revolving with the same number of revolutions as the rotor of the pump, the slide valve of governor 13, spring of the slide valve of the governor 15, piston 1 of the thrust bearing which is the principal component of the governor, piston of control equipment 4, which moves the slide valve of control equipment 8 and is connected through lever 12 with bushing 49 of the slide valve of the governor.

In order to decrease the friction of the governor slide valve and the resulting increased sensitivity, the slide valve is made to revolve with the same number of revolutions as the governor.

During the operation of the engine in any stage of automatic control range, the regulator is in the so-called balanced position, which is characterized by the following:

1. the centrifugal force of weights 48 are in balance with the tension of the spring of the slide valve of governor 15.

2. the setting of the slide valve of the transmitter is such in relation to the openings of bushing 49 that the fuel from the constant pressure valve passes to ducts 10 and 11 and compensates for the leakage from them by absorbing nozzles 47.

3. the slide valve of the control equipment occupies such a position that by its settings it overlaps channels 7 and 9, and the inter-piston

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area cannot be connected either with the feed of the fuel from channel 9 nor with its discharge through channel 7.

4. the pressures in the range of the governor control range are such that the resultant force on the servo-pistons and on the inclined thrust bearing ensures the delivery of fuel to maintain the desired speed of the engine.

Let us examine in detail how the maintanance of a constant number of revolutions of the governor is carried out, even in case of their temporary change, which may occur, for example, as a result of a change in the flight conditions.

Let us assume that the rpm begin to fall due to the increase in back pressure of the turbine, caused by the decrease in flight altitude. In this case, the balance of forces which have an influence on the slide valve of regulator 13, is broken by the decrease in the centrifugal forces of the weights, and the slide valve of the regulator under the influence of spring 15 begins to move to the left, increases the passage diameter on the route of the fuel to space 5 of the servo-pistons of the regulator, and lets out the diameter from space 50.

The pressure in space 5 of the servo-pistons of the slide valve of the control equipment begins to increase, and in area 50 of the servo-piston of the inclined plate to decrease on the basis of the passage of fuel to the outlet area.

The increasing of the pressure in area 5 effects the rapid change of position of servopiston 4 of the slide valve of the control equipment. Because inter-piston area 2 is closed space, filled with fuel, together with the moving of servopiston 4, also the piston of the slanted plate, which moves it on the side of increase of fuel supply, begins to move.

If the volume of inter-piston space 2 did not change during the switching on of the regulator, pistons 1 and 2 would move during the entire period as one unit to the left, that is, to the side of increase of fuel supply. At the left, by the lever of control equipment 12, bushing 49 would be moved far enough to avoid sufficient increase of revolutions to affect the increase of the quantity of fuel fed to the engine. Afterwards, the mechanism would again reach a balance position. During this work of the regulator, the reliability of the regulation would be assured, but the starting number of revolutions would not be renewed with the necessary level of accuracy, because the slide valve of the transmitter, together with the bushing, assumes a new position (it moves to the left) and in this way, also, is changed the tension of the spring of the transmitter (on the basis of its lowering) and the revolutions of the engines.

The renewal of the starting number of revolutions with the necessary level of accuracy during the operation of the regulator is attained by the change of the volume of the inter-piston space, and in reality the regulator operates in this way: upon deviation from the required number

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of revolutions, both pistons 1 and 4 initially move together, that is, in the way that was described above, and the supply of fuel to the engine is increased. However, together with servopiston 4, also the slide valve of control equipment 8 moves to the left, and opens the opening, by which the fuel passes to inter-piston space 2 from channel 9 from the constant pressure valve. The pressure in the inter-piston area grows, which leads to the further movement of piston 1 and to the increasing of the delivery of fuel to the engine and to the increasing of its revolutions.

The process of filling the inter-piston chamber and also the further moving of the servo-piston is done slowly, because on the route of the supplied fuel there is a so-called throttle assembly 3, with a large hydraulic resistance.

Together with the moving of the slide valve of the control equipment to the left, the bushing of slide valve 49 is moved on the same side opposite the slide valve of the transmitter, with the aid of the lever of control equipment 12.

The moving of the servo-piston of the control equipment to the left is interrupted when the bushing of the control equipment assumes in relation to the slide valve of the regulator position corresponding approximately to a balanced position. From this moment on, there begins the closing stage of the process of regulation, during which the servo-piston of the control equipment, with the slide valve under the influence of the fuel, passing to the inter-piston area, returns slowly to the starting position, which corresponds to the overlapping of the channel leading to this area.

At the same time, the bushing of the control equipment comes to the starting position, firmly connected by the lever of the control equipment with slide valve 8, and the slide valve of the regulator, like the piston of the pin,by increasing the distance between the pistons, assumes a new position necessary for the supply of fuel, corresponding to the changed flight altitude.

As a result of this action of the regulator in the initial stage of the process of regulation, the effective action of the control equipment is assured (the moving of the bushing opposite the slide valve of the regulator), which makes possible reliable regulation. Together with this, there arises the possibility of maintaining the desired number of revolutions with great accuracy.

If the number of revolutions of the engine increases over the desired amount, the switching on of the regulator is effected in the reverse manner. In this case, the slide valve of the regulator, under the influence of the centrifugal forces of the weights, moves to the right. The servopistons initially also move to the right until they incline the slanted board in such a way that the feed of fuel to the engine decreases.

The slide valve of the control equipment, which had deviated from its level position, connects by means of channel 7 the inter-piston space through the throttle group with the outlet chamber. Together with the

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movement of the slide valve of the control equipment, the bushing also, begins to move on the same side (opposite the slide valve of the transmitter).

The inter-piston space begins to empty slowly; the pressure in it falls, which leads to a further decrease in the feed of the fuel, until the revolutions of the engine return to the required value. The process (as in the first case) ends with the returning of all parts of the regulator to the starting position (except for the piston of the plate).

2.1.4. Combined operation of the PN-28B and PN-15B pumps.

The inclined plate of pump PN-28B, depending on the required quantity of fuel, for the engine, may under the influence of the valve for constant distribution of pressure (in the manual range), or the centrifugal regulator (in the automatic range) assume any position within specific limits. These limits are created by two stops:

- the stop for maximum inclination (maximum output).
- the stop for maximum pumping out.

The inclined plate of pump PN-15B is also limited in its movement by two stops corresponding to:

a. Qmin = 2,500 per hour.
b. Qmax = 7,200 per hour.

Within the limits of these stops, the plate must change its inclination under the influence of the altitude-speed corrector or the maximum-pressure valve. The maximum angle of inclination of the plate is given in accordance with how much fuel the engine requires, in order that its work might be reliable. The spontaneous raising of the incline of the plate by its adaptation or change is not permissible, because it could damage the pumping parts. The stops for minimum output are selected in such a way that the altitude characteristics of the engine conform to the technical conditions.

As is known, the consumption of fuel by the engine for the maintenance of required revolutions in accordance with the altitude of flight falls as a result of the decreasing of the thickness of the air. If the delivery from pump PN-15B remained unchanged at all altitudes, at a relatively low altitude the delivery of one pump PN-15B would be greater than is necessary to assure the required engine revolutions. In order that the required revolutions of the engine should be preserved, pump PN-28B moves the plate of pump PN-28B to the position of negative angle, that is, pump PN-28B will pump out the remainder of the fuel fed by pump PN-15B.

However, the PN-28B's capacity for pumping out is limited by a stopping device for reasons of design, and with further increase of altitude, the regulator will not be in a position to maintain the required revolutions, the revolutions will begin to increase, and the engine will start. In order to avoid this, the delivery of the PN-15B is corrected

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automatically in accordance with the altitude of flight. In order to increase the supply of fuel during lfight at great speed near the earth the supply of the PN-15B is corrected in accordance with the rush of air at the entrance to the engine. The characteristic of the altitude-speed corrector of the PN-15B and the size of the negative angle of inclination of the pin on the stop of the PN-28B are selected in such a way that the entire minimum delivery of pumps PN-28B and PN-15B during any flight conditions does not exceed the consumption of the engine, and the engine does not over turn.

Let us describe the principle of action of the altitude-speed corrector.

The automatic device consists of sensitive elements of aneroids 82, lever 69, and flat valves 80, cams of control equipment 68, and pistons 67. The servo-equipment of the automatic device is controlled by the fuel, whose pressure on entrance to the automatic device is constant, which is assured by a constant-pressure valve 78. The principle of action and the construction of the valve are the same as in pump PN-28B.

The fuel passes from the constant-pressure valve through nozzles 79 and 77 to the right and left chamber of piston 67, through the connecting rod connected with the slanted plate of the pump.. From the displacement of the pump, part of the fuel is conveyed to nozzles 71 and 81, by which the fuel flows. The passage diameter of the nozzles, and also the flow of fuel, vary depending on the space between the nozzles and the plates 80.

Lever 69, on one end of which are mounted the plates, rests with its middle part on the shaft in the connecting rod of the aneroids, and with the other end on the cam 68. Pressure of the lever of the aneroid connecting rod on the cam is maintained by spring 70. Cam 68 is firmly fastened to the gear wheel, which is meshed with the connecting rod of piston 67.

In a balanced position, the space between plates 80 and nozzles 71 and 81 is set up automatically in such a way that a balance of forces is assured on the servo-piston from the right and the left.

With the increase of altitude in flight, the pressure decreases in the chamber in which aneroids 82 are placed. The aneroids expand, press through the connecting rod on lever 69, and overcome the tension of spring 70. Thus, they press the lever at the left of cam 68. Upon shifting of the lever, the area of the passageway of nozzle 71 decreases, while that of nozzle 81, it increases. As a result of this, the pressure rises in the left chamber of piston 67 and falls in the right chamber. Due to the difference in pressure between the chambers, piston 67 moves to the right, that is, to the side of reduced fuel supply. On moving to the right, the piston turns the gear on which is fastened cam 68, i.e., clockwise. The upper end of the lever, under the action of spring 70, moves behind the cam (it is deflected to the left) rotating on the shaft thus re-establishing the area of the passageways of the nozzles.

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The movement of the piston continues as effected by the rotation of the cam until the passageway areas of nozzles 71 and 81 is re-established and the balance of the entire mechanism is restored. After this the regulation of the smaller fuel supply will be completed.

With decrease of altitude, the entire process proceeds in the reverse order. In this case, the aneroids are compressed by the increased pressure of the ambient air, and spring 70 pulls the lever to the right in relation to its contact point on the cam (the connecting rod of the aneroids also moves). With the shifting of the lever, the area of the passageway of nozzle 71 increases and this leads to a rise in pressure in the right chamber of the piston and a fall of pressure in the left chamber.

Due to the change of pressure distribution on piston 67, this piston begins to move to the left increasing the supply of fuel and at the same time rotating cam 68 counterclockwise. During rotation of the cam the lever turns on the center shaft following for the entire period the cam and extends spring 70 restoring the passageway area of the nozzles.

The piston moves sufficiently slow to permit the rotating cams to effect the change in the area of the passageway in nozzles 71 and 81 and to restore the balance of the entire mechanism. In this way, the regulation of the increased delivery of fuel will be completed.

A specific position of the inclined thrust bearing of the pump corresponds to every value of air pressure in the aneroid case and also to the altitude and speed of flight.

2.1.5. The minimum-pressure valve.

With the rapid reduction of fuel supply, that is, with the rapid change in position of the control lever for pump PN-28B to correspond to the idling speed, spring 15 will release the transmitter, and the governor will rapidly incline the thrust bearing of the pump so as to reduce the supply of fuel.

Because the engine, not withstanding the decrease of fuel supply decelerates relatively slowly due to great centrifugal momentum of the rotating parts, the governor would have a tendency to supply too little fuel for normal combustion in the combustion chambers of the engine, where it not for a special automatic device which limits the excessive decrease of the fuel supply.

This type of automatic device is a minimum-pressure valve, mounted on pump PN-15B; the valve maintains a minimum allowable pressure and also a minimum delivery of the fuel by the nozzle of the engine, which in turn affects the delivery of pump PN-15B.

The minimum-pressure valve consists of membrane 74, and slide valve 73 nad spring 75. Spring 75 exerts pressure on the membrane from one side, and the pressure of the fuel in front of the idling nozzles from

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the other.

Slide valve 73 is under pressure of fuel fron above and below in front of the idle nozzles. Because of this, it is always "floating".

In all the stabilized stages of operation of the engine, the fuel pressure in front of the nozzle is always higher than the minimum allowable pressure so that membrane 74 is pressed against the stop, and slide valve 73 overlaps duct 72 which leads to the right chamber of piston 67 of the altitude corrector.

When the fuel flow is drastically reduced the pressure in the nozzles falls, and the spring moves slide valve 73 upward, connects duct 72 with duct 76 which is connected to the high-pressure line behind the pump.

The fuel from duct 72 passes to the right chamber of piston 67 and changes the inclined thrust bearing to the position of increased fuel supply.

As the piston moves, cam 68 rotates counterclockwise, and lever 69 which turns on the central shaft, closes nozzle 71 and opens 81. The left chamber is thus closed, and the fuel from it is displaced by a piston through the constant-pressure valve. The piston will move until, due to the increase of the fuel delivery, the pressure at the idling nozzles increases to the minimum limit; then the forces on the membrane, caused by the tension of the spring and the pressure of the fuel, balance out, and the valve cuts off the feed of the high-pressure fuel to the servo-control.

2.1.6. Control of engine in the range of manual control.

As was stated above, the control of the fuel feed to the engine in the range of manual control is carried out by the change of the passageway opening in the throttle valve. In contrast to the automatic range, in which the centrifugal governor maintains the desired rpm independently of the speed and altitude of flight, in the manual range constant feeding of fuel to the engine is maintained independently of the position of the throttle lever.

In this way, special advantages are achieved in the control of the engine in the manual range. (next page-Insert*) Even when the stages of the manual range (from n - idling to n - 3,400 rpm) are not operational, a situation may arise when the manual range control of the engine must be used.

2.1.7. RPM during idling

When the throttle is in the idling position, the feed of fuel remains unchanged independently of the altitude of flight so that the idling rpms increase with the altitude until it reach the rpm of the beginning of automatic operation.

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*INSERT. As is known, when the altitude and speed of flight are changed, a different amount of fuel is needed in order to maintain the same engine rpm. In increasing the altitude or decreasing the speed of flight, the consumption of fuel decreases, and in decreasing the altitude and increasing the speed of flight, consumption of fuel increases.

After this the centrifugal governor, which maintains the idling rpm constant at high altitudes, goes into operation.

2.1.8. Change of rpm during gliding.

In such flight, if the control lever is set in the range of manual control, the revolutions will decrease evenly with the decrease of the altitude of flight.

2.1.9. Change of revolutions with setting of the control lever.

On the ground and at a low altitude, the revoltuions vary approximately in proportion to the change of position of the control lever.

With increasing altitude, there occurs an increase in the range of idling. On moving the lever from idling position, the revolutions initially increase, and after attaining the rpm at the beginning of automatic regulation at a certain position of the throttle, remain unchanged; then are again changed in proportion to the movement of the throttle lever.

With increase of altitude, the limiting sector of idling expands. At a height of approximately 9 - 10 kilometers, it adjusts to the entire sector of manual control, that is, beginning from the position of idling.

2.1.10. Control of the engine speed in the range of automatic operation.

The control of the engine revolutions in automatic regulation range is achieved by changing the tension of the slide-valve spring of the governor.

The transmission from throttle lever 34 to the spring of the governor whose tension determines the adjustment of the regulator for the required revolutions, is achieved by means of a hydraulic retarder. During the movement of the throttle lever, bushing 45 moves together with the throttle valve. Prior to the cutting in of automatic regulation, the bushing does not touch the support of slide 29, which rests on screw 42, and the spring of the governor maintains a constant tension.

As the action nears the revolutions of automatic regulation, the bushing touches with its front surface the support, and during further movement, the support moves together with the bushing and the throttle valve. The instant of contact of the bushing with the support is regulated by the change of the distance between the support and the bushing.

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The hydraulic retarder is a system for controlling the centrifugal governor, whose actuating mechanism is servopiston 23. Shifting to a given speed is independent of the speed of shifting of the control lever.

The hydraulic retarder is operation tied-in with the process of acceleration of the engine. The left chamber of the servopiston of the retarder is connected through throttle assembly 31, with the area behind the constant-pressure valve, and through the flow opening in the connecting rod with the outlet mechanism.

In the balanced position of the delayer, the flow of fuel to the left chamber through the throttle resistor adjusts the leakage through a clearance created by the opening in the connecting rod. In movement of the throttle lever at any speed to a position corresponding to the selected number of revolutions, the connecting rod by means of the support, moves the slide valve, thus closing the opening in the connecting rod. The pressure in the cavity begins slowly to rise, the servopiston begins to move to the right and pushes smoothly the spring of the regulator to the new stage.

The movement of the servopiston will continue until the appropriate passage diameter is formed in the passage opening, that is, the piston follows the movement of the slide valve. In reverse movement of the throttle lever (reduction of fuel), the slide valve of the hydraulic delayer, under the influence of the spring, moves to the left, opens the passage opening. As a result of this the pressure below the servopiston falls, and the piston is forcefully moved by the spring behind the slide valve letting out the fuel from the chamber to the discharge equipment.

2.1.11. Regulation of fuel during acceleration of the engine:

The supply of fuel to the engine during acceleration must be greater than during the operation of the engine in a set mode, so that sufficient output can be created on the turbine shaft.

During normal acceleration of the engine without pumping, i.e., during the rapid advancement of the throttle to a new position, the specific characteristic of increased fuel delivery must be maintained according to the revolutions of the engine.

During a rapid change of position of the throttle lever from idling, the spring moves the governor and the slide valve of the transmitter to extreme left position, which brings about a change in pressure in the areas of the servoequipment and changes the inclined thrust bearing of the pump to maximum fuel supply.

The inclined thrust bearing of the pump would remain long enough in this position for the engine to reach maximum revolutions, because only at these revolutions the centrifugal force of the governor weights the pressure in the servomechanism, in order to decrease the supply.

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However, acceleration of the engine during supplying of fuel at all revolutions, corresponding to the maximum inclination of the thrust bearing, is not expedient, because excesses of fuel would be too great. For the normal course of acceleration, there is in the governor system an automatic device which supplies fuel during the acceleration of the engine depending on the air pressure behind the compressor and the fuel pressure.

A diagram of the automatic acceleration device is given in Fig. 85.

The following have an influence on slide valve 57:

- from the left - fuel pressure in front of the distribution valve, which is connected to duct 53;
- from the right - the force of overpressure between the air chambers of the automatic device, which is transferred to membrane 93, and the tension of spring 90.

The air chamber to the left of membrane 93 is connected by the outlet duct with the outside air and from the right with the air which is carried under pressure from the last stage of the engine compressor.

Air is admitted to the air chamber to the right of the membrane through nozzle 87 and is exhausted from this chamber to the atmosphere through nozzle 89. Slide valve 57 may overlap or connect duct 88 with the outlet.

Through duct 88 and micro-filter 85, the fuel travels to the slide valve of the automatic acceleration device from the area of valve 37 for continuous distribution by pump PN-28B. Chamber 37 is connected by nozzle 35 with the fuel pressure pipe behind the throttle valve.

During set stages, the automatic acceleration device does not operate. The relationship of the forces which exert an influence on slide valve 57 is such that where the plug in the extreme left position, it detaches duct 88 from the outlet opening. In chamber 37 to the right of the valve for constant pressure distribution, the fuel pressure is equalized to the pressure behind the throttle valve.

During the acceleration of the engine, with rapid change of position of the throttle lever, the relationship of the forces which exert an influence on slide valve 57 changes its position to the right and connects duct 88 with the passageway.

The pressure in chamber 37 falls, because the fuel travels to it through the nozzle and is discharged through a large opening. The difference between the pressures which exert an influence on the valve for constant distribution of pressure, 39, is increased to the extent that the valve moves only to the right and connects chamber 50 of piston 1 of pump PN-28B with the fuel outlet from the pump, and inter-piston area 2 - with a passageway (that is, just as in the previously described operation of the pump during the stages prior to the beginning of automatic operation).

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Piston 1 moves to the right and decreases the fuel supply until the fuel pressure (as a result of decreasing its supply), acting on slide valve 57 of the automatic acceleration device, decreases to the extent that it becomes equal to the force exerted upon this slide valve by the air chamber on membrane 93.

During the entire process of acceleration of the engine, the position of plate piston 1 and also the supply of fuel to the engine, are made to conform with the tension of the membrane of the automatic acceleration device.

When the regulator, as has been described above, gives an impulse during acceleration for a change in position of the inclined thrust bearing to a position of maximum supply, its action is counterbalanced by the action of the automatic accelerating device, because the area below the piston is fed through the differential valve with fuel under high pressure and through a large section, which compensates, with an excess, for the fall in pressure through the slide valve of the regulator.

The fuel supply during acceleration of the engine calls for such characteristics of the automatic acceleration device which will provide proper adjustment in the spring and the nozzle area air passage.

During an increase in the spring bias, slide valve 57 begins to change position under appreciable fuel pressure, i.e., the supply of fuel to the engine increases and the period of acceleration is getting shorter. An opposite effect will be achieved with a reduced spring bias.

In reducing the diameter of the air nozzle, the air pressure increases in the air chamber of the membrand; with the smae pressure at the compressor, it becomes necessary to increase the fuel pressure in order to move slide valve 57 and to decrease of the acceleration period of the engine. By increasing the diameter of the air nozzle, the acceleration time will be extended.

Because the air pressure at the compressor rises more rapidly in the range of higher revolutions, acceleration regulation by the air nozzle is more effective in the range of higher revolutions.

In the idle mode (approximately up to 2,500 rpm), when the air pressure at the compressor is low, it becomes necessary to regulate the acceleration of the engine by changing the bias of the spring.

Because the fuel pressure exerts an influence on slide valve 57 of the automatic acceleration device in front of the distributing valve, the fuel supply during the acceleration of the engine depends on the characteristics of the distributing valve. The movement distributing valve depends on the pressure in front of it.

By increasing the initial tension of the spring, the flow is decreased through the valve, becuase for the same pressures in front of

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the valve, the stroke of the valve, and with it the passageway, decrease. By decreasing the initial tension of the spring, the valve moves in an opposite direction, because with the same pressures the flow through the distributing valve increases as a result of an increase in the passageway diameter.

By changing the tension of the spring of the distributing valve, it is possible to change the acceleration period of the engine without changing the setting of the automatic acceleration device.

By reducing the tension of the distributing valve spring, more fuel will be admitted to the engine during acceleration, so that the acceleration period will be shortened; by increasing the tension of the spring, less fuel will be drawn in, and the acceleration period will be prolonged.

Because the characteristic of the distributing valve has an influence on the performance of the remaining automatic equipment, its adjustment should be within narrow limits.

In order to ensure a more accurate supply of fuel during acceleration of the engine, a hydraulic retarder has been provided to the system of fuel regulation, the operating principle of which has already been described.

On the ground, and at low altitudes, regulation of fuel supply during acceleration of the engine is carried out by the automatic acceleration device. The hydraulic retarder in this case moves the spring of the regulator with a specific acceleration during the acceleration of the engine while the period to full stop of the retarder is less than the period of acceleration of the engine when controlled by the automatic acceleration device.

At medium altitudes, with increased minimum revolutions of the engine, the period of acceleration of the engine is reduced, and for this reason, part of the period is carried out with the aid of the retarder. With the increase of the altitude, the range of revolutions increases constantly, and finally, when the minimum revolutions reaches the revolutions needed for automatic operation, the acceleration of the engine will be effected only by the hydraulic retarder.

The combined system of regulation during the acceleration of the engine makes it possible to utilize the advantages of the automatic accelerating device, which permits to obtain on the ground and at low altitudes accelerations with characteristic close to the optimal, and at the same time obviates the necessity of further regulation during acceleration high altitudes.

At the end of the accelerating period of the engine, there may occur, due to the inertia of the regulator, a considerable increase in engine rpm for a while.

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In order to prevent this, there is provided a special device for accelerating the pump. This is arranged in such a way that the servopiston of control equipment 4 is actuated by power spring 6, which ensures, during acceleration, the setting of the bushing of the control equipment into a position for quick engagement of the governor. As a result of this, the delay in action of the governor at the end of any specific stage is compensated for, and the possibility of exceeding the number of prescribed revolutions is eliminated.

2.1.12. Regulation of fuel supply during the starting of the engine.

In starting up the engine, just as during its acceleration, it is necessary to regulate the supply of fuel to the engine. At the beginning of a start the shaft of the turbine is turned by the turbostarter at a designated speed (expressed in rpm) then the fuel is supplied to the engine, which ensures a specific increase in the output of the turbine over the output of the compressor. An insufficient supply of fuel leads to a decline in the number of revolutions, while an excessive supply of fuel leads to the shooting of flames from the engine exhaust and to an abnormal increase in the temperature of the exhaust gases.

In order that the starting process would proceed normally, there is in the regulation system an automatic starting device regulating the fuel supply to the nozzles in proportion to air pressure behind the compressor.

The following exert an influence on the slide valve of the automatic starting device: from the left, the fuel pressure in front of the distribution valve; from the right, the force from the difference in pressure between the air chambers of the automatic device as transmitted to membrane 99 and the force of tension of springs 96 and 98.

The air chamber, from the left side of the emmbrane, is connected through the exhaust channel to the atmosphere and from the right side to the air supply from the last stage of the engine compressor.

The air is conducted to the membrane chamber through nozzle 97 and is let out from this chamber to the atmosphere through nozzle 103. The slide valve may close valve 53 or connect it to the passage duct.

An increase or decrease of the fuel supply depends on the pressure at the compressor, which in turn depends on the revolutions of the engine. With the increase of the engine revolutions, the pressure rises in the right chamber, slide valve [9] 5 moves to the left, and reduces the passage of the fuel from the duct in front of the distribution valve.

When the engine returns to idling speed, the air pressure on the membrane of the automatic starting device reaches such a value that the passage of the fuel to suction is interrupted and the automatic starting device [word missing?] suction.

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The mode of fuel supply during the start-up of the engine depends on the selection of the characteristic of the automatic starting device, i.e., the adjustment of the spring tension and the diameter of the air nozzle.

By increasing the tension of spring 98, slide valve 95 begins to change position during greater fuel pressures; this means that the supply of fuel to the engine increases and the period of start-up decreases. The opposite occurs when the tension of the spring is decreased.

In decreasing the diameter of the air nozzle, the air pressure increases in the air chamber of the membrane while the pressure at the remains the same, which leads to an increase of fuel pressure necessary to move slide valve 95 and to a reduction of the period for starting up the engine.

By increasing the diameter of the air nozzle, the start-up period is prolonged.

The regulation of the start-up with the aid of the air nozzle is most effective in the range of high speed, when the air pressure at the compressor is not large. It is necessary to regulate engine starting by changing the tension of spring 98, because the fuel pressure in front of the distribution valve exerts an influence on side valve 95 of the automatic starting device. The fuel supply during the start-up of the engine depends on the performance of the distribution valve.

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By decreasing the spring tension of the distributing valve, it is possible to change the period of engine starting without changing the adjustment of the automatic starting-device. By weakening the spring tension of the distributing valve, more fuel will enter the engine during start-up, so that the start-up period will decrease; by increasing the spring tension, the period of start-up will be prolonged.

2.2 Fuel System Units for Main Fuel.

2.2.1. Pump CN-1A

Fuel pump CN-1A serves to assure constant fuel pressure at the main nozzle of the engine.

Basic data:

Drive of the Unit	from the engine
Permissible ambient temperature during the operation of the unit	from -60 to +60°C.
Permissible temperature of the unit and of the fuel during start-up	from -60 to +60°C.
Maximum pressure at the pump outlet in kg/cm^2	2.2 + 2.5

The make-up of CN-1A unit - the CN pump consists of a single-stage centrifugal pump with mechanical drive from the engine and the automatic regulator, which maintains the pressure of the fluid at the output of the pump within the limits of 2.2 to 2.5 kilograms per square centimeter.

Make-up of the pump - the centrifugal pump consists of the following parts: housing 8 (illustration 86), cover 14, shaft 2 of the impeller and impeller 12 and the guide vanes.

The housing and the cover are cast from AL5 aluminum alloy. Housing 8 of the pump has an opening for placement of the impeller, an outlet pipe for the exit of fuel, and a flange for connecting cover 14. On the opposite side, the housing has a flange for fastening the pump to the engine. In the housing, there is a concentric groove for shaft 2, ball bearings 3 and 9, and rubber sealing cup 7.

Bearing 3 is mounted at the center of cover 14, which is fastened to housing 8 by screw 5. Bearing 9 is mounted to the cover 11, which is fastened by screw 10.

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Cups 11 are pressed to the groove of the housing. Cavity "a" between them is connected by discharge pipe 17 to the atmosphere. To protect the front cup from the hot oil coming from the engine drive, case 4 of the ball bearing 3 is provided with oil grooves for cooling shaft 2.

The cover of pump 14 is fastened to the flange on the housing and forms with it an area for the placement of the impeller and also serves as a collector for the emerging fuel. The cover has in its center an inlet opening for fuel and a flange for fastening the fuel pipe.

Shaft 2 of rotor 13 has, on the side of the drive, grooves to which are fastened grooved assembly 1 for connection with the drive of the pump. On the other side, the shaft has grooves for fastening the impeller and inlet vane 15, and a thread to secure it with the aid of a bolt to the shaft, in regard to bearing 9, in the axle direction. For the adjustment of a space between the case, the impeller, and the cover regulation ring 12 is used.

In order to decrease the wear on the shaft from the friction of the cup, there is pressed on the shaft steel bushing 6, which has been nitrided and heat treated to extreme hardness.

The shaft is cooled by circulating fuel from the case area to the inlet hole. For this purpose, screw grooves have been cut on the shaft placed under bushing 6 and are connected (through radial cutting) with the central opening of the shaft, which is located on the side of impeller fastening.

Impeller 13 of the pump is of a closed type, it has six vanes bent backward and is cast from AL5 aluminum alloy. The discs of the impeller have outer ribs entering into appropriate grooves 14 of the pump and cover 11 of the bearing with small spaces. The ribs serve to cut down the passage of the fuel from the area of high pressure to the entrance to the impeller. At the head of the impeller are three tapped openings 6, necessary to counteract the influence of high pressure and to mount the receiver.

Four inlet guide vanes 15 are fastened to a head with an opening and grooves. The vanes, together with the impeller, are firmly secured to the shaft by grooves and are fastened by a bolt.

<u>Structure of the Valve</u> - the valve consists of the following basic parts: the body 14 (Fig. 87), guide equipment 7, connecting rod 12 with two valves 10 and 13, membrane 6, and spring 2.

Body 14 of the valve consists of three parts, cast from AL5 aluminum alloy: body 14, enter body 9 and bushing 3 of the spring.

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All three of the parts are joined by stud bolts.

Between the center body 9 and the bushing guide 7 for steel connecting rod 12 and rubber membrane 6, whose outer 1 circumference is pressed between the flange of bushing 3 and the flange of guide 7. The membrane is firmly connected by a bolt to connecting rod 12, carried by bronze bushing 8, which is pressed to guide 7.

At the opposite end of the connecting rod are fastened two disk valves 10 and 13. Valve 13 has a seat in body 14, and valve 10 in body 9. Between the valves there is located adjustment washer 11; through the selection of the thickness of this washer, the proper placement of the valves on the seat is ensured.

The upper end of the connecting rod has the shape of a cone, on which rests disk 4, conveying to the connecting rod the tension of spring 2. The tension of the spring and the fuel pressure from the valve, is regulated by cap 1, screwed to bushing 3. The cap is secured by bolt 5.

Operation of the pump - during the rotation of the shaft of pump 12 (Fig. 88) the fuel passes to the receiving outlet pipe of the pump and reaches guide vane 14, which admits it to the entrance of impeller 13. Because the flow velocity on the guide vanes is greater than the flow velocity in the impeller, a somewhat increased fuel pressure builds up at the entrance to the impeller; this improves the operating conditions of the impeller.

The rotary blades of the impeller carry off the fuel and create through the centrifugal force an increase in the pressure. When the oil reaches the outer periphery of the impeller, it emerges from its channels and passes to a vaneless ring diffusor and then to the case, where it is directed to the area of the valve regulator.

Function of the valve regulator - the valve (Fig. 88) maintains a constant fuel pressure of the main pumps of the engine through automatic throttling of the flow of fuel coming out of the pump.

The changing of the position of the valve is controlled by rubber membrane 3, firmly connected to the connecting rod of the valve and forming two separate hollows 4 and 16.

Hollow 4 is connected through valve 10 with outlet pipe 11. When the pressure in the outlet pipe rises, the oil moves by channel 10 to hollow 4 and acts upon the membrane which overcomes the tension of spring 2, bends on the side of the spring, and moves the valve. The passageway becomes narrower, the feeding of fuel from hollow 7 to outlet pipe 11 decreases, which results in a decrease in pressure at the exit of the valve.

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Upon the fall of pressure in outlet pipe 11, membrane 3 and valve 4 move in the opposite direction and increase the fuel supply.

In order to adjust the pressure of the fuel in accordance with the altitude of flight, hollow 16 is connected to the atmosphere by opening 1.

In order to prevent a rapid increase of fuel pressure, during a rapid decrease of consumption (up to zero) area 6 is connected with area 9 by duct 8, and with the inlet pipe of the pump by a special duct with nozzle 15.

2.2.2. The fuel regulation equipment

The equipment for controlling the supply of fuel consists of pump PN-28B and PN-15B and is used for automatic supply of fuel to the nozzles of the engine in a quantity necessary for maintaining a given number of revolutions at all the work stages of the engine and during a rapid change in the position of the control lever.

Pump PN-28B (Figs. 89, 90, 93) is a high-pressure plunger pump with reciprocal movement of the plungers, with an automatic rpm governor for all stages, a throttle valve, and a hydraulic retarderd.

Pump PN-15B (Fig. 91, 92, and 94) includes, in addition to the high-pressure pump itself, an altitude-speed corrector, an acceleration valve, a minimum-pressure valve, and a distributing valve, directing the supply of fuel to the channels of the engine nozzles.

Basic technical data:

Diameter of plungers in millimeters................................15

Maximum stroke of the plungers in millimeters:

Pump PN-28B..24

Pump PN-15B..22

Number of plungers... 9

Drive...................................mechanical, from engine

Direction of rotation (GOST 1630 - 46)......to the left

Maximum pump pressure in kg/cm ....90 maximum

Maximum output of fuel pump PN-15B at 4,420 rpm for pump rotor at fuel pressure of 90 kg/cm^2 in liters per hour...7,200 ± 200

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Maximum output of fuel pump PN-28B at 4,300 rpm for pump rotor at fuel pressure of the pump of 85 kg/cm^2 in liters per hour....8,200 ±300

Automatic control of number of revolutions occurs in the range (in accordance with the shaft of the pump rotor) in rpm.......from 3250 ± 95 to 4490 + 30

Range of work temperatures of the device............from -60° to +50°C

Total output of the PN-15B and PN-28B at 4,420 rpm, with pressure at 80 kg/cm^2 in front of the throttle valve in leters per hr ...... 13500+500

1. Pumping equipment of the pump

The pumping equipment of pump PN-28B and PN-15B consists of the case of the pump with suction and displacement channels, a distribution valve, rotor 1 (Fig. 93) and inclined thrust bearings whose angle of inclination varies with the change in position of servopiston 37.

The principle of action of the pumping equipment is as follows: During the rotation of rotor 1, through the action of the inclined thrust bearing and bearings 4, the plungers 2 move with rectilinear reciprocal movement drawing in fuel by suction during approximately one-half a revolution of the rotor, and displace it during the second half of the revolution through the discharge opening to the high-pressure pipe.

The pump rotor is made of bronze and has nine slanted openings for plungers 2. The axes of these openings form with the axis of rotation of the rotor, an angle of 14^0.

In order to reduce the leakage of fuel from the high-pressure pipe, and also in order to prevent excessive pumping of the fuel, the spaces between the plungers and the openings are selected within the limits of 14 to 22 microns, and each pair (opening and plunger) is numbered by the same consecutive number.

A reduction of the leakage at the front side of the rotor is attained by an increase in the force, which presses the rotor to the slide valve, and by an increase of the pressure in the area of the pumping equipment. For this purpose, between the openings below the plunger in rotor 1 there have been drilled openings "a" (Fig. 93), which ensuring the fuel-pressure rise in the area of the pumping equipment. Through opening "b" in the distribution washer, the area of the pumping equipment is connected with the slide valve. By this, an uninterrupted circulation of fuel and the cooling of the pump case are assured in the area of the pumping equipment.

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The front wall of the rotor is plated with indium, protecting the surface of the rotor against corrosion and rapid wear.

2. Fuel regulation equipment, mounted on pump PN-28B

Throttle valve - by means of throttle valve 12, parts the bronze needles with shaped ends, the needle box, and the control lever of the valve are connected with the shaft, whose single gear wheel is connected with the needle.

The profile of the needle is selected in such a way that in the stages which are higher than the beginning of the automatic operation of the governor, the over-pressure on the valve does not exceed 10 kilograms per square centimeter. The profile of the needle is actually a surface of two cones.

The throttle valve also has the function of a stop valve. In the "Stop" position, the pressure behind the valve cannot rise to such a valve as to open the distribution valve and cause the fuel to pass to the nozzles.

The possibility pressure rise behind the valve is explained by the fact that there is a space between the needle and the bushing of the valve.

In order to prevent the discharge of fuel through the nozzles, there is, in the needle of the valve, opening C, by which it is possible to discharge the fuel from the space behind the valve to the suction pipe when the position of the lever of the cock is at the "stop" position of the stopping device.

The governor of revolutions of the engine rotor consists of the following basic parts:

centrifugal weights 49, mounted on levers; these weights are brought into rotation by the shaft, connected with rotor 1 of the pump;
slide valve 47;
spring 44 of the slide valve for control of the governor;
servopiston 37 of the inclined thrust bearing;
piston 38 for reverse connection (control equipment), moving slide valve 41, connected through lever 42 with bushing 48 of the slide valve.

In the construction of the governor parts, special attention is paid to reduction of friction in the packing of the slide valve of the control slide valve 47. An increase in such friction could cause an

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excessive fluctuation in the revolutions of the engine. The friction is lowered by mounting the packing of the governor and the centrifugal weights 49 on ball bearings. The control slide valve 47 is of a rotary type.

The tension from the governor spring 44 is carried through needle 46, which rests on the center of the slide valve in order to prevent it from catching. Slide valve 47 of the governor is arranged in such a way that when even revolutions occur, the openings of the bushing for reverse connection are opened. They connect chambers 35 and 40 of the servomechanism both with the fuel feed and with the discharge.

In the control of the slide valve between the settings, a pressure rises to 10 kg/cm^2. This condition is fulfilled by a proper selection of the nozzle without any further setting of the slide valve or openings in the bushing.

The servo-equipment of the governor consists of servo-piston 37, mounted on the connecting rod, whose other end is connected, by an eye, with an eye in the holder of the inclined thrust bearing. The hollows of the servo-equipment are sealed by a rubber cup. The bonding of the cup with the piston is ensured by the fact that during vulcanization the rubber flows into the six openings of the piston. The sealing of the piston rod is effected by a rubber ring.

In order to decrease the friction in the connections of the servo-mechanism, a bronze bushing has been pressed in the pump case which accommodates the connecting rod of the piston.

Control equipment - piston 38 of the control equipment is, from the structural point of view, the same as the servopiston, and it is located on the end of slide valve 41. On this slide valve there is a ring groove, which is always connected with inter-piston space 36 through throttle assembly 6.

The throttle assembly consists of a set of washers with openings. Between the individual washers are placed spacer rings, forming labyrinthine hollows. The fuel passing to the throttle assembly is filtered through a screen filter, mounted on the throttle assembly.

When slide valve 41 of the control equipment moves, the channels, which conduct the operating fluid to inter-piston area 36 and the discharge channel from it become overlapped. The extend of the movement is 1.2 millimeters.

Lever 42 of the control equipment is attached by a joint to the case of the regulator, and with the aid of two ball joints is connected with the bushing and the slide valve of the control equipment. The transmission ratio of the lever belt is 1:10.

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The ball joint of the lever, connected with the bushing, is excentrically located in relation to the openings in the lever. The bushing and slide valve, connected with it, are accurately positioned in relation to the openings of the bushing. Spring 39, acting upon piston 38, is the element which assures the work of the control equipment and acts as a limiter to a sudden increase of the revolutions during the control of acceleration. This spring holds the bushing of the control equipment in the extreme position prior to switching on the regulator.

The hydraulic retarder - piston 17 of the retarder has, in contrast to the servo-piston and the piston of the control equipment, a cup for unilateral packing. Lhe throttle assembly is, from the construction point of view, executed in the same way as in the control equipment, but it has a greater hydraulic resistance. Screw 27 is a regulating element. The change in the position of screw 27 changes the beginning of automatic operation of the regulator. When screw 27 is screwed in, the tension of the spring of the regulator is increased. The revolutions for the beginning of automatic operation increase. The switching on of the hydraulic retarder is effected after the free play of rod 25 A has been taken up. During the turning of screw 27, the position of bushing 25, which is screwed on to rod 25 A, changes. In this case, the free play of the rod changes up to the stopping device at disk 24 of spring 22.

The screwing on of screw 27 leads to a decrease in the free play. With a small angle of movement of the control lever of the engine, the governor is switched on to a new speed of rotation of the rotor of the turbine.

Screw 13 plays the role of a limiter of the maximum number of revolutions. When it is screwed in, the tension of the spring of the regulator decreases. Then, the maximum number of revolutions decreases.

Valves for the constant distribution of pressure and constant pressure - the valve for constant pressure 28 and the valve for constant distribution of pressure 9 have greater groove clearances. These clearances decrease the friction between the sliding valve and the bushing; an increase in friction may lead to the jamming of the sliding valves.

The regulation of the valves is carried out by changing the thickness and the number of washers mounted between the front part of the spring and the cap.

3. The fuel regulation equipment on pump BN-15B.

The altitude - speed corrector - a sensitive element of the altitude-speed corrector is a set of aneroid boxes (see illustration 94). Regulation screw 46 is used for their adjustment.

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The control element of the servo-mechanism is in the form of a valve mechanism. It consists of two smooth [word indistinct], fitted to the milled openings at the end of lever 51 and nozzles 54, 55, screwed on to the steel body. The body of the nozzles is pressed into the case of the pump. The total clearance between the valves [and the front] wall of the nozzle is 0.3 + 0.005 mm.

The servo-mechanism consists of a piston fastened to connecting rod 12 and spring 6 of the servo-piston. On the [word missing] connecting rod of the piston are placed the bevel gears. With the aid of the gear and the [word indistinct] teeth, the cam of control equipment 52 of the height-speed corrector is connected with the flange. The bronze eccentric bushing, which carries the gear shaft, makes it possible to regulate the clearance of the gears.

The cam of the control equipment has a special profile. The surface of the cam is carburized.

The setting of the minimum and maximum angle of the inclined thrust bearing is effected with the aid of stop screws. By means of screw 42, the movement of the inclined thrust bearing to a maximum angle is limited, and by means of screw 5, the movement of the inclined thrust bearing to a position of mimimum angle is limited.

The automatic acceleration device - the fuel passing from the constant-pressure distributing valve to the groove of the sliding valve of the automatic acceleration device is strained through a fine filter.

In addition to the main groove, by which the fuel enters by suction to fuel pump PN-15B here are on the side of the slide valve, facing the air chamber, two more grooves. The fuel, entering the clearance between the slide valve and the bushing, reaches the first groove, from which it passes to the sliding valve of the pump. If the fuel penetrates still further to the second groove, it reaches the drainage system. In this way, the penetration of the fuel to the air chamber of the automatic acceleration device is eliminated.

The distribution valve - on the bushing of the distribution valve there are sections and openings which become uncovered by the slide valve when it changes position under the influence of the pressure of the fuel.

In order to lead the fuel to the feed pipe of the nozzle, there have been cut on the bushing two shaped sections. The fuel passes to the main pipe by two longitudinal sections and four openings.

The form and the placement of the sections are determined by the condition of almost linear dependence of the consumption of fuel on the pressure in front of the distribution valve.

The minimum-pressure limiter consists of bronze sliding valve 19, connected by screws with rubber membrane 20 and with spring 21.

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The tension of the spring can be changed by regulating screw 22. The hollow of the spring is connected with the [suction?] pipe of pump PN-15B, and for this reason if the membrane breaks, it is not possible for the fuel to escape. In order to prevent the breaking of the membrane under pressures exceeding 6 kilograms per square centimeter, there is a ring in the interlined pipe between the membrane and the spring cap flange, limiting the bending of the membrane.

The automatic starting device consists of the following main parts: seat of valve 35, piston 36, membrane 33, springs 31 and 34, the disks of the spring, stopper 29, and regulation screw 30.

The seat of the valve is screwed on to the case of the automatic device for distributing the fuel and it has four passage openings with a diameter of 2 millimeters.

The steel piston 36 has clearance of 0.01 + 0.006 mm. Two discs, of which one, a support disc, has a cylindrical projection and is pressed by a spring to the head of the piston, are rivated to the membrane made of rubberized fabric. In order to avoid crushing of the membrane, tightening of the stud nuts for fastening the lid is affected by a torque-limit wrench.

The air from the last stage of the compressor leads to the automatic starting device through an opening of the rotating flange.

The regulation characteristic of the automatic starting device is effected by a screw and by a removable passage nozzle 41A, screwed on to the flange.

2.2.3. Main fuel manifold.

Feeding of the fuel to the main nozzles is effected by two manifolds made of flexible high-pressure rubber hose (Figs. 95 and 96).

The idle manifold A consists of 14 rubber hoses with a diameter of 20 x 10, connected to the appropriate screwed joint of nozzles 1.

The main manifold B also consists of 14 hoses 5 with a diameter of 30 x 16, to which are screwed the T pieces 6 for connecting with the nozzles 1.

The connection of individual sections of the hose among themselves and the connection with the nozzle is effected by a screwed joint, sealed by rubber ring 2. The ends of the rubber hoses are pressed flanges 3 and cups 4. This type of connection is sufficiently firm and assures the necessary tightness.

The fuel passes into the main manifold and the idle manifold by screwed joints located in the upper part of the manifold. In the lower part of both manifolds, there are screwed joints for passing the fuel to the drain tanks during the stopping of the engine.

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Before mounting on the engine, the manifold together with the nozzles is hydraulically tested with oil under a pressure of 120 kilograms per square centimeter for a period of 5 minutes.

In mounting the manifold on the engine, it is permissible to disconnect the connection of the manifold in two places (at the 4th and 11th nozzle. These connections need not be tested hydraulically again.

2.2.4. The main jet.

The purpose of the nozzle is to atomize and feed the fuel to the burner. In order to assure the feeding of fuel in broad ranges of consumption, and to preserve proper atomization, the main nozzle has two stages and two vortex chambers. The nozzle is of the centrifugal type.

It consists of the following basic parts: body 3 (illustrations 97 and 98) and a flange for fastening the nozzle screen filters 10; dividing tubes 13 and two orifices 14 and 15.

Body 3 of the nozzle is forged from steel and has a hard nitrided bushing 12. The bushing [has] openings 16, serving for the passage of air which blows away carbon accumulations from the front part of the nozzle.

Bushing 12 is secured by lock 11 after it has been screwed on to body 3.

There are two channels in the body: Channel 2, I stage of nozzle, and Channel 4, II stage. In front of the entrance to the channels is screwed joint 1, the weldment, and the two screen filters 10, protecting the mouth of the nozzle from clogging. The filters are fastened by bolts 17. Body 3 of the nozzle also serves to support the burner.

The distributing bushing 13 separates stage I of the nozzle from stage II. This bushing is sealed by a conical copper ring 8, which is attached by screwed joint 7. Screwed joint 7 is secured by a spring [missing word?] against the falling out and bolt 5.

The orifices together with distributing bushing 13 are fastened to body 18 by screwed joint 19. Body 18 and bolt 5 are secured by washers 20 and 21, which seal them the same time.

<u>The operation of the nozzles</u> - the fuel passes to the first stage of the nozzle through the distributing valve located in pump PN-15B. The fuel passes through the stage I (channel 2) during start-up at low engine speed (on the ground up to n = 3,800 rpm, and

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at operational stages during air starts.) Stage I operates independently until the pressure in the system reaches 20 to 25 atmospheres.

Through channel 2, annular channel between distributing bushing 13 and bushing 19, through eight partial openings on the front side of the distributing bushing, and by the annular channel between body 18 and the pipe, the fuel passes through three tangential openings with a diameter of 0.8 millimeters within the idling orifice 15 and by its opening, which has a diameter of 3.2 millimeters, passes to the burner.

When the speed of the engine increases, the pressure of the fuel rises, the distribution valve of pump PN-15B gradually opens, and the fuel passes to stage II (channel 4).

Because the nozzle is composed of two chambers, the fuel passing from stage II is directed through the channel of stage I. In this way, sufficient atomization of the fuel is attained at the beginning of operation of stage II.

The fuel passing through stage II channel, reaches the interios area of distributing bushing 13 and by the six tangential openings with a diameter of 1.1 millimeters passes to the chamber of stage II nozzle. Through the orifice with a diameter of 6.2 mm, it passes to the stage I vortex chamber and becomes mixed with the fuel entering stage I; then it is injected to the burner of the engine.

When the distributing valve is fully opened, two channels, 2 and 4, of the nozzle become operative. The full opening of the stage II channel conforms to the stage of operation of the engine during flight at high speed near the ground. Usually, this channel is partly closed.

During the operation of two channels, with a pressure of 30 kg/cm^2 and fuel TS-1, the nozzles have an output of 760 ± 12 liters per hour, and for convenience of selection and exchange, are divided into two groups: group A, from 748 to 760 liters per hour; group B, from 760 to 722 liters per hour.

The nozzles of each group are interchangeable.

2.3 The fuel-starter system.

2.3.1. Operation of the units of the fuel-starter system.

The starter fuel system (Fig. 85) operates only during start-up, and when the engine attains 810 ± 70 rpm, it shuts off automatically. It consists of gasoline fuel tank 113, filter 114, mounted on the aircraft, gear pump PNR10-3M, which is put into motion by electric motor MU-102A, starter fuel collector 117, supplied with four igniters 119, a reverse valve, and two blocks of ignition coils. Each block of coils furnishes high-voltage current to the spark ignitor plugs of the two igniters.

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In starting the engine, at the same time that the ignition is turned on, the electric motor of the pump for starter fuel is switched on. The fuel passes from the pump through electro-magnetic valve 116 to the nozzles of the igniters. After starting, the feeding of the start-up fuel is discontinued.

Valve 116 closes the fuel pipe and prevents the flow of fuel from the fuel tank through the gear pump to the starting manifold collector. During the running of the engine, the same valve shuts off the access of compressed air from the engine to the starter fuel system.

2.3.2. Units of the starter fuel system

Pump PNR10-3M is of the gear type with an electric motor drive, and serves to feed the starter fuel from the tank of the aircraft to the combustion chamber of the engine at the time of start-up.

Basic specifications of the pump:

Type .... gear

Operational fuel ..... oil - gasoline mixture, specific weight $0.72 + 0.76$ g/cm^3

Reduction-suction valve driven by electric motor MU-102A, with a flow of $Q = 80^{+5}$ liters per hour, and the voltage on the clamps of electric engine 24 V are regulated for a pressure of	$2 + 2.2$ kg/cm^2
Drop in pressure during the fall of voltage to 18 volts and the constant section at the throttle cock	up to 1.7 kg/cm^2
The output of the regulated pump during operation with electric motor MU-102A with a voltage on the clamps of the electric motor of 24 volts, a counter-pressure of $2 + 2.2$ kg/cm^2, and a maximum current of 6.6 A	at least 80 per hour
Drive	electric motor MU 102A

Pump PNR-10M consists of a single-stage starter pump of the gear type with an electric drive from electric motor MU-102A, which are assembled together as a single unit.

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Structure of the pump - the gear pump consists of the following basic parts:

Case 8 (Fig. 99), cover 3, pumping stage, and reduction valve.

The case of the pump is cast from aluminum alloy and has on one side two cylindrical recesses which accommodate the gears. In the case there are two tapped ducts for attaching the reduction valve, inlet and outlet screwed joints, and blank flanges. The inlet and outlet screwed joints have a screen filter. On the opposite side of the recess for the gears is placed a supporting flange with pins 14 for fastening the electric motor.

In order to prevent seepage of fuel into the electric motor, a packing box has been placed near the groove of the supporting flange. The packing box consists of bushing 13, packing cup 15 and spring 16, which is held at the discharge opening with a screwed joint. The cup is attached to the outlet of the case groove by the bolt through the bushing 13. The bolt of the packing box is secured by sheet-metal lock 10 and screw 9. The rubber cup seals the drive shaft and prevents the leakage of fuel from the pump.

In the pump case, on the side of the supporting flange for the electric motor, there are four channels, tapped at their ends, to which are screwed on the discharge pipes of the placking box and the blind flanges.

On the polished surface of the case and cover 3, there are six tapped openings for the clamp screws [word missing] and two openings for the fastening pin of the case cover. Two bronze bushings 2, serving as bearings of the gears, are pressed into the groove of the chamber of the cast case and the cover. The bushings are secured by pins 1.

The pumping equipment of the pump consists of two cylindrical gears 4 and 5 and their chambers, consisting of case 8 and cover 3.

Drive gear 4 and driven [gear?] 5 are executed as a single unit with their shafts. The long end of the drive-gear shaft terminates in a square section. The shaft of this gear has a channel by which the fuel seeps to the bearing of the cover and is drained to the area of the case in front of the washer, and from there by a duct to the suction pipe of the pump. In this way, an undesirable one-sided thrust on the drive shaft of gear 4 is eliminated. The extended part of the drive - gear 4 shaft is closed by a plug.

The front clearance between the gears and the case varies from 0.015 to 0.06 mm, which is adjusted by applying appropriate pressure on lead-foil gasket 6, mounted in the connecting pipe of the case and the cover.

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In order to regulate the pressure of the gasoline supplied by the pump to the nozzles, the pump has a reduction valve of a slide-valve type (Fig. 100).

The reduction valve of the pump consists of the following parts:

- box 6 with a screw for valve 5;

- spring 4;

- regulating screw 3;

- cap 2 and bolt.

Valve 5 is in the form of a hollow cylinder, on the end of which there is an axial and radial opening, connecting the hollow of spring 4 with the suction hollow. The interior of the valve is used for housing the spring. During the displacement, the fuel pressure is regulated by spring 4 with the aid of regulating screw 3. When the pressure has been adjusted, screw 3 is secured by pin 1.

In order to prevent damages to the screw, cap 2 is mounted on box 6, and is secured by a wire to an eye on the case of pump 8 (see illustration 99).

Electric motor MU-102A is attached to the flange of the case by pin 11 (Fig. 99). The armature shaft of the electric motor is connected to the shaft of gear 4 of the pump by connecting piece 11. On the electric motor is mounted a socket with a plug for connection to the electrical network of the engine.

Operation of the pump - the drive gear, which is firmly connected with electric motor MU-102A, puts the drive wheel into motion. When the teeth of the gears on the suction side (Fig. 101), become disengaged, they create low pressure, and under the influence of which the fuel begins to flow from the tank to the pump filling between the teeth the spaces. Then, the fuel is transferred to the displacement side, where it is forced into the discharge pipe by gears in mesh. If the pressure rises above 2 + 2.2 kg/cm^2, then the packing of the reduction valve lifts and admits the excess fuel from the discharge pipe to the suction pipe through openings in the case of the reduction valve and the channel in the case of the pump.

In this way, the reduction valve will maintain in the discharge pipe the necessary steady fuel pressure. With a fully closed discharge pipe, all the fuel will pass by the reduction valve to the suction pipe.

The electro-magnetic valve consists of box 1 (Fig. 102), solenoid 8, plug 10, filter 5, bolt 6, screwed joint 4, valve bushing 2, needles 2, solenoid coils 7, and spring 11.

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The electro-magnetic valve is fastened to pump PNR10-3M by bolt 6, and the fuel from the pump passes through the filter to the interior area of the valve.

If the solenoid is not energized, then the core is moved by the spring to the extreme right position, the opening in the bushing of the valve is closed by pin 2, and the fuel does not pass through the valve.

If the current passes through the solenoid, the core force overrides the tension of the spring and moves to the extreme left position; needle 2 makes an opening in the bushing of valve 3, and the fuel from the interior hollow begins to pass through screwed joint 4 to the collector of starter fuel.

2.3.3. Manifold starter fuel.

The starter manifold serves to feed the starter fuel to the igniters. This is a tube bent in the shape of a semi-circle, made from tubes with diameters of 8/6 (Fig. 103).

The semi-circle has four screwed joints to which are fastened tubes for feeding the fuel to the igniters, mounted on burners nos. 3, 5, 10, and 12. In addition, there is a screw joint for measuring pressure 1, and one screw joint for feeding of fuel 2.

In screw joint 7 of the collector (Fig. 104) are located the filters with check valves. The filter consists of box 5 and screen 9, fastened to the box of the filter.

In the box of the filter is mounted a check valve, consisting of ball 4 with a diameter of 5.5 m; cones 3, spring 8, and guide bushing 1. The guide bushing is secured against longitudinal movement by safety ring 2, mounted on the ring groove of the filter box.

Tightness of the connecting pipes of the manifold is ensured by washers 6 and 10. For quick dismantling of the filter, there is in the box an internal thread and bolt 11.

The structure of the igniter (With newly made modifications) - the fuel-mixture ignition during the start-up of the engine is effected by four igniters.

The igniter (Figs. 105 and 106) consists of the following: safety device 7; lid 2; bushing for spark igniter plug 1; bushing for ionizer 9; screw joint for nozzle; 4; flange 6; nozzle 5; discharger 3; spark igniter plug 8 and ionizer 10.

In two igniters, the spark plug, ionizer, and nozzle are located on the left side, for chambers 3 and 10, and in two igniters they are located from the right side, for chambers 5 and 12.

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Safety device 7 of the igniter by its spherical surface secures the burner in the axial direction, and at the same time connects the hollow of the igniter with the burner. In order that the spherical part should not wear out too fast, it is chrome-plated. The safety device has a falnge with four openings for screws, for fastening it to the back case.

On the surface of the safety device is longitudinal groove "b" and two openings "a", serving for the feeding of air from the space in the middle of the burner to the area of the igniter. This air is used to blow out the spark igniter plug and the ionizer.

Flange 6, which facilitates the formation of the mixture in the hollow of the igniter, is spot welded at six spots to the safety device from the inside. On the upper front area of the safety device, there is a cylindrical surface serving for the support of lid 2. The lid is arc welded to the safety device. On the spherical surface of the cover, at an angle of 10 degrees to the axis of the safety device, discharger 3 is arc welded.

All the parts of the igniter are prepared from 1CH18N9T steel. [1Kn18N9T].

Spark igniter plug SD-96A (8) is screwed on screw joint 1, and ionizer SD-96I (10) is screwed on to the second screw joint 9, which ensures the proper jumping of the spark from the electrode of the plug to the discharger.

The electrodes of the spark igniter plug and the ionizer are mounted at a distance of B - 1.4 mm from the axis of the discharger with the aid of copper washer-spacer 11. The washers are mounted below the plug and the ionizer, two at a time at most. In addition, between the surface of the electrodes of the plug and the ionizer, from one side, and the front side of the discharger from the other, a space of A = 4 mm is set by the adjustment of the front side of the discharger.

Operation of the igniter - the fuel injected by the nozzle to the area of the igniter is atomized, mixed with air, and ignited by a spark from the spark igniter plug. The resulting flame shoots out from the area of the igniter to the burner and ignites the mixture of fuel and air in the combustion chamber of the engine.

2.3.4. Starter nozzle

The nozzle consists of a connecting pipe 3 (Fig. 107) and atomizer 4. The connecting pipe has 6 openings - four openings 2 for the feeding of fuel and two openings 1 on the securing head.

Atomizer 4 consists of an orifice and the bottom of vortex chamber 5. The orifice has two tangential openings 6 with a diameter of 0.6 mm and a central opening with a diameter of 0.6 mm. The tangential location of the openings ensures better mixing of the emerging fuel, resulting in better atomization.

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The orifice is made of 4CH14N14V2M [4Kh14N14V2M] steel and the other parts of the nozzle from 1 CH18N9T [1Kh18N9T] steel.

The flow of fuel through the nozzle is 8 kg per hour under a pressure of 2 kilograms per square centimeter. The normal operating pressure of the fuel in front of the starter nozzles varies from 1.4 to 1.75 kilograms per square centimeter.

The nozzle is screwed into threaded joint 4 (Fig. 105), which is welded to the body of igniter 7.

Main fuel drain system [2.4]

The drain system serves to discharge fuel accumulated in the engine and also to discharge fuel which has leaked into the drain space of the fuel unit on the engine.

The fuel is discharged to drain tank 105 (Fig. 85), located under the engine, and by pipe outboard. The fuel is discharged to the drain tank from the main and auxiliary manifolds during [stopping] of the engine, from the area behind the plunger of the fuel pump of TNR-3R, and from the area [under] the gaskets of fuel pumps PN-28B and PN-15B.

The discharge valve is used to admit the fuel from the amin and auxiliary manifolds. The discharge of the fuel from the collectors is necessary to avoid the igniting of accumulated fuel in the engine [word missing?] housing. Air is admitted to the drain tank through the nozzle from the compressor which during starting and running of the engine forces the fuel into the tube coming out of exhaust nozzle.

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In order to eliminate the effect of the air carried to the drain tank during the operation of the automatic starting device and the automatic acceleration device, the fuel is discharged from the membrane chambers of pump PN-15B to tank 104 (Fig. 85).

The discharge tank has a vent opening, which connects the tank with the area below the engine compartment.

By means of individual tubes, fuel is discharged outboard from areas on the case of the combustion chamber and the stator vane assembly of the turbine.

[2.4.1]. Discharge valve

The discharge valve consists of: box 1; lid 12; valve 13; spring 2; check valve 9; stop of valve 3 and filters 4, 7, and 10 (Fig. 108).

Box 1 is made of D1T aluminum alloy and has screw joint 5 for feeding the fuel from the auxiliary collector, screw joint 6 for feeding the fuel from the main collector, and screw joint 8 for discharging the

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fuel to the drain tank.

Lid 12 is made of 2CH13 [Cr13] steel and has screw joint 11 for feeding the fuel.

Operation of the valve - during stopping of the engine, the pressure in channel 53 (Fig. 85) falls and spring 2 moves valve 13 to the extreme left position thus discharging the fuel from both manifolds to the discharge tank.

During starting and running of the engine, when the fuel pressure in front of distribution valve PN-15B begins to rise, valve 13 presses on the stop of valve 3 and opens the ducts of the main and auxiliary manifolds.

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Chapter V.

Anti-icing Equipment

The anti-icing equipment (Fig. 109) prevents the formation of ice by heating with warm air areas which would become covered with ice at low temperature and high humidity of the air. All the heated areas of the inlet equipment have small openings which the hot air, carried from the VII stage of the compressor, is admitted with the exception of the guide vanes of the front housing of the compressor, for which the hot air passes from the fifth stage of the compressor through the relief cavity of the front bearing of the compressor.

The anti-icing equipment consists of the following parts: intake c/bow pipe 9; pipe for carrying air 6; fitting 5; reinforcement arms 3; internal struts 11; cover 2 of the turbo-starter, and guide vanes 10 of the front housing of the compressor.

On the center case of the compressor there is mounted from the left side a elbow pipe for taking in air with flap 8, by which the hot air is directed to the heated areas. The equipment is of the throttle [type], and the flap is controlled by compressed air from the pilot's cabin. It consists of the following parts:

Body 9 of the elbow pipe for intake of air; flaps 8; piston mechanism 1 for control of the flap.

Body 9 is cast from aluminum alloy and has two flanges: a flange with four openings for screws, fastening the knee pipe to the flange of the center case of the compressor, and a flange with four tapped holes into which are screwed pins fastening the flange of the pipe which carries hot air to the fittings. The body of the elbow pipe has two lugs with bronze bushings supporting the shaft with a flap attached by screws.

It also has two outlets with tapped holes for stop screws, limiting the movement of the lever, which is fastened by the pin of the flap shaft during the opening and closing of the flap, and still another lug with a thread on which is screwed the rotating shaft of the piston mechanism.

Mechanism 1, serving to control the flap of the air intake, consists of a body, piston, retracting spring, lid of the body, packing, a pin, connecting rod, and two rubber rings.

The body is made of Z2 material, has a connecting pipe for conducting compressed air, an opening with a spherical surface for the packing, and an internal thread for the lid of the body.

The piston is made of Z3 material and has on the surface two grooves

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for the rubber packing rings and at the end an internal thread for screwing on of the connecting rod, which is connected with the lever of the flap by a pin. The spherical coupling of the body and the bushing compensate for the bending of the body.

Pipe 6 for carrying of air to the anti-icing system is made of aluminum alloy AMgM. On the outside the pipe carries layers of heat insulating winding, which is made of tightly wound asbestos cord with a diameter of 1.2 mm, and layers of serge strip, impregnated with water glass.

Fitting 5 is cast from magnesium alloy ML5, has a flange with two openings for screws, serving for fastening to the flange of the front case of the compressor, and three other openings; one for the pipe carrying hot air from the compressor and two for carrying the hot air. Through one of these two openings, the air is admitted to the struts and the aerodynamic cover of the turbo-starter, and by the other to the inlet diffusor and to the exhaust tube of the turbo-starter.

The anti-icing equipment operates as follows: should the danger of icing arise, the supply of compressed air to the control mechanism is switched on by a lever from the pilot's cabin. In this mechanism, the air moves the piston, which transfers the movement through the connecting rod to the lever, coupled to the pin of the shaft of the flap. Through the movement of the lever, flap 8 turns 75 degrees, opens the body of the knee pipe to the intake of air thus admitting the hot air to the anti-icing equipment. In shutting off the anti-icing system, the compressed air is released from the body to the atmosphere. Under the influence of the retracting spring, the piston returns to the starting position, closes flap 8, and the access of hot air to the anti-icing system is blocked.

The total intake of air to the engine is controlled by element 7. A pipe for feeding the air to struts 3 has telescopic connections on the ends. The path by which the hot air passes into the channels of the anti-icing equipment is shown on illustration 109.

The inlet equipment consist of:

1. six struts 3, fastened to laminated arms of the front housing of the compressor each one by four pins.
2. aero-dynamic cover 2 of the starter.
3. internal strut 11.
4. external strut 4.

Cover 2 with a spherical coupling and a discharge pipe of the starter are fastened to the strut of the aero-dynamic cover.

A diffusor is fastened to the forward side of the external strut on the aircraft, on which the exhaust pipe of the starter is connected by a spherical connection with the outlet pipe of the starter. Through the exhaust pipe gases pass out to the atmosphere. At the exit from the

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exhaust pipe are mounted flaps which are automatically closed after the completion of start-up.

The reinforcing struts (Fig. 110) are made of metal material AMgM, and have a double-wall sheath. The walls are spot welded to each other with a small space between them. Hot air passes through this space. On the interior wall 2 there are openings for the discharge of air. Cap 3 and bottom 4 are welded to outer wall 5 and inner wall 2. The lower bottom has an opening for the passage of air from internal strut 11 (Fig. 109).

Bushing 1 is welded onto the upper bottom of the left reinforcing strut for the feeding of hot air to the struts and to the cover. In the other struts, this bottom is blind.

In the front wall of the right reinforcing strut there is an opening into which is rolled the end of the pipe for feeding of air to the altitude - speed corrector of pump PN-15B.

The profile of the reinforcing strut together with the profile of the cast arm of the front housing of the compressor form an aerodynamic shape.

The aerodynamic cover (Fig. 111) consists of two parts connected by six high-speed shut-off devices of the aircraft type. Each half has two walls, is made of AMgM sheet, and is spot welded and, in parts, seam welded.

Both halves have the same cross-section with the exception of the place for closures. For the fastening of the aero-dynamic cover on the strut, collector 5 of the square grooved cross-section is welded to its base. The collector fits into the ring groove of the cover having the same cross-section (see Fig. 112). At the same time this collector takes in the air which has passed between the walls of the cover. Sheath 7, by which hot air is fed to the front part of the cover of the turbo-starter is electric-seam welded and in part gas welded to the inside sheath of both halves of the cover.

From the front, there is riveted to the center a graduated machined ring 1 (Fig. 111), by which the cover is centered on the spherical connecting piece of the turbo-starter. The spherical connecting piece is connected to the exhaust tube. In the steel ring are openings 2, which partially draw the hot air for heating the steel ring and the spherical connecting piece.

On the surface of the cover there are six openings, closed by gratings 6, by which fresh air passes to the compressor of the turbo-starter during its operation.

In the front, center, and back part of the cover, there are welded, in the dividing area holders 3, on which are mounted high-speed shut-off devices. On the interior sheath of the cover there are corrugations 4,

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by which the sheath is welded to the outside sheath of the cover and forms a space for the passage of hot air.

The strut of the cover (Fig. 112) is cast from magnesium alloy ML5 and has a flange with six grooves 8 for the reinforcing arms and twelve openings 6 for screws, fastening the strut to the front body of the compressor. From the front side, the strut has ring grooves 2 of the square cross-section - for fastening the cover.

Between groove 2 and grooves 8, there is a ring channel with six openings 1 and 7 for the feeding and drainage of hot air to the reinforcing arms, and two elliptical openings 3 for the feeding of hot air to the aero-dynamic cover of the turbo-starter. Opposite openings 3, the strut has two slots 5 for the sheaths of the aero-dynamic cover.

The spherical connecting piece (Fig. 113) - the body of connecting piece 2 is made of heat-resistant sheet steel. On one of its ends is rolled in a slightly rotating spherical ring 1, to which is attached the exit pipe; the second end of the body is rolled out along the inside spherical surface of ring 3 to center the aero-dynamic cover.

The second spherical ring 1, to which is telescopically fitted the exhaust tube of the starter, is mounted on the expanded spherical part of the connecting piece through special slots, located in ring 3.

The movable spherical rings forms a telescopic coupling taking up the mis-alignment, crossing, and heat deformation.

The high-speed device for closing the cover (Fig. 114) consists of:
cover 3 with welded cylindrical packing 4 (in it is assembled stop 5 and spring 2;
lever 1;
loop 12;
screw with eye 11;
spring 10, and other parts.

Screw 11 with eye for closing of the aero-dynamic cover is extended to the opening of holder 9, riveted to the lower half of the cover, and is fastened by special bolt 8. Inside the bolt is mounted spring 10, which presses in both halves of the aero-dynamic cover.

In the upper half of the cover, a grooved piece is welded by cylindrical pins 6, on which lever 1 is supported by the cylindrical groove. On these pins, the closing lid, which is packed into the groove, rotates with its mechanism; to which [the groove?] fits stop 5 placed on the cylindrical packing. Support pin 13 is pressed into the stop. When stop 5 is pressed and rotated 90 degrees around the axis, pin 13 extends perpendicularly to the groove and through the action of spring 2 pressed against the wall of the groove and prevents the opening of the cover. The lid is connected with the lever by spring 7; the lever pulls the lid from the groove during the opening of the closure.

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CHAPTER VI ELECTRICAL EQUIPMENT

1. General Data

The electrical system of the RD-3M engine has the following functions:

a. Automatic starting control

b. Cranking the engine, cold

c. Cranking the S-300M starter, cold

d. Restarting in the air

e. Automatic and semi-automatic opening and closing of the compressor air bleed system, as well as blocking air bleed system

The electrical equipment includes: sources of power for aircraft and engine accessories, equipment for the bleed air system from the compressor (see section entitled "Compressor"), as well as the starting mechanism for the S-300M starter.

The principal control unit among the automatic starting devices is the PT-4M relay box designated as PT-4V after modification for air starting. This relay box is operated in series with generator No TD-1.

2. Sources of Power for Aircraft and Engine Accessories

2.1 Generators

To supply the aircraft electrical system with direct current, two GSR-18000D generators are mounted on the engine.

The generator GSR-18000D (Figs 115 and 116) supplies direct current. The generator is driven by a drive unit having a gear ratio of 1.879.

Basic Technical Data on the d.c. Generator GSR-1800D

Rated voltage -- 28.5 V

Output (at 30 V -- 18,000 W

Rated current at full load -- 600 A

Range of RPM -- 3,800 to 9,000 RPM

Type of Operation -- constant speed

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Electric Schematics -- The GSR-1800D generator has eight main salient poles with parallel excitation windings and four auxiliary salient poles with separate windings. The coils of the winding on the main pole are connected in series. One terminal of these windings is connected to the negative brush holder and the other to the external circuit.

The coil windings on the auxiliary pole terminals and the armature windings are connected in series. One end of the winding of the auxiliary pole terminals is connected in parallel to the negative brush connector ring; the other end passes outward through the terminal point block.

The positive brushes are connected with the aid of a connector ring and this connection also passes to the outside through a terminal block.

For purposes of external hookup, the GSR-18000D generator has three terminal leads:

Two load leads (each consisting of two wires) whose ends are stamped either " + " or " - ", and one exciter lead, stamped "S". The schematics of the electric generator are shown in Figure 117.

Direction of armature turning: left (counter-clockwise), when viewed from the drive side of the generator.

To ease the strain on the brushes resulting from load variations, so-called equalizer or equivalent contacts are used in the generator (see description of armature below).

Schematics of External Contacts -- In order to retain a constant load, to protect against current backflow and to facilitate parallel operation, the GSR-18000D generator operates in conjunction with the following equipment.

a. RUG-82 voltage regulator

b. TS-8 stabilizing transformer

c. DMR-600A reverse current relay

d. BS-18000 resistor

To reduce the level of radio interference resulting from the operation of the generator and regulator, a KBM-31 capacitor with a capacitance of 4mkF is inserted into the circuit. The schematics of the exterior connections of the GSR-18000D generator, wired for parallel operation, are shown on Figure 118.

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Generator cooling system -- The generators operate at a low voltage, so that for a relatively large generator output, a flow of heavy current results. Because losses are equal to the product of ohms times the square of the current strength, such losses become quite substantial and result in significant heating of the generator parts. Commutator losses are particularly high.

For the GSR-18000D generator, commutator losses reach the value of 3,500 w when the generator operates at high RPM under rated load; during emergency procedures (loaded to 660A) such losses are even higher. Commutator losses account for about 80 percent of all generator losses. To reduce the amount of overheating, it is necessary to cool the generator and especially its commutator, intensively.

The fan mounted within the generator does not assure adequate removal of heat, even under favorable circumstances and, when operating at altitudes of 10,000 meters or more, where the density of the air is reduced considerably, fails to guarantee normal functioning of the generator. Consequently, the required cooling of the generators is accomplished through use of the compressed air. With such a procedure, the quantity of cooling air passing through the generator depends on the overall aerodynamic pressure at the air intake. The air speed increases with increasing altitude; this results in an increase in the overall aerodynamic pressure of the cooling air notwithstanding the fact that the air is less dense at higher altitudes, and the generator gets proper cooling and can operate reliably.

During flight, the total pressure of the cooling air, measured at the generator air intake, must be at least 400 millimeters of hydrostatic pressure. The air must not be heated in the air intake duct.

In conducting ground tests and shock tests of the GSR-18000D generator at full pressure in the air intake duct (400 millimeters hydrostatic pressure) the volume of cooling air passing through the generator must be at least 235 liters per second at a barometric pressure equivalent to 760 millimeters of mercury and at a temperature of $+ 25^\circ \pm 10^\circ$C.

The cooling air passes over the commutator, the brushes, brush holders, the armature and its winding, and the main and auxiliary pole windings thus absorbing the heat which is then passed outside. The air entering the intake is divided into two parts within the generator. The first portion of the air passes through the channels in the cruciform

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commutator base and over the body of the commutator, removing heat from the metal and from the surface of the winding; then it is removed by a fan through openings in the housing on the drive side. The second portion of the air passes above the commutator, cools the commutator plates, brushes and partially cools the faces of the main and auxiliary pole windings before passing out of the housing above the commutator through slots and openings in the housing and through the protective strap. A portion of the air passes along the housing between the windings of the main and auxiliary salient poles and leaves through openings in the housing on the drive side.

With the engine running while on the ground, the fan assures adequate cooling at a load of up to 30 percent of the rated capacity.

Generator Design -- The generator (Fig 116) consists of the following principal parts: housing 6, armature 8, and cover 16.

The generator housing is composed of two parts which are welded together into a single unit. In the forward or face part of the unit is the centering bushing and holes 10 for mounting the generator on the engine. The interior side of the face of the generator housing has a grating 9 which protects the exciter winding against damage during mounting of the generator on the engine and protects the inside of the generator against entrance of foreign bodies.

The central portion of the housing holds 8 main poles 29 and four auxiliary pole 30, made of reinforced sheet steel. The exciter windings are mounted on the main poles, and the auxiliary coils on the auxiliary poles. The winding and poles are held to the housing with four screws each.

The commutator side of the generator housing has access openings 2 to the commutator and to the brushes. Towards the edges of the openings and in an axial direction, four screws each hold eight brush holders 3 made of an aluminum alloy, each of which has three openings for brushes. The brush holders are insulated from the generator housing with glass textolite washers and nuts made of plastic. The brushes are held in place by special levers and coil springs.

Small plates with felt inlays are fitted to the brush holders with screws.

The openings in the generator housing are closed by a steel strap 15 which has a plastic substance rivetted to its underside.

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The armature is made of electrical quality ST1 grade sheet steel. Pack 28 made of sheet steel and insulated on the ends, is press fitted on the hollow shaft 12 from one side of the shaft; a commutator is press fitted on the cruciform spider 17 from the other side.

The commutator of the generator is composed of a housing 19, an insulating cone 26, commutator segments 1, insulation between the segments, lock washers 4, and nuts 14. The ends of the commutator plates 19 are tightened to housing by nut 14 which exerts pressure on lock washers 4.

To improve generator comutation, the armature is wound with a lap winding 7 with equalizing connections consisting of eight copper rings mounted on the insulated case. The equalizing rings tend to equalize the currents in the parallel circuits of the armature due to the asymmetric magnetic flux over the individual pole faces. To prevent the establishment of contact between the parts, they are separated by glass laminate rings. Each equalizing ring has four eyes which are attached to the commutator plates and have the same potential. The pins are bonded to the commutator plates and to the eyes of the equalizing rings with a special alloy "K1".

The face of the winding is prevented from bulging out from the armature due to centrifugal force by soldered sleeves 5.

Ball bearing 18 is mounted on the commutator end of the hollow shaft and another ball bearing and fan 11 are mounted on the other end. The latter are intended to supplement the flow of cooling air which passes through the canals of the cruciform spider of the commutator and armature.

Drive shaft 13 is located on a conical mounting in the front part of the hollow shaft and is fastened by nut 20. The end of the drive shaft is provided with key slots for connection with the engine drive.

The generator cover is made of aluminum alloy AL5. In the front part of the cover, a throat accomodates two plastic posts (24) which serve to crimp cable terminals 25 of outgoing cables 27. Busbar 23 of the contact rings are connected to the cable terminals by screws 22.

The front part of the generator cover has a plastic post 21 with a crossover terminal for the shunt winding lead. The throat of the cover has a socket, which is held in place by four screws, and through which the leads pass. The center of the cover has a bushing for mounting the ball bearing.

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2.2 Differential Relay DRM-600A

The differential-minimum relay DRM-600A (Fig 119) serves to connect the generator to the aircraft power system when the generator voltage exceeds the voltage of the aircraft power system; it also serves to disconnect the generator in case of reversal of current flow. Simultaneously, the relay prevents discharging of the storage battery. The automatic connection between the generator and the aircraft power system is accomplished only if the generator has correct polarity.

The relay can be used with any type of aircraft d.c. generator with a rated voltage of 28.5 v and a rated output of 600a.

Technical Data Pertaining to Relay

Rated voltage -- 28.5 v

Rated current passing through the contact points -- 600 a

Return current flow -- from 25 to 50 a

Type of operation -- continuous action

The relay functions normally when the voltage in the network varies from 20 to 30 volts. The output relay must close when the difference between the voltage in the generator and in the aircraft power system is equal to 0.3-0.7 v.

Differential minimum relay (120) consists of the following principal components:

Contact points -3;

Differential polarized transmission relay with permanent magnets -- 2;

Computator relay -- 1 TKE-210B;

Voltage relay 5TNE-210A and a resistor calibrated at 4PO-10-02 Ohms

All the above components are mounted on one panel.

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The winding of relay TKE210B is connected to the aircraft power system and to the generator and, through the generator contact points, to the winding of the transmission relay. The winding of the contactor is inserted between the contact of the transmission relay and the main switch.

When starting the generator with a correct polarity, the relay contact 1 closes and the current is transmitted to transmission relay 2. The transmission relay is a polarized relay with permanent magnets. The magnetic flux of the permanent magnets is built up when the shunt coil, reacting to the voltage of the generator which exceeds the voltage of the aircraft power network, creates a magnetic flux which is stabilized in the same direction as the flux from the permanent magnets. In such an event, the relay is activated, the contacts close and the voltage from the generator is applied to the winding of contactor 3. After the main switch is thrown, the contractor is activated and cuts the generator into the aircraft power system.

When the current passes through the load resistance, it also passes through the winding of the transmitting relay which is connected in parallel with the load resistance, and will create supplementary ampere turns to conform to the number of ampere turns of the shunt coil winding.

As soon as the voltage in the storage battery of the aircraft system exceeds the voltage of the generator, reverse current begins to pass through the load resistance and thus also through the in-series winding. The ampere-turns of the winding are set up in an opposing direction to those of the ampere turns of the shunt winding.

When the reverse current attains a certain value, the contact points on the transmission relay are opened, the winding of the contactor is deprived of current and the generator is cut off from the aircraft power system.

When the contactor closes, the voltage is impressed on the winding of relay No 5 which, when the voltage reaches the value of 18 volts, is activated, opens the normally closed contact points and cuts in supplemental resistance (4) into the circuit of the contactor winding. As soon as 10 v are impressed on the winding the relay is disconnected and introduces the supplemental resistance across the normally closed contact points.

2.3 Voltage Regulator RUG-82

Regulator RUG-82 (121) serves to automatically maintain stabilized generator voltage under varying RPM and load and also serves to distribute the load evenly between the generators which work in parallel.

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Technical Data

Rated voltage -- 28.5 v

Voltage maintained by regulator when generator RPMS vary from 3800 to 9300 and generator load varies from 0 to maximum -- from 26 to 30 V.

Maximum output distributed across the carbon column -- 170w

Type of operation -- Continuous

The following are the components of regulator RUG-82:

The regulator itself;

TS-8 Stabilizing transformer;

DS-20 Resistor;

KBM-31 capacitor with a capacitance of 4 microfarads.

Function of the Carbon Regulator -- The simple carbon regulators (Fig 122) is commonly composed of an electromagnet and a carbon column 9, connected in series with the exciter winding of the generator.

The electrical resistance of the carbon column depends on the pressure of armature 6 on the carbon column. In the absence of a voltage at the generator terminals, the attractive force of the electro-magnet is equal to 0. In this case, carbon column 9 is compressed by springs 7 to a maximum and its resistance is exceedingly small. As the generator voltage increases, so does the attractive force of the electromagnet; the pressure on the carbon column is diminished and the resistance of the carbon column is accordingly increased. With the generator in operation, the armature assumes a certain position, due to pressure exerted on the carbon column, thus maintaining the required voltage at the generator.

Special Characteristics of the Electric Circuitry of the Generators and RUG-82 Regulator. In contrast to the schematics of the simplest regulators shown in Figure 122, the circuit of regulator RUG-82 (Fig 123) contains elements which increase the accuracy and reliability of regulator operation and also insure parallel operation of the generators. The coil of the electromagnet, apart from having a working winding 4 has a winding 6 to increase the accuracy of voltage adjustment, as well as a temperature compensating winding 5. The equalization of voltage of the generators which work in parallel and the distribution of the load between them is the function of winding 7.

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Automatic setting of generator voltage is carried out within the following closed circuit: generator--working winding of the regulator--carbon column--exciter winding--generator.

Despite the greatest degree of reliability of components within the system, certain deviations can occur, caused by the delayed action of individual components. The occurance of such deviations is prevented by the stabilizing transformer TS-8 as well as by resistor 10, which are connected in series with winding 6 via a selenium rectifier.

Stabilizing Transformer TS-8 is a coil with dual winding and a core made of E-grade sheet metal. The low resistance winding is connected in parallel with the shunt winding of the generator. The current in the primary winding of the stabilizing transformer is determined by the voltage drop across the exciter winding of the generator and by the Ohm-resistance of the primary winding. The current in the secondary winding of the transformer corresponds to the current in the working winding of the regulator.

Resistor VS-20 serves to establish the current level which can be varied during the operation of the regulator.

Setting is accomplished by changing the resistance in the rheostat which is connected in series with the working winding of the regulator. With increasing rheostat resistance, the level of the current is increased; with decreasing resistance the level of current is decreased.

Capacitor KBM-31 with a capacitance of 4 microfarads serves to reduce the level of the radio interference arising during the operation of the carbon regulator. The capacitor is mounted separately from the regulator.

3. Equipment for Starting the Engine and the Starter

The MZK-2 electro-mechanism (124) serves as a drive mechanism for opening and closing the exhaust valve on turbo starter S-300M.

The electro-mechanism consists of the following:

Reversible motor 1 (Fig 125);

Reductor 2;

Friction clutch 3;

Panels of terminal switches.

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The B-12 TU reversible electric motors (direct current, series excitation) develops a rated torque of 2.5 kg-m at a rated voltage of 27 v and at maximum current of 3.6 a. The reversing action is achieved by the two independent exciter windings. The action is accomplished with the aid of a single pole switching operation.

The parallel coil of the electro-magnet of braking clutch 12 is fitted into the electric motor, serving to decrease the inertial forces and thus assisting the engine in starting.

The 5-stage planetary gear reductor 2 with a transmission ratio of 3275.91:1 is connected to the shaft of the reversible motor which drives the friction clutch 3. Clutch 3 serves as a protection against short-circuiting within the electric motor caused by over-loading the drive shaft of the mechanism.

The friction clutch is equipped with a central device -- regulator 4 -- which assures the constant maximum torque transmitted by the clutch. The slipping of the friction clutch is minimum for a torque of 3 kg-m and maximum for a torque of 5 kg-m.

Terminal switches 5 are activated by a face cam 6 which has two lobes of varying dimensions. In starting, these lobes exert pressure on the levers which open the contact points. The terminal switches for signal lamps 7 are activated by the support screws 8 held down by nut 9 located on a turning bolt 10.

When the 1D-12TU reversible electric motor is switched on to the aircraft power supply system, the 5-step reductor 2 begins turning drive shaft 11, which is connected with the exhaust pipe valve of starter S-300M. When the drive shaft has been turned to the required degree, the contact points of the signal device close. The maximum possible angle of rotation of the drive shaft is 50-95°. The maximum operating time for the mechanism while accomplishing a turn of 95° in six seconds.

As soon as the drive shaft reaches its special stop, the friction clutch of the mechanism begins to slip. It continues to slip as long as the face cam, mounted on the housing of the friction clutch, does not press with one of its lobes onto one of the levers to break contact at a terminal switch which is connected with the electrical mechanism, and thus break the electrical circuit feeding the electric motor.

The type of operation of this device is of short-duration. At given values, it is permissible to switch on twice in succession, (without an interval) so that the drive shaft travels through an angle of 50 - 95° to the right or to the left; movement is limited by mechanical stops. Thereafter, an interval of 30 seconds must be observed.

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It is permissible to institute two such cycles. Thereafter, it is necessary to wait 20 minutes.

3.1 Pneumatic Switch PK

Pneumatic switch PK (Fig 126) consists of a diaphragm transmitter, and serves to activate the winding of electro-mechanism MZK-2 which controls the exhaust valve under given conditions of air pressure, fed to the pneumatic switch from the engine compression.

Basic Technical Data

At the instant of switching under increased air pressure, the pressure at diaphragm housing--0.35 + 0.45 kg/cm^2

At the instant of switching of the electric circuitry with reduced air pressure, the pressure at diaphragm housing--0.35 + 0.1 kg/cm^2

Maximum working air pressure--up to 6.5 kg/cm^2

Rated dc voltage applied to the device--24 V

A pneumatic switch is hooked to the supply circuit of the winding of electric motors D-12TU and mechanism MZK-2 with the aid of a pronged plug. Nozzle 8 serves to feed compressed air from the 8th stage of compressor-motor into diaphragm housing PK.

With rising pressure within the diaphragm housing, up to certain limits, diaphragm 4 begins to shift to the left, compressing spring 2. Simultaneously, push-rod 11, which acts upon switch KV-6, also begins to move. The movable contact plate 12 of switch KV-6, which breeches a pair of permanent contacts 13, changes position to the second pair of permanent contacts 1, thus admitting current into the winding of the electric motor.

With increasing pressure within the diaphragm housing (approximately 2 kilograms per square centimeter), the diaphragm drops into a special position within housing 3, and disc 9 of the diaphragm rests against the coni-form area of the housing. This reduces the tension on the diaphragm due to further increase in pressure within the diaphragm housing.

As the pressure entering the diaphragm housing is reduced, both the diaphragm and the push rod begin to return to their starting position. As a result, the movable contact plate 12 within the electric motor KV-6, which has been pulled back by the push rod, returns to the permanent pair of contacts 13, thus switching over to the other winding of the electric motor.

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In order to facilitate setting of the pressures required for switching, the pneumatic switch is equipped with a special device located in cover 5.

When set screw 7 is turned in a counter-clockwise direction, the number of revolutions for switching operations is reduced; when the set screw is turned in a clockwise direction, the number of revolutions required is increased. It is necessary to set the opening value to a different position for a speed of 1850 + 2050 RPM.

3.2 Electromagnetic [probably solenoid] Fuel Valve

Two electromagnetic fuel valves are hooked into the fuel system of starter S-300M -- in front and behind fuel pump TNR-3R -- which control the flow of fuel to the starter during starting operations.

The electromagnetic valve has the following principal components.

Housing 2 with entrance and exit nozzles

Electromagnetic 4

Core 5 which is closed off by plunger 1;

Return Springs 3 and 7.

Closing plunger 1 is equipped with a rubber gasket ring 6 on the face side, which presses against the thin valve walls in the OFF position and assures a tight fit. The valve components located within the plunger serve to free the plunger of the effect of fuel pressure.

The valve has a plug with prongs 8 which serves to feed power during starting. In operating position, the electromagnet draws a current of 2a.

3.3 Electric Motor SA-189BM

Electric motor SA-189BM (Figs 128 and 129) serves to turn turbostarter S-300M during starting and is attached to it from the right side of the forward reduction.

The electric motor is of the sealed type, operates on direct current, and is designed for short-duration repeated action. The motor consists of steel armature 1 made of laminated plates (the geared armature is open and has sections of oblong copper wire), stator 2 with four poles 18, which carry the winding 3 made of copper wire. All windings are connected in series. One common lead from the windings is connected to terminal

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screw 7 and the other lead is connected to a pair of brush holders. The second terminal screw is connected to the second pair of brush holders. The stator and its poles and windings are mounted on aluminum frame 10 with screws.

Four brush holders are mounted directly on the aluminum housing. They are insulated from it and interconnected electrically in pairs. The brushes 4 are under pressure from coil springs, one end of which rest against the brushes with the other end fitting into recesses 5. The spring recess container is mounted in the opening of the case and is lined up with selected slot. Openings in the housing are tightly closed by protective strap 8 which is tightened with wing nut 17.

The shaft of armature 19 is fitted into two ball bearings 6 and 16. The ball bearing is inserted from the side of the commutator into the aluminum frame and is closed off by a steel cover. Bevel gear 14 is fitted on to the slotted end of the armature shaft and tightened with nut 15. The gear transmits the torque to the shaft of the starter via a bevel gear and a free running clutch.

To keep oil out of the electric motor, rubber packing 13 is placed in spacer 12. In shaft opening 19 in the lower part of the frame is placed a gasket ring which serves the same purpose.

Electric motor SA-189BN is mounted on the reductor housing with four bolts.

Basic Technical Data

Rated voltage -- 24V

Power source -- Storage battery with capacity rating of 25.5 to 60 ampere hours.

Current drawn by the freely-running device at 12 volts -- maximum 48 a.

Revolutions of freely-running device at 12 volts -- minimum 12,000 rpm.

Direction of rotation when viewed from drive side --to the right.

The variation in the current, the voltage, and the number of revolutions at starting are listed on Fig 130.

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3.4 Block of Starting Coils KPM 1-2

The block of starting coils KPM 1-2 (Figs 131 and 132) serves to impress high voltage to plugs SD-96A which insures ignition of the working fuel mixture in starting the engine.

This block services two igniters. The block is fed from a storage battery with a generator hooked in parallel or from the storage battery at rated voltage of 24 volts. It ensures the formation of sparks at the plug during starting of the engine on the ground and, during flight, up to an altitude of 18,000 meters. The current in the primary coil circuit, when functioning with a three-electrode discharge tube, must be 3 (+ 0.3, - 0.6) amperes.

The type of operation of block KPM 1-2 is "short-duration repetition."

The cycle is composed of five switching-on periods of 30 seconds each with a 2-minute interval between switchings and a 15-minute interval between individual cycles. In-flight operation consist of five switching-on cycles for a maximum duration of 60 seconds, with an interval between switchings of at least 2 minutes and a minimum waiting period of 30 minutes following five switching-cycles.

The result (see Fig 131) of feeding current to primary winding 1 is such that current begins to flow through the winding, increases gradually, and forms a magnetic field around the primary winding. As a result, the core is magnetized and, as soon as the magnetic flux reaches a certain value, the force exerted on the armature of the vibrator overcomes the resistance of the spring and draws it to the face side of the core.

The contact points of the vibrator are now opened, the current in the primary circuit of the coil begins to diminish, the magnetic flux also diminishes and the vibrator spring is returned to its starting position and once more closes the contact points of the vibrator. The circuit of the primary winding is thus closed again, and the procedure is repeated.

The rapid changing of the magnetic current in the coil, resulting from the opening of the vibrator contact points, induces an electromotive force in the secondary winding as a result of which the necessary voltage required to form a spark for starting the engine develops at the electrodes of the spark igniter plugs. When the vibrator contact points are opened and the values of the magnetic flux change, an electromagnetic force also develops in the primary winding. It will act to retard a drop of the primary current.

As a result of the opening of the primary circuit and formation of voltage on the vibrator contact points, an electric arc is formed which causes the contact points to burn. Due to this arc, the drop of primary

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current is retarded, a factor which reflects on the speed of change in the magnetic flux in the core of the coil. Thus the current will not change as rapidly, and the build-up of the electromotive force in the secondary winding will be retarded. In order to forestall the occurrence of these undesirable effects, a capacitor is interposed in parallel with the contact points of the vibrating circuit breaker. As the voltage at the vibrator contact point is increased, so is the sparking at the contact points. In the primary winding circuit, as well as in the capacitor current oscillations cause a sharp change in the magnetic flux within the core of the coil, increasing the induced electromotive force in the secondary winding. Because the primary circuits of both KPM 1-2 induction coils are connected in parallel, the above-described process takes place in both coils independently of each other.

Block Design -- The block of KPM 1-2 starting ignition coils (see Fig 132) consists of the following principal connections and components:

Housing 1

Two induction coils 2

Two mica capacitors 3

Mounting braces 4

Brackets 5 to hold two coils

Two plugs with prongs 6

Contact point assembly 7

Packing sleeves 8

Covers 9

Insulating sleeves 10.

The housing is a one-piece aluminum alloy casting; it has a number of openings for mounting the main contacts and component parts.

Nipples 11, mounted on the side of the housing, serve as entry points for shielded high-voltage leads which are connected to the secondary winding through the contact point assembly. The plug-in connectors 6 are fitted in the following manner: one in the recess on the right front side wall and the second on the front wall of the housing.

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The induction coil consists of the following main parts:

Form 12

Primary and secondary winding

Core plates

Panel

Vibrator connection (composed of plate and spring)

Housing

Contact screw 14

Armature 15

The coil form is made of pressed powder and has the primary and secondary winding of the starter coil mounted on it.

The primary winding has 240 turns of enameled copper wire (diameter 0.8 mm). The secondary winding has 7,000 turns of the same material (diameter 0.18 mm).

Three screws are fitted in the flange of the coil form, of which screw 16 and one other screw are conductors. Screw 17 also serves to hold the panel to the body of the coil. One end of the primary winding, which passes through an opening in conductor screw 17, is attached to screw 16 and to the face of screw 17.

One end of the secondary winding of each coil is connected to the output point leading to "mass" [ground?]. The other end is brought to the surface of the coil and to the terminal of high-voltage lead 18. The contact point assembly then passes the current to the high-voltage lead. The core of the coil is made of transformer sheet metal and mounted within the body, where it is bonded in place. Panel 13, made of plastic powder, serves to hold the leads and vibrator components.

The capacitor (capacity 0.3-0.4 microfarad) is mounted within a carbolite housing. The capacitor plates are made of aluminum foil. Mica is used as insulation between the plates. The capacitor is wired in parallel to the breaker point.

Plug-in contact 6 serves to hold the lead connecting the block of starting coils with the power source. The coils are held to the housing with braces 4 and brackets 5 gasket sleeve 8 seals the area into which the end of the secondary winding is led.

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3.5 Starting Coil KP-21

Starting coil KP-21 (Fig 133) serves to feed the two SD55ANM spark igniter plugs, mounted on the igniters of the turbostarter, with high voltage. This is an induction coil with two leads. The secondary winding has two separate windings on one core.

The starting coil ensures the formation of sparks, without breakdown, providing the voltage of the power source is from 12 to 28.6 V.

The current in the primary circuit is 3 ± 0.3 a. The voltage in the secondary circuit is at least 10 kv, when the voltage at the coil terminal is 12 V.

The type of operation of the coil is "short-duration repetitions." It is permissible to switch on five times for a period of 30 seconds with a minimum interval of two minutes between switchings.

After 5 minutes, an interval of at least 15 minutes must be observed.

The starting coil (Fig 134) is composed of the following main parts:

Housing 3

Induction coil 5 with breaker points 1

Capacitor (capacity $0.3 + 0.4$ microfarad and plug-in contact 4

The coil housing consists of two parts: the body of the coil and the cover, which helps to reduce radio interference during the operation of the coil. The shielding parts include nipples 6 and 7 which protect the high-voltage leads, as well as the plug with the prongs connecting the primary winding of the coil with the power source.

The body and housing of the coil are made of steel and are connected with screws 8, equipped with nuts and split washers.

Between the housing and the body is a brass gasket. The housing has an opening for access to screw 10 which is used to adjust the strength of the current (by changing the tension in the armature spring and by changing the gap between the armature and the core). During operation, the opening is closed by a cover. Brackets 9, with openings for attaching the coils to the reductor of the turbostarter, are welded to the body and housing of the coil.

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Induction coil (Fig 135) consists of the following main components:

The skeleton for the primary winding 1 consisting of 240 turns of enameled copper wire (PEL) with a diameter of 0.8 mm;

Secondary winding 2, consisting of two parallel branches, each having 11,000 turns of PEL wire with a diameter of 0.06 mm;

Breaker 3 and core 5.

The circuit breaker is mounted on a carbolite panel and consists of teo platinum-iridium contact points, one of which is attached to adjusting screw 10 and the other to the spring of the armature. Whenever the starting coil is inactive, the contact points of the circuit breaker are always closed.

Capacitor 4 is a paper-dielectric capacitor. Its plates are made of aluminum foil 0.001 mm thick. The interior of the capacitor is filled with wax.

The principle of operation is similar to that of the block of KPM 1-2 starting coils.

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3.6 Spark Igniter Plugs SD-55ANM and Ionizer SD-96I

Spark igniter plug SD-55ANM and SD-96A operate in the ignition system of the turbostarter and the engine. The plug SD96A has a ceramic core (insulator) with a central electrode fitted into its shielding. The plug has a ceramic sleeve in its interior.

The plug does not have side electrodes, and sparks are formed between the central electrode of the plug and the discharger which is mounted in the igniter of the engine. The spark gap between the central electrode and the discharger is 4-0.5 mm.

Spark igniter plug SD-96A (Fig. 136) consists of the following parts:

Core
Flange 6
Insulating sleeve 3

The core of the plug consists of ceramic insulator (7) with electrode 11, made of refractory steel CH20N80T3 (20Cr80Ni3Ti) fitted into a channel.

Thermal cement ensures a hermetic seal between the central electrode and the insulator; and when the air pressure surrounding the central electrode is equal to 10 kg/cm^2, the leakage of air does not exceed one cubic centimeter per 30 seconds.

Copper heat-dissipating case 9, with which the core of the ignition plug is pressed into the flange, is fitted onto the insulator.

Within the flange, ceramic sleeve 3 is installed over "paronite" washers 2 and 8 and held in place by form rings 1.

Spark igniter plug SD55ANM differs from plug SD96A only in dimensions.

The ionizer SD-96I (Fig. 137) serves to ionize the air in the space between the electrode of the plug and the discharger, thus increasing the conductivity of the inter-electrode gap. It differs from igniter plug SD-96A only by the shape of its central electrode, which terminates in a 60° conical point.

3.7 Starting Pump PNR10-3M

The PNR10-3M starting pump is driven by a MU-102A electric motor (d.c., fire-proof--series excitation).

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Basic Data Pertaining to Electric Motor MU-102A:

Rated voltage -- 24 v
Rated output -- 60 w
Current -- maximum of 6.6 a
RPM -- 3,000 ± 250
Torque -- 1.65 kg/cm

The electric motor of the pump is connected in parallel with the blocks of KPM1-2 starting coils and operates in conjunction with the ignition system.

In automatic starting, the pump is activated when the engine attains a speed of 250 ± 30 RPMs and is cut off when the engine reaches 810 ± 70 RPMs.

3.8 Starter [Control] Box PT-4M

The PT-4M starter control box (Fig. 139) works within the starting system of the engine and ensures automatic functioning of the engine components under the following conditions:

a. During automatic starting of the engine
b. During starting the engine in the air
c. While cranking the turbo starter, cold
d. When cranking the engine, cold

The starter coil PT-4M is a piece of complex communtator equipment consisting of individual interconnected relays and resisters.

These relays and resistors are mounted in a box made of cast aluminum alloy. The box contains the following components:

1. Maximum RPM relay RMO-4--1
2. Contacts K-100--1
3. Signal relay RLN-4--2
4. Ignition relay RL-20G--1
5. Interposed relay RP-2B--9
6. Variable resistor (160 ohms)--2
7. Enamel resistor PO-10-3 ohms--1
8. Variable resistor (46 ohms)--2
9. Variable resistor (300 ohms)--1

The Maximum RPM Relay RMO4--is a contact relay which is activated simultaneously with the electro-magnet, with which it is connected and which has a closed magnetic circuit (Fig. 140).

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The relay is used for remote off and on control of electric motor SA-189BM, if the current in the armature circuit of the electric motor is within the limits of 80-110 a (at 22 volts across the circuit of winding 2). The electromagnet of the relay has three windings, - shunt winding 3, series winding 1, and compensation winding 2. Shunt winding 3 ensures initial switching-on of the maximum RPM relay RMO-4.

Series winding (1) serves to hold the relay in the "ON" position after the shunt winding has been cut off and serves to automatically shut off the SA-189BM electric motor when the RPM range is between 8,000 and 12,000. Compensation winding 2 is used to stabilize the speed when cutting off electric motor SA-189BM if the voltage of the storage battery drops (based on the amount of its discharge). The supplementary variable resistor (300 ohms), which is connected in series with the compensation winding, facilitates the adjustment of relay RMO-4 to the speed of electric motor SA-189BM.

<u>Switch K-100 (Fig. 141)</u>--serves to prevent switching on of the turbo-starter when the valve in the starter exhaust nozzle is closed. This is a plug-in electromagnetic relay with a closed electromagnetic circuit.

When voltage is impressed on the terminals of the winding, the armature is attracted, the working contacts are opened and permit the flow of current. The maximum current for the working contacts is 200 a. To assure a specified contact pressure, the movable collector with its contacts is connected with the core by spring 1.

<u>Signal Relays RLN-4</u>--Each of these relays serves to activate the interposed relay RP-2B and is a type of electromagnetic relay of the valve type. The relay (Fig. 142) consists of a contact system which as a pair of normally opened contact points and a controlling electromagnet with two windings (a shunt winding and a compensation winding).

The ampere turns of the shunt and compensation windings are in opposition to each other. Therefore, the relay is activated by the difference of their magnetic fluxes. Both windings of the relay are needed to vary the voltage during the switching-on operation and to compensate for the influence of surrounding temperature and initial heating at the moment of contact. Signal relays RLN-4 are fed from tacho-generator TD-1 and are connected in the following order:

Signal relay 3 (see Fig. 139)--when motor speeds are 250 $\pm$ 30 and 810 $\pm$ 70 RPMs.

Signal relay 5, when motor speeds are 300 $\pm$ 40 RPM and 1,200 $\pm$ 50 RPM.

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Ignition Relay RL-20G (Fig. 143)-- Serves to connect the two KBM 1-2 blocks of pump PNR10-3M and the electromagnetic fuel valve. This is an electromagnetic relay with a magnetic circuit in the shape of the letter E. The relay consists of an electromagnet and a system of contact points.

The contact system of the relay is composed of two movable contact points and four fixed contact points. The movable contact points are mounted on the armature of the electromagnet and move together with it. The armature is of the rocking lever type which moves through a fixed angle.

When the winding is not energized, the free end of the armature and the movable contact point plates are in the extreme upper position. In this position, the upper permanent contact points are cut in the circuit. When current is fed to the winding of the relay, the circuits of the lower fixed contact points cut in.

The dc current at the working contacts is at its maximum of 20 amp. when the two pairs of contact points are connected in series.

The interposed RP-2B relay serves to switch the starting devices of the engine and turbostarter (see automatic starting of the engine). The PR-2B relay (see Fig. 143) is an electromagnetic relay and consists of a system of contact points and a controlling electomagnet. The system of contact points is controlled by armature 3 of the electromagnet with movable contact points 2.

The armature is essentially a lever with its axis mounted in the eyes of the coil form 5. When power is fed to the winding of the relay, the normally closed contact points are opened and those which are normally opened are closed. The permissible current for the working contact points is 5 amps.

Variable Resistors 20,22, 23, and 24 (Fig. 139)--These are connected in series to the circuit of the shunt winding of signal realys 3 and 5 and are rheostats made of Constantanwire which is wound on a porcelain sleeve.

Resistors 22 and 24 are gradually cut in into the circuit of signal relay 3 (Fig. 139). Resistor 24 has a high resistance, therefore, signal relay 3 with resistor 24 are activated when voltage across the terminal points TD-1 is high. Resistors 20 and 23 are connected in the circuit of signal relay 5.

By changing the resistance of the rheostats it is possible to vary the setting of signal relays 3 and 5. Change of resistance is carried out by shifting the slide contact which is connected to the set screw.

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Variable resistor 19 is connected in series to the circuit of compensation winding RMO-4. This resistor changes the current, and thus the ampere turns of the compensation winding -- a factor which counteracts the ampere turns of the series winding. This results in a change in the "revolutions needed for disconnecting" the SA-189BM unit.

The cover of housing PT-4M has an opening which holds the set screws for all variable resistors that are connected in the circuit of the signal relays andthe PMO-4.compensation winding. Each screw is marked and the direction of rotation for setting is also indicated.

Control box PT-4M has the following sockets for the purposes indicated below.

1. Socket No 12 -- For incoming power from the aircraft power network to electric motor SA-189BM
2. Socket No 10 -- To connect the motor
3. Socket No 11 -- To connect the service outlet
4. Socket No 9 -- To connect the ignition signal lamp
5. Socket No 1 -- To connect the turbostarter
6. Socket No 21 -- To connect the MZK-2

3.9 Tacho-Generator TD-1

The tacho-generator TD-1 (Fig. 144) is a transmitter which ensures control of the starting mechanisms with respect to motor rpm. It is a direct current generator with independent excitation. The exciter winding is fed by the storage battery. The tacho-generator is enclosed. It rotates to the left (when viewed from the drive side).

The voltage generated by the tacho-generator is proportional to the number of revolutions of the motor, as follows:

At 100 RPM -- minimum of 4 volts
At 1300 RPM -- minimum of 6 volts
At 3500 RPM -- minimum of 17 volts
At 5100 RPM -- minimum of 25 volts

The tacho-generator must normally work when the voltage across the exciter winding changes from 18 to 25 volts.

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The tacho-generator has two poles with exciter coils. The hookup of the winding is executed in accordance with the schematic drawing (Fig. 145).

The TD-1 tacho-generator is mounted on the housing of the starter-reductor having a ratio of 1:4.32 to the drive shaft of the motor. It begins to rotate at the instant the motor is started (after the hydraulic clutch is cut in) and is cut off at the same time as the starter.

3.10 Cables for Automatic Equipment and Cables for the Starter

Hook-up of all accessories, the starting system and the automatic equipment of the engine, including control box PT-4M, is accomplished by cable connections for the automatic equipment (Fig. 146), starter cables S/300M (Fig. 147), by the connection between the blocks of starter coils KPM 1-2 (Fig. 148), by the leads from the lower block of the KPM 1-2 coils to pump PNR10-3M and to the electromagnetic valve (Fig. 149).

The cable connection for the automatic equipment (Fig. 146) consists of a shielded brass conduit and six outlets, two boxes attached with PCp-25, ten shielded cables, four shield lines, six partitions equipped with prongs of the terminal switches, as well as an outlet with a push-button (hand control) for the air bleed valve.

Cable hose 18 is attached to the face adapter of tube 19 which has threads of 30 x 1.5; with the aid of the hose, cables are automatically attached to the plug in socket SR40P16ES2 of control box PT-4M. The cables of the following equipment are connected to the remainder of the outlets:

1. "Pneumocontact" -- lead 14 with terminal SU-4E, via shield line 15 and lead 16;
2. Electromagnetic air valve -- lead 20 with terminal SR20U4EG;
3. Centrifugal transmitter -- lead 5 with terminal SU-4E, via shield sleeve 6, lead 7, adapter piece 9 with push-button of the manual control 8 and fire-prevention terminal 10SP-4, lead 11, shield sleeve 12 and lead 13;
4. Circuit switch 4VK2-140B-1, lead 3;
5. The upper block of starting coils KPM 1-2 through hose No 1 with plug SR-4E through shield sleeve 2.

The cable array for the automatic equipment uses low-voltage BPVL wiring through VTU MEP 673-47 with a cross section of 1, 1.5, and 2.5 mm^2.

The shield sleeves are made of aluminum alloy AMgM.

Shield 18 is of the VTU-MET 130-54 type and the remainder are of the R3-0-8 type.

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The shielding is composed of an aluminum form (a strip of corrugated material [in theform of the letter "S"] which is wound into a spiral form) and braiding of copper wire with a diameter of 0.3 mm.

The ends of leads are fixed to cases with bus openings. The braiding of the leads is bonded to the interior wall of the case, and the end of the case is bent into the interior of the lead and flattened. Before the terminals are tightened, two clamping nuts are mounted on the leads.

The leads are connected to posts in case of plug-in connectors. Plastic insulating collars, with a length of 20-25 mm, are then fitted over them.

To connect the hoses to terminal switch VK2-140B-1, the lead ends are equipped with terminals (copper cases) which are soldered on the face side with the leads. Where the insulation ends, a silk thread is wound around and painted with shelac. The terminals are fitted into terminal sockets and secured with screws.

Where the leads to the centrifugal transmitter come close to the push-buttons of the manual control, local adaptators are used to facilitate connection of the leads which go to the terminal points of the push-button. The lead going to the "Fire-extinguisher" socket is attached to one of the push-button leads.

The cables of starter S-300M combines all leads which connect the accessories of the starter.

The cables with the main 1SR48P9E1 plug (Fig. 147) connect with control box PT-4M. At a distance of 750 millimeters from the main plug connector, all leads are joined into a single strand with P16 x 24, VTU MEP 124-54. Upon leaving this united strand, every lead is covered with its own P6 x 10 braiding. The junction point between the united strand and individual leads is wound with shellacpainted thread for a distance of some 20 millimeters.

The ends of the braiding, which lead to the plugs, are enclosed in two retainer grommets. One grommet is placed inside the braiding and the other over the braiding. The wires of the braiding are thus compressed between the grommet bosses and are soldered in this position.

Before soldering, the clamping nuts of the plug connector are threaded onto the braiding, this ensures contact between the braiding and the plug.

The joint conduit connects the leads of the following equipment:

1. Tacho-generator with plug SP-4E (position 2);
2. Coils KP-21 with plug SU-4E (position 3);
3. Two electromagnetic fuel valves with plug SU-4E (position 4);

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4. Two leads 5 of electric motor SA-189BM with terminals which are mounted on the terminal outlets of the electric motor and are held in place by nuts. The end terminals of the leads are shielded by rubber sleeves which are widened to accommodate the tightening nuts.

The ends of the braiding for leads SA-189BM are covered with thread and shellacked for a short distance from the terminal.

The conductor between the blocks of starting coils KPM 1-2 (Fig. 148) consists of a BPVL lead with cross section 1.93 mm^2, an aluminum alloy shield tube, two cables, and two SU-4E plugs for connecting both blocks.

The conductor leading from the lower KPM 1-2 block to pump PNR10-3M and to the electro-magnetic valve. (Fig. 149) consists of a BPVL lead with a cross section of 1.5 mm^2, a shield tube, a 3-hose adapter, two SU-4E plugs for hooking up with the KPM 1-2 and with the electromagnetic valve, and an SU-2E plug for hooking up to the PNR10-3M pump.

High voltage from starting unit KPM 1-2 is fed to plugs SD-96A through individual leads (Fig. 150). Each lead is shielded by an aluminum tube and two hoses. The PVS7 VTU MEP OAA 505-029-52-type leads are high-voltage leads. Each lead consists of a strand of seven stainless steel wires with cross section of 0.3 millimeters, which are covered with an insulating coating, a layer of semi-conductive rubber, a layer of insulating rubber, a fibreglass covering, and a rubber protective coating. Contact between the ends of the leads and the terminals of the block of starting coils KPM 1-2 and the heads of the SD-86A spark igniter plugs is maintained by the special DU-10 contact device.

The ends of the leads leading to the block of starting coils are equipped with conical gasket tubes, which ensure a reliable contact and tightness of fit.

4. Automatic Starting of Engine

For purposes of automatically starting the engine it is necessary to conduct the following operations:

1. Open fire [extinquisher] valve
2. Set throttle control lever in idle position
3. Cut in aircraft fuel pump
4. Turn on master switch or open engine throttle release device [flap on cover] (the main power switch is cut in upon opening this device)
5. Upon ignition of the indicator lamp, signalling the opening of the starter exhaust nozzle valve, depress, and after 1-2 seconds release the button marked "Start."

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After the execution of the above operations, the engine should begin to function normally in not more than 120 seconds, when the idling speed reaches 1750 ± 50 rpm.

When the master switch 33 is activated (Fig. 151), current passes from terminal 2 of connector 36 to terminal 9 of connector 12; thereafter, it passes across closed contact points D and B of pneumatic breaker 24, via terminal 16 of socket 12 to terminal B of socket 49, from which it is fed to the winding of the electromechanism via terminal 2 of socket 50 and the closed contact points C of the device. The other end of the winding is connected with negative commutator 10 of control box PT-4M, via terminal 1 of connector 50, terminal A of connector 49 and terminals 7 and 4 of connector 1. Electromechanism 51, influenced by the flow of current, begins to rotate and opens the exhaust nozzle valve of starter S-300M. Some 6 to 10 degrees before complete opening of the valve, the signal points of contact A of electromechanism 51 are closed. At this point, current passes from terminal 3 of the connection to terminal E of connector 49 and on to terminal 6 of connector 50; the current then passes through closed contact points A of electromechanism 51, through terminal 5 of connector 50, through terminal D of connector 49 to terminal 11 ~~of connector~~ of connector 36, from where it is fed through to indicator lamp 27, which glows indicating the opening of the starter exhaust nozzle valve. The current further passes to terminal 4 of the winding of contactor 39. By this method, breaker 39 effectively prevents the starting operation of starter S-300M if the exhaust nozzle valve is closed.

The time required to open the starter exhaust nozzle valve is 3 to 4 seconds.

During the second phase engine starting, when the button "Ground Start" is depressed, relays 38 and 2 are activated and current is fed to the winding from terminal 6 of connector 36.

Closing of relay 38 leads to the formation of a parallel electric current which blocks interposed relays 38 and 2, feeds current to the excitor winding of turbostarter 52 and closes breaker 39.

Due to this blocking action, interposed relays 38 and 2 remain active even though the "Ground Start" button 26 is released; current to their windings is then fed from terminal 2 of connector 36, via the closed contact points 6-5 of relay 38 and across the normally closed contact points 5-4 of relay 40 to the winding of relay 38 and, in parallel, from terminal 7 of relay 38 via terminal 6 of connector 36 to the winding of relay 2.

Current is fed to the winding of the tacho-generator from terminal 2 of connector 36 via contact points 6-5 of relay 38 and via terminal 6 of connector 1.

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Breaker 39, whose terminal No 4 was fed with current during the lighting of indicator lamp 27, is activated when the negative terminal 3 of its winding connects with negative commutator 10 via the closed contact points 2-3 of relay 38.

Closing of breaker 39 activates relay 43 because current passes through its shunt winding which is fed from the power network via terminal 5 of breaker 39 and via the normally closed contact points of relay 42 of the starter ignition system.

The closing of maximum rpm relay 43 results in the formation of a parallel electric current. In this phase of operation, the following pieces of equipment are activated:

1. Electric motor 55, which is powered by the main power circuit (terminals 1 and 2 of connection 1). The starter now begins to turn. Series winding of relay 43, which is connected in series tothe power circuit of electric motor 55, also become energized.

2. The compensation winding of relay 43, which is powered by the main power circuit via variable resistor 44. The ampere-turns of the compensation winding of relay 43 are in opposition to that of the ampere-turns of the series winding.

3. The starting coil of the starter mechanism.

4. Relay 42, whose winding is fed from terminal 4 of relay 43.

Activation of relay 42 leads to the closing of its contact points 5-6 and 2-3 and to the opening of contact points 5-4; as a result:

1. Relay 42 is blocked because current is fed from terminal 5 of breaker 39 via contact points 5, 6, and 7, 8 of relay 42 and negative commutator 10.

2. Fuel valves 56, which are supplied with current from terminal 8 of socket 36 via contact points 2-3 of relay 42 and from terminal point 3 of socket 1, are opened.

3. The shunt winding of relay 43, which was formerly fed from terminal 5 of breaker 39 via contact points 5-4 of relay 42, is switched off. Relay 43 remains active as a result of functioning of the series and compensation windings.

Thus, if the direct result of the first phase of starting -- namely the activativation of the master switch -- was the opening of the starter exhaust nozzle valve, then the direct result of the second phase of starting -- the activation of the push-button marked "Ground Start" is the beginning of rotation of the starter by the electric motor, ignition and feeding of starter fuel to the starter combustion chamber, and the beginning of functioning of the starter.

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As the starter begins to rotate and accelerates, an ever-increasing portion of the torque is transferred to its turbine which also turns together with electric motor 55. This leads to a gradual lightening of the load on electric motor 55 and thus reduces the amount of current passing through the series winding of relay 43.

As soon as the starter attains the speed of 8,000-12,500 rpm, relay 43 due to the action of its spring, which is set for a certain value of current, is automatically opened, cutting out automatically electric motor 55 of the starter and the starting coil 54. During this phase, relay 42 remains activated to insure proper functioning of electromagnetic fuel valves 56 during the entire phase of operation of the starter.

As the engine begins to turn, so does tacho-generator 52 which provides voltage proportional to the number of rpm of the engine and feeds it via terminal points B and C to terminal points 8 and 5 of connector 1.

From terminal point 5 of connector 1, the voltage is impressed on terminal 4 of the windings of signal relays 4 and 6 and after terminal 8, on terminal 1 of variable resistor 48 via the normally closed contact points 5 and 4 of relays 7, 3 and 41, and then on relay 4 on its terminal 3 directly and on terminal 5 through variable resistor 48. Thus, the winding of signal relay 4 is connected to the circuit of the tacho-generator from the moment the engine begins to turn.

As soon as the engine attains a speed of 220-228 rpm, the voltage developed by the tacho-generator is sufficient to activate signal relay 4. Activation of signal relay 4 results in the activation of relay 9 (current is fed from terminal 2 of connector 36 via contact points 6-5 of relay 38 via terminal 6 of connector 1, via terminal 8 of relay 7, via terminals 2 of relays 8 and 6, via contact points 2-1 of relay 4, via contact points 2-1 of relay 3, via terminal 2 of relay 41, across terminal 9 of connector 36, terminals 4-1 of relay 9 and terminals 4-5 of relay 8 to negative commutator 10).

The following pieces of equipment are activated simultaneously with relay 9:

1. Block 13 of starting coils KPM 1-2
2. Electromagnetic fuel valve 20 of the engine
3. Electric motor 18 of the starting fuel pump PNR10-3M
4. Interposed relay 41 (RP-2B)

Power is fed to block 13 of starting coils, to electromagnetic fuel valve 20 and to electric motor 18 of fuel pump PNR-10-3M from terminal 4 of socket 36 via contact points 2, 8, 7, and 3 of relay 9 and via terminal 7 of socket 12.

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Simultaneously, power is fed from terminal 7 of connector 12 to terminal D of connector 11 to feed the ignition indicator lamp. Power is also fed to the winding of relay 41 (terminals 7, 8,) from terminal 4 of connector 36 via contact points 2, 8, and 7 of relay 9 and passes further to the negative commutator 10 across contact points 3-2 and terminal 7 of relay 3, terminal 7 of relay 5, and terminal 7, 5 of relay 8.

When relay 41 is activated, its contacts 3-2 and 5-6 are closed and its contacts 5-4 (which served to feed power to the winding of signal relay 4) are opened.

When contact points 3-2 of relay 41 closed, the power to the winding of relay 9, which was formerly cut in across terminal 6 of connection 1 via the signal relay 4, contact points 2, 1 of relay 3 terminal 2 of relay 41 and terminal 9 of connector 39 is switched over to terminal 2 of relay 4, terminal 3 of relay 41 and contact points 3-2 of relay 41 and terminal 9 of connector 36.

When contact points 5-4 of relay 41 open and contact points 5-6 of relay 41 close, the winding of signal relay 4 is cut out of the circuit of the tacho-generator and the winding of signal relay 6 is cut into the circuit; power if fed from terminal B of tacho-generator 52 via terminal 8 of connector 1, contact points 5-4 of relay 7 and 3, contact points 5-6 of relay 1, terminal 1 of resistor 47, whence it is fed directly to one of the windings of relay 6 and via resistor 47, to the other winding.

With increasing engine rpm (260-340 rpm) the voltage developed by the tacho-generator is sufficient to activate signal relay 6. With the activation of relay 6, power is fed to the winding of relay 5 from terminal 6 of connector 1, via terminal 8 of relay 7, terminal 2 of relay 8, contact points 2-1 of relay 6 and contact points 2-1 of relay 7 (the current passes further across terminals 7, 5, of relay 8 to negative commutator 10) which is activated.

With the activation of interposed relay 5, relay 5 is blocked in parallel and relay 3 is activated. The power is fed from terminal 2 of relay 36 via contact points 6-5 of relay 38 and terminal 5 of relay 40, terminal 5, contact points 2-3 and terminals 8,7 of relay 5 and terminals 7, 5 of relay 8 to negative commutator 10. Simultaneously, current passes from terminal 5 of relay 5 via terminal 6 of relay 5, terminals 7, 8 of relay 3 and terminal 7 of relay 5.

With the activation of interposed relay 3, its contact points 5-4 are opened and its contact points 5-6 are closed. As a result, the winding of signal relay 6 is cut out of the tacho-generator circuit and the winding of signal relay 4 is cut into the circuit.

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As engine rpm reaches 740-880, the voltage developed by the tacho-generator is sufficient to activate signal relay 4. Current passes from terminal B of the tacho-generator connection via terminal 8 of connection 1, contact points 5-4 of relay 7, contact points 5-6 of relay 3, terminal 1, 3 of variable resistor 46 to terminal 3 of resistor 48. From this point, current flows directly to one winding of signal relay 4 and passes to the other through resistor 48. The current further passes across terminal 5 of connector 1 to terminal C of the tacho-generator 52.

When interposed relay 8 is activated, current is fed from terminal 6 of connector 1 across terminal 8 of relay 7, terminal 2 of relays 8 and 6, contact points 2-1 of relay 4, contact points 2-3 of relay 3 and terminals 8, 7, and 5 of relay 8 to negative commutator 10. The following takes place with the activation of relay 8:

1. Relay 8 is blocked (from terminal 6 of connector 1 via terminal 8 of relay 7 and contact points 2-3 and terminals 8, 7 of relay 8).

2. The block of starting coils KPM-1-2 and the pump PNR10-3M are de-activated because engine ignition relay 9 is cut off.

3. Relay 7 is activated (from terminal 6 of connector 1, power is fed across terminals 8 and 7 of relay 7 and contact points 6 and 5 of relay 8 to negative commutator 10).

With the activation of relay 7, the winding of signal relay 4 is cut out of the tacho-generator circuit and the winding of signal relay 6 is cut into the circuit.

As soon as the engine attains 1150-1250 rpm, the voltage developed by the tacho-generator is sufficient to activate relay 6.

<u>Path of Current:</u>

From terminal B of the connection of tacho-generator 52 across terminal 8 of connection 1, contact points 5-6 of relay 7, terminals 1 and 3 of variable resistor 45 to terminal 3 of the resistor 47, from which a direct connection leads to one of the windings of relay 6 and another connection, passing through resistor 47, leads to the second winding of relay 6.

Resulting from the activation of signal relay 6, electric current flows as follows:

From terminal 6 of connector 1 across terminal 8 of relay 7, terminal 2 of relay 8, contact points 2-1 of relay 6, contact points 2-3 of relay 7 terminals 7 and 8 of relay 40 and terminal 8 of relay 42 to negative commutator 10. The result of this is the activation of relay 40.

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The activation of relay 40 results in the opening of its contact points 5-4 which were blocking relay 38. Relay 38 is cut out, resulting in the cutting out of the entire starting mechanism. Starter S-300M is cut out. The engine spontaneously passes to idling speed.

After the engine has been started and is developing a 1850-2050 rpm, the increased pressure results in the activation of pneumatic breaker 24, located behind the compressor. Contact points D and A of the breaker are closed and the feed circuit to electromechanism (MZK-2) is closed across contact points B.B. In this case, the current progresses from terminal 2 of connector 36 across terminal 9 of connector 12, terminal D, A of the pneumatic breaker 24, terminal 12 of connector 12, terminal C of connector 49, terminal 3 of connector 50, contact points B, B of electromechanism 51, terminal 1 of connector 50, terminal A of connector 49 and terminal 7, 4 of connector 1 to negative commutator 10. The electromechanism begins to rotate and closes the starter exhaust nozzle valve, thus protecting the starter against excessive turning during "auto-rotation". At the same time, signal contacts A of electromechanism 51 are opened and disconnect the feed circuit of the winding of breaker 39. Because of the cutting out of breaker 39 it is impossible to activate the starter when engine rpms are higher than 1850-2050 rpm.

Electromechanism 51 also closes the starter exhaust nozzle flap when main power switch 33 is turned off. Power to contact points B, B of electomechanism 51 is fed from terminal 7 of connector 36, via terminal 12 of connector 12, terminal C, of connector 49 and terminal 3 of connector 50, passing to negative commutator 10 via terminal 1 of connector 50, terminal A of connector 49 and terminal 7 of connector 1.

As soon as the engine attains a speed of 3800 ± 50 rpm, centrifugal governor 16 is activated. Power is fed from terminal 6 of connector 36 via terminal 5 of connector 12, terminals B, C of centrifugal sender 16 and terminals 6, 10 connector 12 to the electromagnetic air valve 19 and across its terminal 4, 1, and 15 of connector 12 to negative commutator 10. The electromagnetic air valve opens the way for access of compressed air into the mechanism of the air bleed valve.

Push-button 17, which permits closing of the air bleed valve when the engine is off, is hooked up in parallel with the terminal switch of the centrifugal governor. In this particular case, the current passes from terminal 5 of connector 36 across terminal 5 of connector 12, through contact points of connector 12, which had been closed when push-button 17 was pressed, to terminal 6, 10 of connector 12, terminal 4, 1 of the electromagnetic air valve 19 and to terminal 15 of connector 12 and finally to negative commutator 10.

In addition, the closing of the air-bleed valve (to restrict the spread of fire) is connected with the "stop" position of the throttle control and with the fire warning light mounted on the aircraft. When the contacts of the fire warning light are closed via terminal A of connector 23 and terminal switch 21, whose normally opened contact points are closed when the throttle control lever is moved to the "stop" position,

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power is fed to the winding of relay 2 (to terminal 7) which is mounted on the aircraft. As a result, contact points 2, 3 of relay 22 are closed. Power is then fed through the fuse of the power network 34, through the open points 2-3 of relay 22, through terminal C of connection 23 and terminal 6, and 10 of connection 12 to the winding of the electromagnetic air valve 19 which closes the air bleed valve.

4.1 Cranking the Engine While Cold

By switching on master switch 33, the automatic equipment is readied for cranking the motor when cold:

--The starter exhaust nozzle valve is opened and the indicator light goes on, signaling the opening of the valve;
--Power is fed to the terminal of breaker 39 and its circuit is thus prepared for action.

When switch 28 is turned on, it receives power from terminal 10 of connector 36 and transmits it to the winding of relay 40. When relay 40 is triggered, power is fed from terminal 3 of connector 36 via terminal E of connector 49, terminal 6 of connector 50, contact points A, A of electromechanism 51, terminal 5 of connector 50, terminal D of connector 49, terminal 11 of connector 36, terminal 4, 3 of breaker 39, via the closed contact points 3-2 of relay 40 and terminal 8 of relays 38, 40 and 42 and passes to negative commutator 10. Breaker 39 is triggered and followed immediately by activation of relay 43 because its shunt winding is fed from terminal 5 of breaker 39 via contact points 5-4 of relay 42.

Relay 43, which is also activated, feeds power to electric motor 55, to the starting coil 54, and to the winding of relay 42 (from its own terminal 4).

Relay 42 is blocked across its own closed contact points 5-6 and cuts in electromagnetic fuel valve 56 across contact points 2-3 (the path of the current is the same as in starting the engine). Starter S-300M is activated and cranks the motor.

Cranking of the motor when cold is terminated by switching off switch 28. This cuts out relay 40, breaker 39, and relay 42. Relay 42 cuts off the ignition and the fuel for the starter.

4.2 Cranking the Starter When Cold

For this purpose, switch 13 and switch 29 are connected. The procedure by which the automatic equipment is cut in is the same as when the engine is cranked when cold, with the difference being that the fuel feed to the starter is not opened because terminal 8 of connector 36 is deprived of power.

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4.3 Air Starting

In starting the engine while in flight, push-button 25. This button causes relay 9 to function (power passes across terminal 9 of connection 36, terminals 4 and 1 of relay 9 and contact points 4-5 of relay 8). Simultaneously, the blocks of starting coils 13, electric motor 18 of the starter fuel pump and electromagnetic fuel valve 20 are fed with power from terminal 4 of connection 36 via contact points 2, 8, 7, and 8 of relay 9 and terminal 7 of connector 12. The engine begins to turn over automatically.

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Chapter VII

TURBOSTARTER S-300 M

The turbostarter S-300 M (Fig 152 & 153) serves to spin the rotor in starting the RD-3M turboject engine. The starter is located in the middle of the inlet channel of the engine, is fastened by brackets to the housing of the main drive, and is covered by an easily dismountable aerodynamic fairing which has openings for bringing air to the compressor.

1. GENERAL DATA ON THE STARTER

The starter consists of a small turbine engine and reduction gearing.

The basic parts of the gas engine (Fig 154) are:

- centrifugal compressor with unilateral vanes 6 and stator 5;
- a number type combustion chamber 4;
- single stage gas turbine 2 with fixed blade system 3;
- exhaust 1;
- auxiliary equipment.

Outside air enters through a protective screen and the directional intake 7 to the rotor of the centrifugal compressor 66.

With the turning of the compressor's rotor, the air which is between the vanes of the rotor is caused to revolve around the rotor's axis and, under the influence of centrifugal force, is forced outward. At the same time, a vacuum is created at the intake point of the rotor and this ensures passage of outside air through the intake.

Air pressure is increased as the air passes between the rotor vanes. Having passed over the compressor's rotor, the air enters the stator where its pressure is increased in proportion to its decreased velocity. The rate of flow of air through the compressor is 1.5 kg/sec. The degree of increased pressure is a factor of 30.

The compressed air enters combustion chamber 15 and the opening into the cavity of the burner. The burner is coiled in order to decrease the length of the combustion chamber.

Simultaneously with the entry of the air into the combustion chamber, five operating jets inject atomized fuel. The mixture is ignited by two igniters consisting of a starting jet and a spark plug.

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The fuel burning process uses about 25 percent of the injected air; the remainder, mixed with the burning products, lowers the temperature of the gas to a value compatible with the heat-resistant vanes of the turbine. The temperature of the gas ahead of the turbine is T = 850°C.

The gases pass from the combustion chamber through the fixed blade system 3 to the turbine vanes 2, where thrust is converted to motion. The output of the starter turbine is 400 hp. Most of this -- 300 hp -- is used to drive the compressor, generators, and starter. The remainder -- 95-100 hp -- is transmitted through the reduction gearing of the starter to the shaft of the engine and is used to turn the shaft in starting.

The gases from turbine 1 pass through the exhaust outlet into the atmosphere. The motor with gas turbine is fastened by the intake rim 7 to the reduction gearing. The latter consists of the mechanisms driving the engine and other components.

The turbostarter is started by an electric motor SA-189BM through the idling clutch 13, which prevents the electric motor from being turned by the starter. The electric motor disconnects when the starter reaches 8,000-12,500 rpm, and the turbine brings the starter to the operating level of 31,000-33,500 rpm. The control of the speed with which the starter is brought up to operating level and smoothness of rotation are ensured by fuel pump TNR-3R. In addition, at 29,000 rpm the pump releases oil into the hydraulic coupling. Since the coupling is located in the reduction gearing system, the turning of the shaft of the engine is accelerated steadily and evenly.

When the engine reaches 1,200 ± 50 rpm, the centrifugal clutch ensures that the starter is disconnected.

On the housing of the reduction gearing are located components belonging to the starter (see Figures 152 and 153):

- electric motor 2 SA-189BM;

- tachogenerator 3 TD-1;

- tachometer 4 TE-45;

- fuel pump 5 TNR-3R;

- oil pump 7.

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Fastened to brackets on the housing of the reduction gearing are:

- spark plug 8 (KP-21) and electromagnetic valve 1;
- a second electromagnetic valve 6, fastened to the turbine housing with a special brace.

2. THE STARTER DRIVE

The starter is started and its rotor turned by electric motor SA-189BM through two bevel gears -- drive gear I and drive gear II (Fig 155), with a gear ratio of 0.714.

Drive gear I is seated on the splined end of the armature shaft of the electric motor and is held with a nut. Rotation is transmitted through the drive gear II and the idling gear to the drive shaft of the reduction gearing and the rotor shaft, which is connected to the shaft of the reduction gearing by a splined sleeve.

From gear III, made as a unit with the reduction gearing drive shaft rotation is transmitted to gear IV, whose rim is coupled to the left housing of the hydraulic coupling. Press fitted to the left housing of the hydraulic coupling is a small gear V which operates through gear VI of the oil pump and through gear VII of the fuel pump.

The gear ratio between the rotor of the starter to the oil and fuel pumps is the same, $\sim$ 0.138. The drive of the transmitter is driven by the fuel pump gear VII through gears VIII, IX, and X with a gear ratio of 0.0498.

As soon as the hydraulic coupling is filled with oil, rotation is imparted to its driven half by the gear of rear gear assembly XI, which transmits rotation to gear XII. By means of a centrifugal gear coupling, gear XII transmits rotation to the drive shaft of the engine.

In this way, motion transfer is ensured from the starter to the engine rotor and equals

$$\frac{z\ III}{z\ IV} \cdot \frac{z\ XI}{z\ XII} = 0.0416$$

Gear XIII of the drive of tachogenerator TD-1 is driven by a ratcheted gear.

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3. CONSTRUCTION OF THE SUBASSEMBLIES OF THE STARTER

3.1 Compressor

The compressor of the starter (see Fig 160) is composed of the intake 4, rotor 27, diffuser 1, cover 2, and compressor housing 19.

The intake of the compressor (Fig 156) is cast from magnesium alloy ML5. The cover of the compressor is fastened to the front flange, and the intake is fastened by its rear flange to the housing of the reduction gearing. A duraluminum bushing 9 (see Fig 160) with polished inner surface is press fitted in the center of the intake. Channels lead to openings in the bushing which have been drilled in the frame of the intake and which force compressed air against the seal to prevent oil leakage into the compressor from the reduction gearing. Protective screening 3 prevents entry of extraneous particles into the intake.

3.1.1 Compressor rotor

The rotor of the compressor (Fig 157) is of the semi-closed type with unilateral inlet. The rotor is fashioned from forged aluminum alloy AK4 with 16 radial machined vanes. The leading edges of the vanes are curved longitudinally in the direction of rotation so that air enters the rotor without buffeting. The compressor rotor is press fitted, while hot, onto splines of rotor shaft 16 (see Fig 160) and is pressed over seal 7 with nut 8 with safety lock 5. The forward face of the rotor is pressed on the rotor shaft over the sleeve of shoe 15, rear seal 23, and stamped washer 24, which serves to adjust the necessary tolerance between the vanes of the rotor and the cover of the compressor. This tolerance is equal to $0.8^{0.2}$mm plus the vibration tolerance in the shoe.

3.1.2 Diffuser

The diffuser is of the vane type and is cast from aluminum alloy ML5. The 24 vanes which make up the expanding channel are fashioned as a single unit with the wall. The angle between the vanes is 4°. The wall of the diffuser is fastened to the housing of the compressor by six recessed bolts 10.

The heads of the bolts are completely recessed and are set with a center punch. Air is directed from the diffuser to the combustion chamber through the ring opening of the compressor housing.

3.1.3 Housing and Cover of the Compressor

The housing and cover of the compressor (Figs 158, 159, and 160) are cast from aluminum alloy ML5. There are 10 ribs on the outer surface of the housing for greater strength. The recess on the large flange of the cover is positioned on the front seating of the compressor housing.

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The small flange has pins for attaching the intake. In the special casting of the cover is a channel for bringing air to the seal of the intake. The cover and housing of the compressor are fastened with bolts to the turbine housing.

In the projections of the compressor housing are a channel 26 for bringing air to the packing seal of the bearings and a channel 11 for carrying off used oil. The oil channel opens onto the front side where two pins hold a nipple for connecting a flexible hose through which oil enters the housing of the reduction gearing of the starter. The air channel ends on the outer surface of the housing in a flange to which is fastened with two pins air guide valve 17. If the starter is operating, compressed air from the compressor of the starter moves to channel 18 of the valve through a special passage formed by milled recesses on the front sides of the cover and compressor housing (these recesses match the angle of the outlet of the diffuser). The air raises a ball and moves to channel 26, from which it is guided to the front and rear seals, and through channel 28 on the front side of the housing to the seal of the intake. After the starter is disconnected and its rotation slows, the ball again covers channel 18.

If the starter is not operating (in the course of automatic rotation), air from the area of stage VIII of the compressor of the motor is brought to the valve by external tubing. At the same time, the second ball is raised and air enters the same channel 26. The need for tightness of the bearings in such a case is required by the fact that oil is brought from the motor tubing to the bearings during autorotation of the starter.

The bracket part of the compressor housing forms the housing of the rotor shaft, on both sides of which are flanged spots for locating the front and back bearings.

3.2 The Rotor Shaft and Its Bearings

3.2.1 The Rotor Shaft

The rotor shaft transmit torque from the turbine to the compressor and the drive shaft of the reduction gearing. It is hollow and made of steel 12CH2N4A [12Kh2N4A]. The turbine disk is attached at its front end and the rotor of the compressor at its rear end. The inner space from the side of the turbine is closed by a plug, while the rounded end of tube 6 (see Fig 160) which brings oil to the bearings, fits into a special recess from the side of the compressor.

The rotor shaft turns in two bearings: the front bearings 6 (Fig 167) and the rear bearing 22 (Fig 160). On the turbine side the shaft rests directly on the bearing, while on the compressor side it is supported across the sleeve of shoe 15, which is located on the shaft, and is

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prevented from slipping through by a protrusion fitting into a groove of the shaft. The protrusion of the sleeve of the shoe serves to ensure the correct axial position of the rotor and receives the axial thrust of the compressor. Oil is brought to the bearings and the rings by three transverse jets 20, 21 (Fig 160) and 8 (Fig 167), which the oil enters along the axis of the shaft through openings drilled in it.

The jets ensure that the cleanest oil reaches the bearings, since particles which get into the oil are thrown by centrifugal force to the outermost part of the main oil channel.

3.2.2 Front and Rear Bearings

The front and rear bearings are made of steel 15, and the inner faces are lined with lead bronze BrS30. In addition, the working surface of the bearings is coated with a layer of lead 0.005 - 0.007 mm thick to improve their performance.

Front bearing 6 (Fig 167) is fastened with bolts to the front end of the housing together with the cover of seal 4 and flange 10; rear bearing 22 (Fig 160) is fastened at the other end of the housing together with the cover of seal 25. Under the flanges of the covers and bearings are located paronite lock washers.

The bearings are tightened by seals 23 (Fig 160) and 5 (Fig 167) and the covers of seals 25. The covers are of the same design and are made of D1T material. The inner surface is polished and covered with a type of past made from talc and graphite as a fire resistant lacquer. The talc permits the ridges of the seal to bite into the cover and thus ensure a minimum tolerance between them.

On the front side of the cover on the side of the compressor casing are lengthwise grooves which are milled out and terminate in milled recesses for the passage of pressurized air to the ridges of the seal sleeves. The rear bearing is a thrust bearing and receives the axial thrust. Ring 12 (Fig 160) of phosphor bronze BrOF10-1 is fastened to the front side by three stop blocks.

In addition, two free floating rings (bronze 14 from BrOF10-1 and steel 13 from 12VH2N4A) are used to reduce the rate of slip between the protrusion of the shoe sleeve and the forward front wall of the rear bearing. Both sides of calibrated ring 13 and the side of shoe ring 14 facing the protrusion of the shoe are provided with six profile beveled areas for providing an oil film. At the same time, ring 13 adjusts according to the applied force to maintain tolerance K, equal to 0.3 ± 0.1 mm.

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3.3 Combustion Chamber

The combustion chamber (Figs 161 and 162) is of an annular type is made of steel E1602 and consists of five separate castings welded together:

-- front wall 8;

-- rear wall 1;

-- connecting ring 9;

-- inner wall 5 and outer wall 3.

On the side facing the compressor are openings on the front wall of the chamber to allow passage of air. Openings A are waste openings.

In the ring-shaped exhaust part of the burner are three aerodynamic braces 10 which strengthen the chamber. Each brace is hollow so that it can be cooled by air and is made of two telescopically joined sleeves individually welded to the inner and outer wall of the combustion chamber.

Ring 2 with an inner recess is welded to the outer wall, and flange 4 is welded to the inner wall. In the ring cross-section between flange 4 and ring 2 is the guide vane system of the turbine. Five pockets 7 are welded on the combustion chamber on the turbine side; each has an opening through which the main spray jets are introduced into the chamber.

Welded to the chamber symmetrically with the vertical axis are two sleeves 6 into which the ignition assembly covers fit.

3.4 Turbine Housing with Ring

The turbine housing (Figs 163 and 164) consists of the cylindrical housing 3 of the combustion chamber, the turbine housing 1 welded to it, and flange 4. All components are made from 1CH18N9T [1Kh18N9T] material.

Twelve segments of the ring are fastened at specific intervals within the turbine housing. On the outer surface of each segment are longitudinal grooves, and on the inside of the smaller diameter of the turbine housing is a ring-like recess. Air enters through openings A in the space between the turbine housing and the segments and lowers the temperature of the outer surface of the bases of the stator vanes.

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The bases of the stator vanes are fastened to the cover on the inside by bolts with recessed heads. The heads are completely recessed by turning on a lathe. On the cover of the combustion chamber in the area between the largest and smallest diameters are welded additions [contact plates] 5 with flanges for attaching the main jets. Two flanges 7 for attaching the ignition assemblies are welded symmetrically with the vertical axis at the widest part of the cover.

A projection with nipple 6 is forged in the lower part of the cover for removal of waste from the combustion chamber.

The spaces formed by additions 5 are jointed by openings B.

Openings are cut in flange 7 for attachment bolts of the compressor housing. The exhaust pipe is fastened to the housing flange 1.

3.5 Turbine

The starter turbine (Figs 165 and 167) consists of the guide vane system 2 and turbine rotor 1.

3.5.1 Stator vane System of the Turbine

The stator vane system of the turbine (Figs 166 and 168) consists of 24 vanes 1 made by precision casting from alloy ZS8 [ZhS8]. The profile part of each vane ends in an upper and lower mount which form the outer and inner walls of the channeling section of the guide vane system and fit into appropriate recesses in the flange and ring of the combustion chamber.

The lower mount of the vane has a hole for attachment to the flange of the combustion chamber. Alternate vanes are fastened with bolts and the other 12 vanes are clamped between the front wall of the flange of the combustionchamber and flange 10 (Fig 167). To secure this overlapping flange 10 is stamped and is extended by an alignment washer 9.

3.5.2 Turbine Wheel [Rotor]

The turbine wheel (Figs 165 and 167) consists of the turbine disk and buckets 3.

3.5.3 Turbine Disk

The turbine disk is made of steel E1395. On the disk's perimeter are 36 fir tree grooves for attaching the rotor vanes. The inner cylindrical surface of the hub of the disk is fitted onto the shaft and prevented from

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turning by six radial pins 7. The front seal 5, which is secured against axial slippage by three protrusions into the ring recess in the disk's hub, is press-fitted onto the outer surface of the disk's hub.

3.5.4 The Bucket

The bucket (Fig 166) is cast from steel ZS3 and consists of a blade and root. The bucket's blade has a variable height. The root is fir-tree shaped to fit the fir tree groove in the turbine disk. Axial slippage of the vane is prevented by a key which fits in a groove of the vane, the ends being bent over on the front side of the disk.

3.6 Exhaust Tube of the Starter

The exhaust tube (Figs 169 and 170) serves to carry off the gases. Its outer wall 10 is cylindrical, while the inner lining is formed by cone 7, into which a head 6 is welded. The inner and outer walls are connected by four aerodynamic telescoping struts 11. To the outer wall of the tube are welded sleeve 9, ring 8, flange 4, as well as socket 5 for inserting the thermocouple for measuring the temperature of the gases. The exhaust tube is positioned and attached in a manner which will compensate for obstructions in the aircraft's gas exhaust channels. To this end, the exhaust tube is attached to the turbine housing by means of a coupling flange 3 whose outer rounded surface fits into the inner recess of flange 4. On flange 4 of the exhaust tube are four projections, one of which is notched.

The shaped heads of the bolts 2 hold the tube by its projections, permitting it to be moved parallel to its axis and also tilted away from the vertical axis. The bolt fits into the notch of one projection and prevents the tube from turning and coming loose.

Between the turbine housing and the tube is a screen serving to reflect the radiated energy and protect the rubber packing of the fuel container.

4. CONSTRUCTION OF THE COMPONENTS OF THE REDUCTION GEARING

4.1 Reduction Gearing Housing

The housing consists of the front (Fig 171) and rear housing 2. Both parts are cast from magnesium alloy ML5 and are shaped simultaneously. The front half is a casting covered on one side and equipped with a flange. In it are located the following components:

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-- rear bearing 5 of the drive shaft;

-- case 9 for the ball bearings of the drive shaft and the sliding bronze bearings of the fuel and oil pump drive gears.

On the front wall of the housing (Fig 172) are located the following:

-- flange 20 for attaching the front bearing of the drive shaft and flange 21 for attaching the intake;

-- flange 19 for attaching the tachogenerator;

-- triangular flange 25 for attaching the housing which provides oil for the hydraulic coupling, and symmetrically placed flanges 26 and 24 for attaching the fuel pump regulator and the oil pump.

Flange 24 has a front opening for the passage of oil into the reduction gearing housing. On the side wall are flanges 28 and 29 for attaching the drive of the tachometer transmitter and electric motor SA-189BM.

In the housing is compartment 23 with a triangular flange. A screen filter with a check valve is located in the compartment. The opening out of this compartment is fitted with a threaded nipple 22, on which is screwed a pipe fitting for connecting the oil pressure gage and the oil supply line to the starter, while inoperative, from the pressure tubing of the engine. Channels for bringing oil to the bearings are located in special projections 30 (Fig 173). The used oil flows into the channels from the housing of the starter compressor.

The forward bearing 15 of the drive shaft of the reduction gearing (Fig 171) is made, for assembly purposes, in the form of a flange in which a slide bearing, babbited with a lead bronze, is press-fitted and secured against rotation by two steel stop blocks.

Rear bearing 5 is steel and the inner side is babbited with lead bronze. A jet is press-fitted into it to bring oil inside the shaft. On the end, projecting from the opposite side, is the ball bearing of gear 3 of the centrifugal coupling.

The rear housing has a flange for attaching the entire starter to the housing of the main drive. The following are located in it:

-- the bearing of the housing of centrifugal coupling 4;

-- the rear ball bearing 7 of the shaft of the centrifugal coupling.

In the lower part is an opening fitted with a tube 8 for carrying off oil from the starter to the front part of the engine housing.

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The front and rear housings of the reduction gearing are connected by pins. On the same pins are brackets for attaching ignition coil KP-21 and one electromagnetic fuel valve.

4.2 Drive Shaft of the Reduction Gearing

The drive shaft 6 of the reduction gearing (Fig 171) is made of steel 12CH2N4A [12Kh2N4A] as a single unit with the spur gear. On the end toward the rotor shaft are grooves for the coupling which joins shaft 6 with the rotor shaft. A tube 14 is mounted in the shaft for carrying off oil from the shaft of the reduction gearing into the rotor shaft. Oil is supplied by this tube to all the bearings. The drive shaft turns in slide bearings.

The sleeve of the disengaging clutch 18 is press-fitted on the shaft up against the teeth of the spur gear. Bevel gear 17 of the electric motor, made as a single unit with the drive plate of the disengaging clutch, is seated on the same shaft on a slide bearing.

4.3 Disengaging Clutch

The disengaging clutch (Figs 174 and 175) serves to automatically disconnect the electric motor after it has been switched off, and consists of a drive plate 1, a cage 4 with rollers 2, and a limiting washer 3. The drive plate 1 of the clutch is beveled. When the electric motor is turning, the rollers wedge between the bevel of the drive plate and the sleeve and transfer motion to the drive shaft. The rollers are wedged only when rotation is in one direction. This is achieved with the aid of the washer which, with its extensions resting against the front projections 5 of the drive plate, limits the movement of the rollers along the bevels. After the electric starter is disengaged, rotation of the driven gear slows as soon as the rotation of the drive shaft of the reduction gearing increases. This causes the rollers to be withdrawn from contact and disconnects the electric starter from the shaft of the turbostarter.

4.4 Driven Shaft of Rotation Gearing

The driven shaft of reduction gear 10 (back gear assembly) (Fig 171) is also made of steel 12CH2N4A as one unit with the spur gear. The shaft is hollow. It is closed on one end with a plug and on the other end is a separate oil supply line for the hydraulic coupling and for oiling the contact surfaces. The oil is supplied as follows: sleeve 16, located in input sleeve 13, butts against the front side of the shaft where there is a concave recess.

Tube 11 is thrust by a spring against the sleeve and fits with minimum clearance through two bands into the shaft. The oil passes through it from nipple 12 and filter 2 into the hydraulic coupling.

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The slide bearing of the hydraulic coupling is oiled by a ring channel formed by the outside of tube 11 and the inside of sleeve 16.

4.5 Hydraulic Coupling

The hydraulic coupling (Figs 176, 177, and 178) is composed of two halves: the left driving half 4 and the right driven half 6. Both halves are located on the drive shaft of the reduction gearing, but the driving half turns freely on slide bearing 1. The driven half is held firmly to the shaft by splined connection and is tightened by a nut. In this way, if the coupling is not filled with oil, the two halves turn freely in opposite directions.

Two gears are attached to the drive half of the hydraulic coupling. The rim of the large gear 3 is fastened by pins and bolts to the housing and is connected to the drive shaft gear of the reduction gearing. The small gear 2 is placed on the hub of the drive housing and secured with pins against rotation. A cover 5, secured by one round bolt 11, is threaded into the outside of the casing. Inside the drive half is a bronze sleeve 8, secured by stop blocks 8 [sic], and a slide bearing 1 of steel 15, whose inner surface is babbited with lead bronze. There is a recess in the bearing which is connected by three openings the coupling housing to the inside of the reduction gearing. These openings serve to release oil from the center of the shaft. The oil passes over a stretched band so that the coupling does not fill with oil too rapidly.

The oil is brought into the hydraulic coupling through 11 openings drilled in sleeve 8.

Twenty-two radial vanes are copper-brazed on the inside of the milled casting. To provide even filling of the hydraulic coupling with oil, the alternate vanes are cut down on the inner edges. An internal ring 10, which is also brazed with copper is seated over the vanes. When the open halves of the hydraulic coupling are fitted together with a tolerance of 1.2 mm, circular hollows are formed in the longitudinal cross-section.

The axial thrust created by oil pressure on the housing of the hydraulic coupling is opposed by a radially positioned ball bearing 12 located on the front end of the drive shaft.

The outer sleeve of the bearing is mounted in a recess of gear 2 and is secured by a support ring 13 and a wire catch 14. On the hub of the driven half of the coupling is a bronze ring 7 used to tighten the points of contact with the cover. During rotation of the driving half of the oil-filled hydraulic coupling, the oil, under the influence of centrifugal forces, moves radially to the edge of the driving half and then to the

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vanes of the driven half, which is thus made to revolve. The driving half of the hydraulic coupling always turns faster than the driven half. Therefore, the hydrodynamic pressure of the oil as it leaves the driving half is greater than at the perimeter of the driven half. Under the influence of this difference in pressure, the oil moves from the driving half to the driven half, from where it again moves to the vanes of the driving half. The circulation of oil accurs in the direction indicated by the arrows (see Fig 178).

At the same time, there is always some slippage of the driven half with respect to the driving half. As a result of this slippage, friction, collision with the vanes, and friction against the inner surface of the coupling, the oil becomes heated. To prevent overheating, the heated oil is lead off by four openings in the cover 5. Three openings are covered by plate valves 15 of spring steel U9 which serve to release the oil when the hydraulic coupling is disengaged. Each plate valve is fastened to the cover with two rivets.

Under the influence of centrifugal force, the plates are pressed to the cover and close the openings. When the starter is disengaged and rotation decreases, the plates move away and the oil is released into the housing of the reduction gearing.

The fourth opening remains open and permits continual passage of oil through the hydraulic coupling.

4.6 Centrifugal Clutch

The centrifugal clutch (Fig 179), which serves to disengage the starter from the motor after reaching a certain number of revolutions, consists of two parts: the drive and driven parts.

The drive part turns freely on a ball bearing and contains gear 5 whose rim is toothed on the inside for ratchet action. The driven part 1 of the centrifugal clutch is the housing; in its ring-like recess are three ratchets 2 on pins 3. It also turns on ball bearings located in the rear housing of the reduction gearing. The ratchets move freely on their pins and are held firmly in contact with the ratched wheel by spring 6.

The elasticity of the spring is such that in the range of 850 to 1,300 rpm the heavier lower part of the ratchet raises up under centrifugal force, the ratchet turns on pin 3 against stop 4 and disengages from the ratchet teeth and rests in the ring recess. The ratchet is protected in this way against damage when the motor is running.

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In the hub of the centrifugal clutch housing are splines on which the shaft fits, transmitting motion to the rotor shaft of the motor. The ratchets can be disengaged only when the starter is disconnected, since the force acting on the ratchets while the starter is operating prevents them from disengaging.

5. OIL SYSTEM OF THE STARTER

The starter has an independant oil system (Fig 180), which is independent of the motor and ensures a supply of oil for all the bearings and gears of the starter, in addition to filling the hydraulic coupling.

Oil from the aircraft's tank passes into the oil pump of the starter through the intake fitting of the engine oil system.

The starter oil pump (Figs 181 and 182) is a two-stage gear pump consisting of housing 7 and middle housing 13, which are cast from aluminum alloy AL5, and cover 1 made from material D1T; inside these housings are the pressure and suction stages of the oil pump.

Each stage consists of a pair of gears. On the end of drive shaft 5, which is made as a unit with the gear of the pressure stage, is gear 2 of the suction stage, which is prevented from rotating by a wedge 3.

Oil pressure in the pressure stage is maintained by relief valve 16 screwed into the housing of the oil pump. The valve is adjusted to a pressure of 4.5 - 5.5 kg/cm^2 at operating conditions. The pressure is adjusted by changing the tension of the spring with adjusting screw 17.

The pressure stage is protected by rubber rings 4 and packing 6. Fittings are located in the housing for the oil supply line 14 from the oil tank to the pressure stage and for outlet 10, in which are mounted screen filters 9 and ball check valve 8. The outlet delivers oil to the hydraulic coupling.

Oil is distributed from the pressure stage of the pump in two directions (see Fig 180): one part is brought to the channels of the reduction gearing through an opening in the flange for attaching the oil pump; the other part passes through check valve 3, filter 4, and the outside tubing to the piston of the regulator pump 5.

With a starter rotation speed of at least 29,000 rpm, oil is admitted to the hydraulic coupling through filter 6 and tube 7 and in this way turns the driven half.

The oil flowing through the reduction gearing passes through screen filter 2 and check valve 1, located in the projection of the reduction gearing, and flows in three directions:

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1) the oil passes through the horizontal channel and then a side channel into the nozzles drive shaft 8, and lubricates the slide bearing and the bearings of rotor shaft 9;

2) oil is brought through a side channel to input sleeve 10; then, through openings in the sleeve and housing, it enters the area formed by the driven shaft of the reduction gearing and tube 7, and from there through openings it lubricates the bearings of the hydraulic coupling;

3) oil is brought from a side channel through vertical milled channels to horizontal channel 11, tangentially placed opposite the slide bearings of the fuel and oil pump drives.

Lubrication of the gear teeth and the ball bearings of the reduction gearing is accomplished by spraying. To lubricate the bearings of the starter during its automatic rotation while the engine is operating, oil is brought directly from the tubing of the engine through a nozzle containing a check valve on the housing of the main drive. The check valve also prevents leakage of the oil (while the starter is operating) into the oil system of the engine.

Check valve 1 prevents leakage of the oil brought from the engine and seepage of oil from the oil tank of the aircraft into the engine during lengthy standstills.

The used oil from the compressor housing is removed by a flexible hose in the reduction gear housing and passes into the front housing of the engine compressor. The total output of the pressure stage of the oil pump with a closed relief valve at a pressure of 6 kg/cm^2 is at least 19.5 liters/min.

The second stage of the oil pump ensures that the oil which is released into the front housing of the compressor and the lower drive of the engine during operation of the starter is pumped into the oil tank of the aircraft.

The oil input fitting 15 (Fig 182) and the fitting for carrying off used oil 18 are located on the middle housing of the oil pump. The suction stage of the oil pump has forced lubrication through channel 12 and ball valve 11. Valve 11, rings 4, and packing 6 prevent seepage of oil from the oil tank of the aircraft when the engine is not operating.

The vacuum maintained by the suction stage during an output of 1 liter/min is at least 550 mm Hg.

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6. FUEL SYSTEM OF THE STARTER

The fuel system ensures a supply of fuel for the starter in amounts necessary for its operation during starting and in the run-up to operating speed during the starting of the engine.

The fuel from the aircraft tank 1 (Fig 183) is brought by gravity through filter 2 and electromagnetic valve 3 to the pump TNR-3R (8). The pump controls the supply of fuel and provides it in the required amounts to the fuel manifold 5 through a second electromagnetic valve 7.

The presence of the second electromagnetic valve in the tubing prevents seepage of oil and fuel which occurs around the piston of TNR-3R into the combustion chamber after the starting system of the starter has been disengaged and the disengaged starter is in automatic rotation.

The fuel manifold (Figs 183 and 184) is a circular tube wound on the housing of the starter turbine. All fittings in the connections of the collector contain rubber gaskets. The manifold has five feeders to the operating jets 6 and two feeders to the jets of the ignition assemblies.

All of the centrifugal type jets have ball check valves 9, 18, and screen filters 10, 17. The check valve prevents passage of fuel in the initial moments of starting and the evaporation of fuel from the manifold through the jets when the starter is not operating.

The tension of the springs of the valves is as follows:

-- the valves of the jets of the ignition system, 0.4 - 0.5 kg/cm^2;

-- the valves of the main jets, 0.8 - 0.9 kg/cm^2.

During starting of the starter, the flow of fuel is ensured initially only up to the jets of the ignition system. Then, depending on the amount of increased pressure, the fuel is sprayed into the combustion chamber by the main jets.

The basic components of the main jets and the ignition system are the atomizers 13 and 19. Atomizer 19 of the main jet is crimped into the end of a bent tube soldered into the housing. The atomizers have tangential openings which give the fuel a circular motion. The configuration of the projecting jet ensures that the jet of the ignition system has a conical angle of spray of 25 - 35° and the main jets have angles of 65 - 85°.

The ignition system is a round body 11, cast from stainless steel CH23N18 [Kh23N18], with a flange for attachment to the turbine housing. In the top part of the body is atomizer 13, which is fastened with a nut 12 and tightened with a copper washer. The fuel to be atomized is brought through a channel. Spark plug SD-55ANM (20) with its cover is screwed into the side projection of the ignition assembly housing.

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The conical part of the jet 14 fits into the body of the ignition system. Between the conical wall of the jet and the body of the ignition system is a ring-type recess for the passage of air entering the field of the ignition system from the combustion chamber through 18 openings, each with a diameter of 2 mm, which have been milled in the flange of the jet. The body of the ignition system and the jet, whose cylindrical part is the attachment for the burner, are fastened to the turbine housing with four screws. "Paronite" washers are inserted on both sides of the jet flange.

Discharger 15, serving as the other electrode of the spark plug, is welded obliquely inside the ignition assembly.

6.1 Fuel Pump TNR-3R

6.1.1 General Data

Fuel pump TNR-3R (Fig 185) is a component of the S-300M starter and serves to provide fuel to the manifold of the starter and to bring oil to the hydraulic coupling.

The component consists of:

-- one-stage gear pump;

-- centrifugal regulator;

-- three adjusting screws.

The centrifugal regulator maintains stable operating speed of the starter regardless of the load, releases part of the fuel from the high pressure area to the low pressure area, and also releases oil to the hydraulic coupling. The amount of fuel provided during starting of the starter and during operation is adjusted by screws.

6.1.2 Basic Technical Data

1.	Designation	TNR-3R
2.	Pump type	gear
3.	Regulator	centrifugal
4.	Drive	from the starter
5.	Direction of drive rotation	to the left (counterclockwise) from the side of the drive

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6.	Main fuel	gasoline B-70 (GOST 1012-54) without ethylene with addition by weight of 1% oil MK-22, or MS-20 (GOST 1013-49), MK-8 (GOST 6457-53), transformer oil (GOST 982-56) of any brand with or without additive VTI-1, petroleum T-1 (GOST 4138-49)
7.	Temperature of fuel in °C. .	60 to - 60
8.	Fuel pressure at input to pump	0.2 - 0.1 kg/cm²
9.	Oil	MK-8 (GOST 6457-53) or transformer oil (GOST 982-56) of any brand (with or without additive VTI-1)
10.	Oil pressure at input to pump	5 ± 0.5 kg/cm²
11.	Temperature of oil in °C	- 40 to + 80
12.	Maximum number of revolutions of pump drive in rpm	4,800
13.	Output of pump at pressure at 35 kg/cm² and 4,500 revolutions ± 15, in kg/cm²	250--300
14.	Revolutions at start of release of fuel through centrifugal regulator	4,550 ± 15
15.	Output of adjusted pump at 4,650 - 25 rpm	68 to 73 kg/hr
16.	Revolutions at start of release of oil through centrifugal regulator to hydraulic coupling in rpm	4,150 + 200
17.	Period of operation of pump until first overhall	450 operational starts

Note: Period of operation does not include starts during adjustment and inspection tests of the starter and the motor, but these must not exceed 200 starts.

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18.	Period of technical guarantee	900 starts (twice the operating period of the component)
19.	Dry weight of the fuel pump in kg	3.70

6.1.3 Diagram and Principle of Operation

The fuel, brought into the component through fitting 4 (Fig 186) at a pressure of 0.2 - 0.1 kg/cm^2, passes into gear pump 5. To compensate for the influence of the heating of the pump on its characteristics, a very high pump output is chosen. At the output of the pump is a screen filter 6.

To vary the supply of fuel to the collector of the starter, fuel pump TNR-3R is provided with an adjusting mechanism located in the openings connecting the pressure stage with the suction stage. The passage of one of the openings is adjusted by screw 2 and the ball-type throttle valve 8.

Screw 2 adjusts the consumption of fuel by the starter during the starting from zero revolutions to operating speed.

The ball valve, whose spring is adjusted to a pressure of 0.9 - 0.1 kg/cm^2, prevents leakage of fuel initially during starting when the output of the pump is insignificant because of too few revolutions.

The pumped fuel also passes relief ball valve 9 which opens at a pressure of 18 kg/cm^2. The pressure of the spring of the relief valve is varied by screw 1, which adjusts the flow of fuel through the starter at operating speed.

The centrifugal regulator is a sleeve with openings in which piston 13 moves; it [the sleeve] is connected to the fork of centrifugal counterweight 16. The piston has three settings:

-- center, for release of oil to the hydraulic coupling.

-- and lower, for release of fuel from the input to the suction intake.

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In starting the motor of the starter at 7,000 rpm (900 + 1,100 rpm for the drive gear of the pump), the fuel is partially released through the release openings by the upper seat of the piston. These openings lead to the sleeve opening.

This flow is interrupted by shifting of the upper edge of the slide valve behind the openings, which corresponds to a starter speed somewhat less than operating speed (26,000 - 28,000 rpm).

The upper end of the piston is held across the ball bearing by spring 11, the tension of which may be changed by screw 3 of the centrifugal regulator. It regulates the start of the release of fuel through the centrifugal regulator and thus also the operating speed of the starter. The quantity of fuel released is determined by jet 10.

Oil is delivered from the starter oil pump to the regulator by means of nozzle 15. At a minimum of 29,000 rpm, the middle step of piston 13 releases the oil through channel 14 into the hydraulic coupling. The geometric dimensions of the piston make possible the supply of oil somewhat sooner than oil begins to be released through the upper seat of the piston.

The cavity of the centrifugal regulator is connected to the engine tank through channel 12.

6.1.4 Schematic Diagram

The fuel pump is mounted on a flange of the starter reduction gearing housing and rotates by means of a small gear of the hydraulic coupling.

The schematic arrangement is as follows:

The drive gear of reduction gear shaft 17 (Fig 187) rotates large gear 18 of the drive half of the hydraulic coupling. Small gear 19 brings into motion gear 20 of the TNR-3R pump drive, which is connected to drive gear 34 of the fuel pump by means of a splined connector.

Set on the plines of the shaft of drive gear 34 is bevel drive gear 21, transmitting rotation to driven bevel gear 22 and fork 16 with the centrifugal weights. The weights press on two pins on piston 13 of the centrifugal regulator by means of their lever ends. With increasing speed of rotation, the weights go farther apart as a result of centrifugal force and transmit a sliding motion to the piston. For greater sensitivity the piston is held in a groove with the fork and both rotate simultaneously.

6.1.5 Design of the Assembly

The TNR-3R fuel pump (Figs 188 and 189) consists of regulator housing 26, the fuel pump, and the adapter unit located between them.

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6.2 Fuel Pump

The fuel pump is of a one-stage, gear type, and is located in the lower portion of the assembly. It consists of housing 44 and cover 38, which are cast of aluminum alloy, and an alloy cross brace 39. Drive gear 34 and driven gear 37 of the pump (section DD) rotate in bearings, the sleeves of which are pressed into the housing and the pump cover. So that the gear will not come into contact with the cross braces, the latter have recesses 0.2 millimeters deep (Fig 190).

The cross brace and pump cover are fastened during assembly by two pins 49 (see Fig 188) and are fastened to the housing by screws 40, screwed into sleeve 41. From the side of the shaft of the pump drive gear, flange 43 has a double robber cup 64 (Fig 191). The flange is fastened by screws screwed into sleeves 42 (see Fig 188).

Mounted on the grooves of the drive gear in the ball bearing is bevel drive gear 21. Between the bearing and the retainer ring is a setting washer 46.

Channels for entry of fuel into the pump and for the exit of fuel from it are milled on the forward wall of the connector between the pump housing and the adapter unit (section AA). They are extensions of analogous channels in the regulator housing. The points at which the channels are connected are sealed by sleeves 48, pressed into the flange of the adapter unit, and by rubber rings 28. The connecting surfaces of the forementioned components [are sealed] by seals 89 and 47. Fuel entering the pump through the system of cast openings 53 (Fig 189) rises in the front to the cross brace and is forced by the gear and a system of channels to the screen filter. Under pressure, the cleaned fuel is carried to the regulator housing through channel 54.

The pump filter is a steel housing 56 with four recesses; on it are soldered two screens 57 and 58 with a various number of openings. The filter is sealed by ring 55 during assembly. It is held in an operating position by spring 59, the other end of which rests against blind flange 60.

The sleeves of angle bearings 36, both in the pump housing and in the cover, are positioned between two steel washers 62. The outer bearings 63 are bronze. They are mounted in the heated housing and cover against the beveled surface.

Adapter unit 24 of the pump (Fig 192) has the shape of a drum with a flange into which are pressed two sleeves 48. Two cross recesses for drainage of oil are machined in the flange.

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A driven bevel gear 22 is located on two ball bearings in the drum part of the adapter unit (Fig 188). Between the bearings are setting washers 23 and retainer ring 35. Bottom washer 23, together with washer 46, provide the clearance in the contact between the bevel gears.

The projection and the pin of fork 16 with centrifugal weights 25 fit into the hollow end of the bevel gear which has a recessed face. Because of this, the fork turns with the gear.

Bronze sleeves 69 are pressed into the shoulders of the fork (Fig 193) and into these are mounted pins 66 of the weights. Control pins 65 are pressed in beside the axles. Pins 66 of the weights have a head on one end, while washers 68 are mounted on the other end and the end is rolled. The weights press pins 33 (Fig 188) against piston 13 by means of their lever ends.

The housing of regulator 26 is made of aluminum alloy and has channels for delivery, removal, and transfer of fuel with the appropriate adjustment equipment, as well as channels for supply of oil to the regulator and into the hydraulic coupling. Steel sleeve 32, in which are drilled two recesses (through) with oval openings between them, are pressed in the center part of the casting. These openings are connected by ring recesses 27, 29, 30 and 31 in the housing of regulator 26, depending on the position of piston 13. The two upper recesses 27 and 29 are connected to the supply and suction fuel channel; the two lower recesses 30, 31 are connected with the oil supply and removal channels.

The piston (Fig 195) moves in sleeve 32. The upper seat of the piston closes the fuel drainage openings from the cavity in the sleeve; the center seat closes the channel for flow of oil into the hydraulic coupling.

In mounting the assembly, the openings for the upper position of the piston are placed opposite the openings of the sleeve. This position of the piston is assured by the proper selection of the upper setting washer 23 (Fig 188). Spring 11, the tension of which may be changed by the position of screw 3 of the centrifugal regulator (stop), bears upon piston 13 (Fig 196) across ball bearing 71.

The position of screw 3 determines the beginning of the flow of fuel throgh the centrifugal regulator and establishes the operating speed of the starter. The greater the load on spring 11, the greater the number of rotations necessary for the centrifugal regulator weights to develop sufficient force them to overcome the resistance of spring 11 and shift piston 13. When the piston is displaced, it opens the opening of sleeve 32 and increases the operating speed of the starter.

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The four sides of screw 3 fit into the opening of stop 74. When the screw is turned, the stop moves along the inner threading of screw-in socket 73, located in the housing of regulator 26. A locking nut 70 is screwed on from above and saftied with wire.

Spring 76, with a tension of 0.13 kilograms, is set against the upper seat of the piston. It holds the piston in the necessary position up to 7,000 rpm. When the number of rotations exceeds this, its tension is overcome by the centrifugal force of the weights and the end of the piston is pushed against the forward side of the bearing. As a result, up to a speed somewhat under the operating speed the piston openings match the openings of the sleeve and release a part of the fuel. The other end of the spring butts against sleeve 72.

Fuel is supplied to the regulator by turning insert 4 (section EZhZIK in Fig 188). The fuel flows through channel 51 through the sleeve of the adapter unit into channel 53 of the pump sleeve (section AA). Fuel is released into the same channel from the cavity through starter screw 2 and relief valve 9 (section EZhZIK), and also from ring recess 29 of the regulator housing (section BB). The fuel, coming from the pump through channel 52 (section AA and VOD) and through screw-in socket 7, passes to the starter collector. At the same time, the fuel flows under starter adjustment screw 2 and relief valve 9.

These spaces are designed with interconnecting passages for the reduction valve which cuts across the two adjoining walls.

Screw 2 is mounted with the throttle valve (Fig 197). Adjustment screw 2 is set in the inside threading of cover 83, into which nut 82 is screwed.

This changes the size of the output opening located in the seat 77 of the throttle valve. The inside of the opening is closed by ball 78 held by valve plate 79 under the pressure of spring 80. The other end of the spring rests against guide sleeve 81 which is screwed into the seat of the valve. Fuel is not released at the initial instant of starting as a result of the effect of the spring. As the pressure of the fuel increases, the ball is pushed back and the quantity of fuel set by screw 2 is released into ring recess 50 (Fig 188).

The reducing valve (Fig 198) consists of housing 85 in which set screw 1 is held by means of threads. On the front of the housing is a relief opening which is closed from the inside by ball 88 under the force of spring 86 exerted across the valve plate. Screw 1, which changes the tension of the spring, controls the amount of fuel released through the reducing valve into ring recess 50 (See Fig 188) during operation of the starter.

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A channel runs from the space where fuel is supplied by the reducing valve to upper ring recess 27 of the regulator housing.

Oil is supplied through angle plate 17 to ring recess 31 of the centrifugal regulator. At a minimum of 29,000 rpm, the center position of the sliding piston permits oil to flow from recess 30 through screw-in socket 14 to the hydraulic coupling. The oil seeps through the lower sliding piston seat and runs out along two grooves in the adapter unit into the fuel pump housing. From there it runs through passage 45 in the flange or in the adjacent passage down into the starter reduction gearing. The screw-in socket of the pump and the adjusting elements are sealed with rubber rings.

7. CONTROL MEASUREMENT INSTRUMENTS OF STARTER SYSTEM

7.1 Thermoelectric Thermometer TST-29

The type TST-29 thermoelectric thermometer consists of a magnetoelectric millivoltmeter and a chromelalumel thermocouple.

The thermocouple is used to measure the temperature of discharge gases of the turbostarter.

The thermocouple system consists of:

1. type TST-2 meter;

2. type T-9 thermocouple (Fig 199);

3. thermoelectric connecting lead.

The operation of the device is based on the measurement of the amount of thermoelectric energy developed by the thermocouple as a result of a difference in temperatures between the cold and hot sides. This thermometer uses a chromel-alumel thermocouple whose operating end (hot junction), enclosed in a special case, is placed in the measured item, and whose free end (cold junction) is placed through the connecting lead on the instrument board and is located in the meter.

The thermoelectric energy arising in the thermocouple (due to a difference in temperature) is measured by a millivoltmeter whose scale is calibrated from 0 to 900°C.

In order to determine the temperature of the measured area on the basis the data of the millivoltmeter, it is necessary to exclude the influence of the change in temperature of the cold end of the thermocouple. For this reason, the free ends of the TST-29 thermocouple are passed through the thermal connections to the instrument board, where there is an area of small temperature differences.

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Occasional fluctuations in temperature from 50 to -60° in the area of the free ends of the thermocouple are compensated directly in the meter by a bi-metal corrector which automatically sets the needle of the instruments at ambient air temperature. The change in air temperature encompassing the meter has an influence on the linear dimensions of the parts and also on the mechanical and electrical properties of materials used in the instruments, which is a reason for the orgination of a number of errors.

The only practical importance is in the change in resistance of the arm of the instrument, since the current developed by the thermocouple and passing through the arm of the meter depends on the resistance of the circuit. The temperature changes in the resistance material cause a change in the current in the arm, which leads to a deviation of the needle from the true position.

In order to eliminate this error, the meter contains a Silit resistor which has a negative temperature coefficient (the temperature coefficient of the alumel lead of the arm of the instrument is positive).

A multi-wire constant an conductor is used as a thermal electric connecting lead.

7.2 Dual-Pointer Remote AC Tachometer TE-45

The TE-45 tachometer is used for remote measurement of the speed of the S-300M starter shaft and consists of two main parts:

dynamo of the transmitter and meter containing a synchronous motor;

dynamo transmitter (Fig 200), which is a three-phase alternating-current instrument with a permanent magnet 8 used as a rotor. The rotor is fastened on shaft 6 which rotates in ball bearings 11 and 5.

Rotation is transfered to the rotor by a geared wheel equipped with friction gear 10, which is used to protect the shaft and other parts against damage which could occur in case of a sudden change in speed. Stator winding 7 of the transmitter has three output conductors which lead to plug connector 2 fastened to cover 3. The cover is fastened to housing 1 by six screws.

In order to lubricate the gear wheels and bearings, a heavy lubricant is used in this area up to area 4. The area is sealed by packing 9 to prevent grease from entering the electrical part of the transmitter.

The dynamo transmitter is connected to the meter by a three wire cable.

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The tachometer (Fig 201) is composed of two parts:

a. a three-phase synchronous motor

b. a magnetic induction tachometer part.

Permanent magnet 3, fastened to shaft 15, serves as the rotor of the synchronous motor. The shaft of the rotor rotates in ball bearings 16 and 12. On the bracket part of the shaft of the rotor is magnet 10 with magnetic shielding 9 and heat compensator 13. Stator winding 2 has three output leads fastened to plug 1.

The magnetic induction tachometer part is composed of sensing element 4, and indicator components consisting of hairspring 5, gear drive 6, and two pointers 7 and 8. The sensing element, the hairspring, and large pointer 7 are on a single shaft. The small pointer 8, set on a hollow shaft through which passes the shaft of the large pointer is turned by gear drive 6 from the shaft of the large pointer.

The large pointer counts off hundreds and tens of revolutions, and the small one counts off thousands of revolutions. Both parts are contained in housing 11 and cover 14.

7.2.1 Operation of the Tachometer

Rotation of the rotor of the dynamo transmitter causes an electric current to be induced in the stator which is passed by the conductor to the synchronous motor, which is in the meter housing. Permanent magnet 10, set on the shaft of the rotor of the meter, induces eddy currents in the sensing element and creates a rotary moment of the latter.

With a given magnetic current and a given resistance of the sensing element, the moment imparted to the sensing element is proportional to the number of revolutions of the magnet and to the number of revolutions of the motor of the meter. The hairspring attached to the shaft of the sensing element creates a moment opposite to the moment of the sensing element. Upon interruption of the operation of the dynamo transmitter and a resultant interruption in the operation of the motor of the meter, the hairspring returns the pointer to the initial zero position. Thus, the pointers indicate on the scale the amount of rotation of the sensing element; this amount is proportional to the number of revolutions of the magnet.

With a change in temperature, the electrical resistance of the sensing element also changes and causes a change in the rotary moment of the element. In order to eliminate the influence of changes in the surrounding temperature, there is fastened to the front of magnet 10 a heat compensator

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(thermo-magnetic shunt) 13 made of an alloy whose magnetic conductivity falls sharply upon an increase in temperature. With constant temperature of the surrounding area, the shunt "removes" part of the operating magnetic current and thus decreases the operating current in the space between the magnet and the sensing element. With a rise in temperature, the operating magnetic current in the space increases due to a decrease in the "removal" by the shunt, and, conversely, when the temperature decreases, the magnetic current increases, since the "removal" of current by the shunt increases.

The above changes in the magnetic current in the space correspond to a change in the electrical resistance of the sensing element and maintain, in essence, a constant value of the rotary moment of the sensing element. The influence of temperature on the sensitivity of the meter is then decreased to a minimum as a result of the action of the heat compensator.

7.3 The SD-24A Pressure Indicator

The SD-24A pressure indicator (Fig 202) provides electrical signals when pressure is reduced in the oil system of the starter to less then 3.5 kg/cm^2. The instrument switches on a 5-watt, 27 $\pm$ 2.7-volt signal light.

The sensing element of the instrument is an elastic diaphragm 11 fastened in the housing by the cover of pressure chamber 9. Ring 10 ensures the necessary space between diaphragm 11 and the cover of pressure chamber 9, which simultaneously serves as a stop for diaphragm 11.

With an increase in oil pressure in pressure chamber A of the instrument, the diaphragm flexes and moves its solid core 12 with attached insulated terminal 13, which, in turn, moves flat spring 17 and riveted terminal 18. At the instant contact 18 closes with contact 19, point which is riveted to the upper edge of flat spring 20, the electric circuit closes. One end of springs 17 and 20 and insulation washers 7 are fastened to the cover of pressure chamber 8 by five screws.

The position of lower spring 17 is determined by the solid core 12 of the diaphragm with insulated terminal 13, and the position of the upper spring 20 [is determined by] insulated stop 16, fastened to set screw 24 by insulated washer 14 and screw 15.

Set screw 24 determines the instant at which the instrument gives the signal. Screw 24 is screwed into bar 29 and is tightened by nut 28. Bar 29 is fastened by two screws 30 to the cover of the pressure measuring device [indicator].

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Conductors 17 and 20 of socket 1 are connected to flat springs 17 and 20. The fork of the socket is fastened to cover 4.

The cover is fastened to housing 4 by five screws 22, under which are placed graduated washers 21. The housing of the component is sealed by rubber washers 3, 6, and 23. The component is provided with screw-in socket 25 for supply (in emergencies) of static pressure to the housing of the instrument.

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Chapter VIII

SECURING THE ENGINE TO THE AIRCRAFT

The RD-3M engines are made in such a way that there are two alternatives for securing them depending on the type of aircraft they are to be employed on.

1. SECURING THE RD-3M ENGINE (1st alternative)

Special suspension mounts are used for securing the engine to the aircraft. The suspension mounts are found at two levels -- forward and rear (Fig 203). The forward (main) level is located at the rim of the rear compressor housing in close proximity to the engine's center of gravity, and the rear level is at the front flange of the stator vane housing of the turbine's first stage. The suspension mounts at both levels are arranged from right to left depending on whether it is the right or left engine of the aircraft.

The suspension mounts located at the first level have six attachment points, from which diagonal struts 4 and 5 are attached at points 8 and 14, bearing the tension. Struts 1 and 3 are attached at points 16 and 17. Points 18 and 19 at the forward level with tie rods 11, 12, and 13 constitute a single suspension carrying the weight of the engine.

Mounted at the rear level are three suspension mounts which have 5 points. Strut 6 is fastened to upper point 9, and auxilliary strut 7 is fastened to lower point 10. Points 22 are used during assembly of the engine. All aircraft struts are secured to the suspension mounts by means of swivel rings 21. The suspension mounts are fastened to the housing of the engine by locking screw-type fasteners and bolts. Also at the front level are suspension eyes (left and right) 15 and suspension mounts 20, used during assembly, testing, and transportation of the engine.

The engine is secured to the aircraft by six struts and one auxilliary strut at four fitting points located on the transverse stiffeners of the fuselage. The forward main fastening level consists of struts 1, 2, 3, and the rear level consists of main strut 6 and the auxilliary [strut] 7. All struts have adjustable end fittings and are fastened by ball-type bushings.

The leveling openings used when leveling the engine during its installation on the forward flange of the engine compressor and on the fittings attached to the flange of the exhaust nozzle are located on the bottom. In addition, the truncated cone of the exhaust nozzle has two longitudinal grooves above and below to check the position of the vertical axis of the engine.

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2. SECURING THE ENGINE (2d alternative)

This alternative also uses suspended mounts for holding the engine at two levels -- front and rear. The suspension mounts at both levels are arranged from the right or the left depending on whether it is the right or the left engine of the aircraft, and they are mounted in the same places as in the case of the 1st alternative with the exception that the suspension mount at attachment point "a" is shifted to the top along the rim of the rear housing to attachment point "b".

3. DIFFERENCE BETWEEN THE RIGHT AND LEFT ENGINE

Eight suspension mounts are made fast to the RD-3M engine for the purpose of securing it to the aircraft. Four suspension mounts are at the first level (on the rim of the rear compressor housing) and four at the rear [level] (on the front flange of the stator vane housing of the turbine's first stage). In mounting the right engine, the suspension mounts at the front level are attached from the left; in mounting the left engine -- symmetrically from the right.

In changing the right engine over to the left side and vice versa, it is necessary to shift the suspension mounts of the front level symmetrically from left to right in the first case and symmetrically from right to left in the second case.

In addition, the pipe coupling for carrying oil from the engine to the cooler at the suction stage of the oil pump must be attached from the left for the right engine and from the right for the left engine.

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Chapter IX. Aircraft Accessories

1. HYDRAULIC PUMP 435VF

The hydraulic pump 435VF is a piston-type pump with a variable stroke. It feeds the hydraulic system of the aircraft.

1.1. Basic Data

Working fluid . . . . .oil AMG-10

Absolute pressure at entrance to pump for all operating conditions and at all altitudes kg/cm^2 . . . . minimum of 1

Speed of pump drive, rmp (maximum) 2200

Rated speed 2050

Minimum speed 800

Operating pressure maintained by pump with output varying from 0 to 28 liters/minute, in kg/cm^2 . . . . 150 $\pm$ 7.5

Permissible temperatures of working fluid while equipment is in operation, in degrees centigrade . . . . from -40 to +70

Equipment drive . . . . .by motor

The equipment consists of the pump and servo equipment, mounted in a common housing.

1.2. The pump consists of the following main components:

- housing
- rotor
- 7 pistons with springs
- washers
- tapered insert and shaft

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All pump housing components are made of aluminum alloy; these include housing 24 (Figure 204) and flange 1, which are connected by bolts and nuts 22.

The housing contains a suction mechanism. The flange serves as the cover for the housing, as well as for mounting.

The nitrided alloy steel rotor revolves on two roller bearings 20 and 26 which are mounted within the housing and the flange of the pump. The face side of the rotor rests against bronze insert 27 which has two openings:

One openings is connected to the suction port of the pump by a channel and is the intake for the working fluid of the pump into the rotor cylinder.

The second opening, connected to the output port of the pump, permits the fluid to leave the cylinder.

The surface of the insert, which is in contact with the rotor, is lined with a thin layer of lead (0.007-012 millimeters) which assures a good fit of the insert to the bearing face of the rotor.

Seven hollow bronze pistons 7 are distributed about the circumference of the rotor. Springs 8, which ensure tight contact of the spherical steel head of the piston with the tapered insert 6 and the bearing face of the rotor, are located within the pistons. The tapered insert is also a holder for the ball bearing. The body of bearing 4 is fitted in the housing of the pump of steel lugs which permit the angle of inclination of the insert to be changed. The angle of inclination of the insert is determined by servo piston 10, which is connected with the ballbearing body through links 5 and push rod 9.

To prevent the working fluid from leaving the pump and entering the engine drive, a gasket consisting of two rubber grommets 3 is fitted into the flange of the pump. The flange also has a drain opening closed with a drain screw.

1.2.2 Servo Control

On the side opposite the partition wall, the housing has a recess into which the steel cylinder case 11 of the servo piston is fitted.

Servo piston 10 is mounted on push rod 9 with the aid of variable inserts 12 in such a fashion that when the piston is at the extreme end of its stroke, the angle of inclination of the plunger insert will be at its maximum. The servo piston is mounted ans secured on the push rod with nuts 13.

Servo piston 10 divides the chamber of the servo mechanism into two areas: "A" and "B". Area "A" is connected, to the output tubing through a special opening in the housing. Area "B" is connected with area "A"

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through a strainer cleaner, an opening in the push rod, and jet 14 which is screwed into the push rod. Within area "B" are two cylindrical springs 15 and 16 which rest against the servo piston from the one side and against base bearing 17, located in cap 18, from the other side.

A joint-mounted needle, whose free end extends over the opening of valve 14, is located in the base bearing 17. During operation of the servo piston, the jet opening is automatically cleansed.

Area "B" is connected with a high pressure valve, which is composed of lever 33, flat valve 31, set 30, spring 35, set screw 36, rubber diaphragm 28 and push rod 29. The fulcrum of lever 33 is mounted on boss 32. Support screw 34 is fitted into the lever so that it touches rod 29. Flat valve 31, which is located in a recess of the lever, closes the calibrated opening in seat 30 which is connected with area "B".

The valve chamber is connected by a channel to the central opening of the insert, which in turn is connected with the housing area of the pump by openings in the rotor.

1.3 Function of Pump

When rotor 8 (Fig. 205) turns, pistons 9 of the pump, due to the action of the inclined insert 10, are activated within their cases, which are located within the rotor. The return stroke of the piston is assured by spring 7. In so doing, the working area of the cylinder is filled [with fluid] through the openings in insert 6. During the second half turn of rotor, the plunger is on its return stroke, as effected by the angle of inclination of the insert, and forces the fluid out of the cylinder through the second opening in the insert to the exit line.

The performance of the piston and thus the efficiency of the pump, depends on the angle of inclination of the insert relative to the axis of the rotor. The angle of inclination of the insert is set automatically in relationship to the need for fluid within the hydraulic system and maintains a constant pressure at the output end of the pump.

With a reduced need for fluid in the hydraulic systems of the aircraft, the pressure in the hydraulic system increases. The pressure acts upon rod 5 which transmits it to lever 4 and partially opens valve 3. Hydraulic fluid is passed from area "B" to the area of the valve, whence it is passed to the fluid reservoir. Pressure in area "B" is lowered because valve 13 retards the passage of the fluid into are "B". The difference in pressure between areas "A" and "B" creates pressure upon servo piston 12 which overcomes the tension in spring 11 and moves to that side. Simultaneously, the push rod of the servo piston reduces the angle of inclination of the insert, the incoming flow of hydraulic fluid is reduced, and the pressure in the hydraulic system is reduced to the intial values. As the requirements for hydraulic fluid in the system increase, the servo piston reacts in the opposite direction.

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The necessary pressure in the hydraulic system is determined with the aid of variable valve 1, whose change of position alters the tension in spring 2 of the valve.

2. AIR COMPRESSOR AK-150 (Equipment No 380)

Air compressor AK-150 (380) serves to provide compressed air to various pneumatic components aboard the aircraft and in the engine.

2.1 Basic Data

Type of compressor -- 3 stage, 2 piston, high altitude.

Dimensions of compressor, in millimeters:

a. Diameter of cylinder for (stage I -- 46
b. Diameter of cylinder for stage II (differential) -- 46/40
c. Diameter of cylinder for stage III (differential) -- 38/35
d. Piston stroke -- 28

Number of revolutions of crankshaft of compressor, per minute:

rated -- 2000 ± 50

maximum -- 2300

maximum filling pressure for compressor (in atmospheres) -- 1.2

operating pressure developed by the compressor under filling pressure from 1.2 to 0.7 atmospheres -- 150.

compressor output at 2000 _ 50 rpm and filling pressure of one atmosphere (in cubic meters per hour) -- minimum 2.4

compressor drive method -- by pressure

permissible temperature of ambient air while equipment is functioning (in degrees centigrade) -- from -55 to +60

output at compressor shaft -- 3.5 horsepower

compressor cooling -- by air

2.2 Design

The compressor consists of the following principal component groups and parts.

- housing (fig. 206) for 2 cylinders 18 and 21
- crankshaft with two connecting rods 20 and 23
- pistons 19 and 22
- intake and exhaust valves

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The compressor housing is composed of two halves 14 and 15 made of cast aluminum alloy. The individual halves of the housing are held together with bolts 13. The forward half of housing 15 has a flange "A" for mounting on the drive housing. The flange has openings for mounting bolts and five special openings. One opening serves to feed oil to the compressor housing, two openings serve to remove oil from the compressor housing to the drive housing, and the two remaining openings serve as ventilator openings for the compressor, as well as for the drive housing.

Two cylinders, 18 and 21, are screwed onto the housing. Each cylinder consists of a ribbed aluminum casing, plus the steel sleeve which is fitted into the aluminum casing. Head 7, cast from aluminum alloy, is mounted on cylinder 21 of stage I. A revolving union 3 is used to hold the tubing which brings pressurized air to the compressor and is mounted on the head. Intake valve 12 and exhaust valve 9 stage I are fitted into the head.

The steel intake valve, which is of a disc type, is mounted on a bronze seat 11, which is held in place by nuts 10 and an aluminum washer. The flat exhaust valve, which is made of stainless steel, is also seated on a bronze head.

On the other part of the head of stage I, 6 bolts hold on cast cover 2 which closes off the valve area.

The intake and exhaust valves of stage II are located in the central portion of the cylinder. Intake valve 6 is fitted into a steel adapter 4 which simultaneously forms the seat of the valve. Exhaust valve 1 is fitted into a similar adapter located at an angle of 90 degrees with respect to adapter 4.

The intake and exhaust valves of stage III are fitted on cylinder 18. The valves of stages II and III identical in design.

The crankshaft, composed of the forward part 33 and the rear part 32, rotates in two ball bearings 36. Both portions of the crankshaft are held in place along their longitudinal axis by nut 31 and the cranks by bolt 34. Counterbalances 30, which equalize inertial forces, are fitted to the cranks of the shaft.

The lower head of outside main steel connecting rod 23 is attached by bolt 27 to steel bushing 26. The internal part of the bushing rotates on the needle bearing of the crankshaft connecting rod pin. Internal main steel connecting rod 20 revolves around bushing 26 on bronze insert 25.

Connecting rod 23 is connected with pin 24 to piston 22 of stages I and II and connecting rod 20 is connected to piston 19 of stage III. The pistons, which are made of steel, are "Free-floating" and have aluminum coatings on their face walls so that they will not wear the cylinder.

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The crankshaft is secured by nuts 37 and 28 and ring 35 inside forward ball bearing 36.

Friction components of the compressor are lubricated by oil fed from the oil facilities of the motor. The oil is fed under pressure through a special opening in the flange of the compressor housing. The oil passes through channels bored in the forward and rear portions of the housing, enters the boring of the crankshaft through rear cap 28 and floating cap 29 and lubricates the needle bearings of the connecting rod heads. The remaining friction areas are lubricated by splashing oil.

2.3 Schematic Diagrams and Principle of Operation

When crankshaft 10 rotates (Fig. 207), pistons 5 and 9 have a straight-line return stroke. When the piston moves to the center of the crankshaft in stage I of the cylinder, a partial vacuum is created, the intake valve is opened, and air rushes to fill the area of stage I.

During the return stroke, that is, during the movement of the piston from the center, air is compressed in stage I, intake valve 4 is closed, and exhaust valve 3 and intake valve 1 of stage II are opened. Air from stage I is forced into stage II through ducts 2.

A similar movement of air takes place between stage II and stage III. Air, which has advanced to stage II of the compressor while the piston moved to the center of the crankshaft, begins to compress and is exhausted through valve 6 and ducts 7 as well as valve 8 into stage III of the compressor. Compressed air is fed from stage III into the storage bottle through valve 11.

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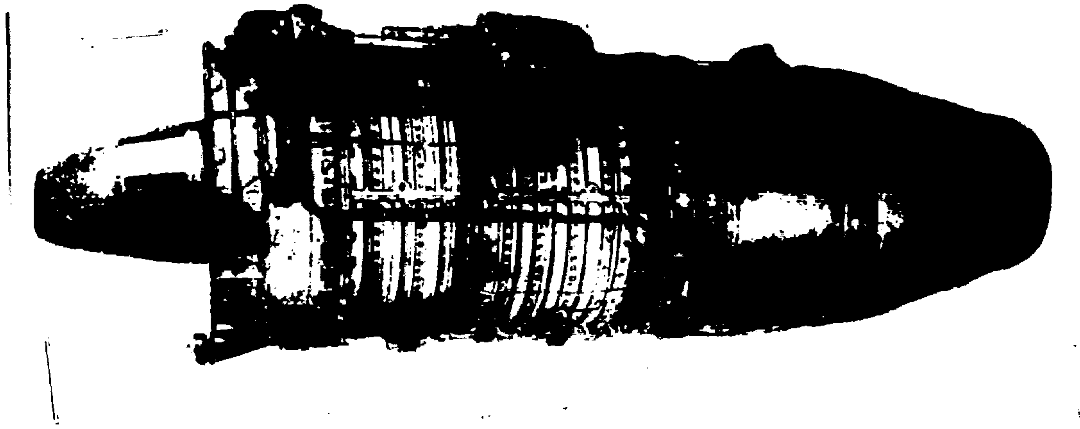

Fig. 1. RD-3M engine (view from the left)

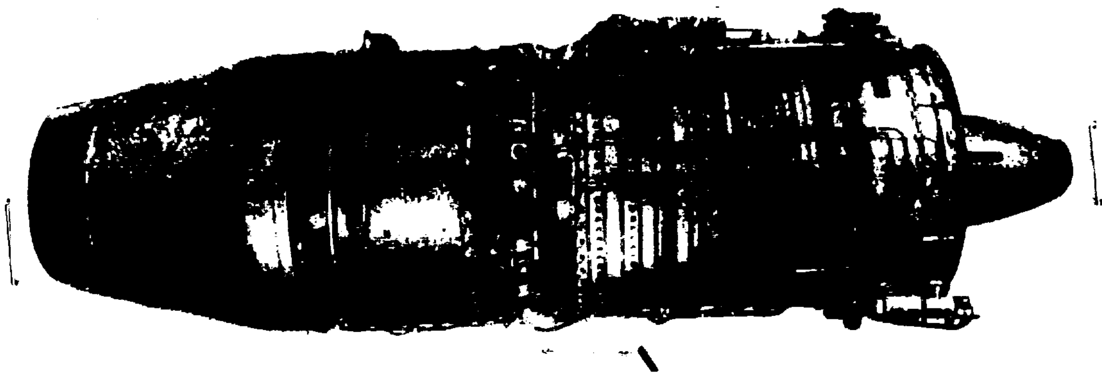

Fig. 2. RD-3M engine (view from the right)

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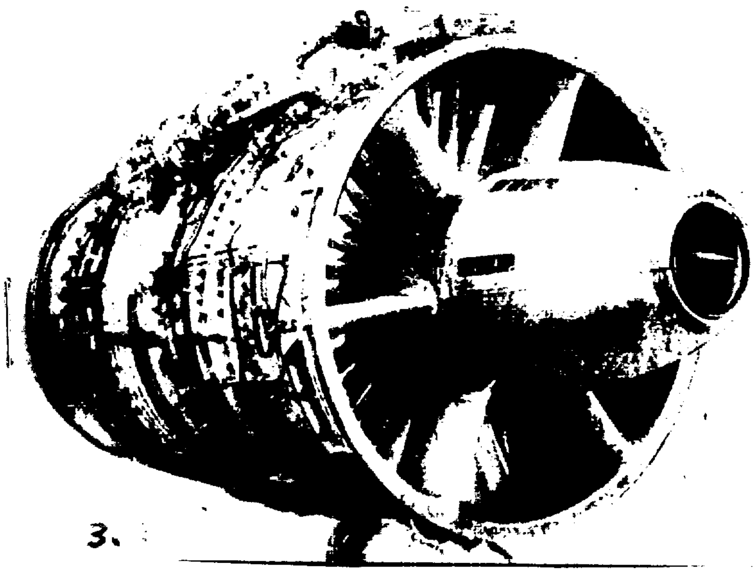

3. [No caption]

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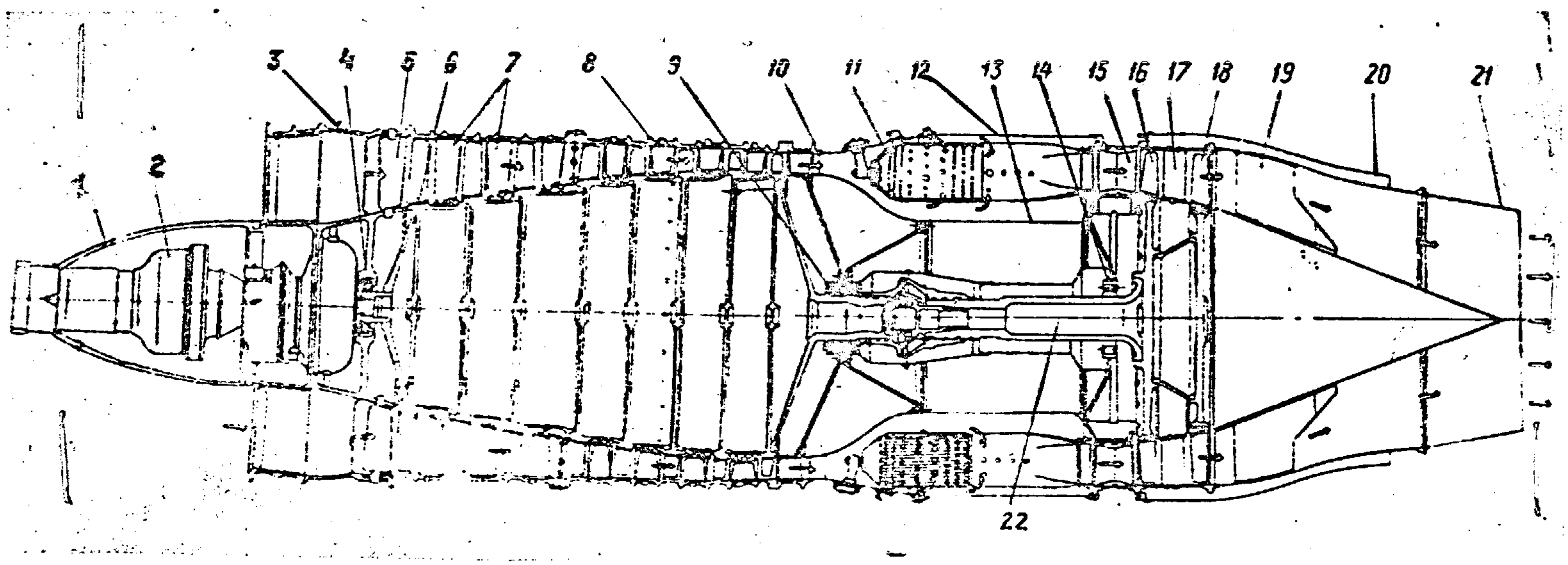

Figure 4. Diagram of engine design
1. Turbostarter cover 2. Turbostarter 3. Front section compressor case 4. Front bearing 5. Inlet guide vanes 6. Compressor rotor 7. Stator vanes 8. Center section of compressor case 9. Center bearing 10. Rear section of the compressor case 11. Burner 12. Combustion chamber case 13. Inner combustion chamber case 14. Rear bearing 15. Stator vanes 16. Stage I. turbine rotor buckets 17. Stator vanes 18. Stage II. turbine buckets 19. Exhaust tube 20. Exhaust nozzle shroud 21. Nozzle extension 22. Turbine shaft

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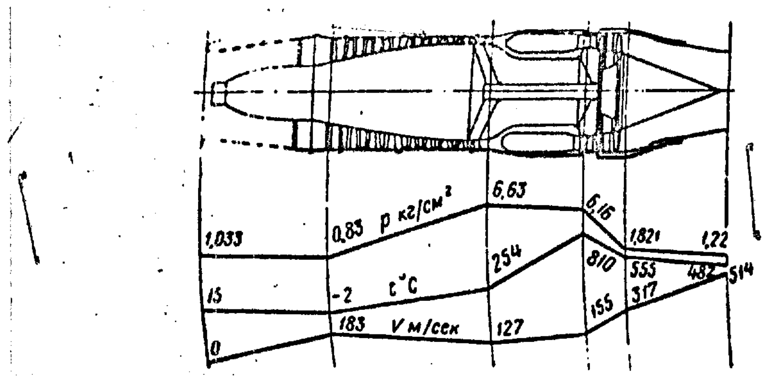

Fig. 5. Gas flow parameters of the RD-3M engine

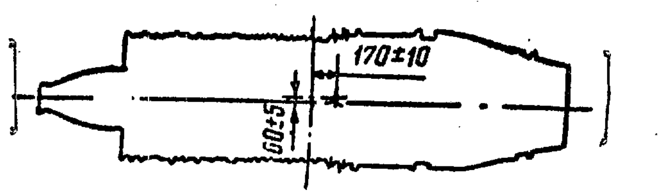

Fig. 6 Load distribution of the engine

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S-E-C-R-E-T
No Foreign Dissem

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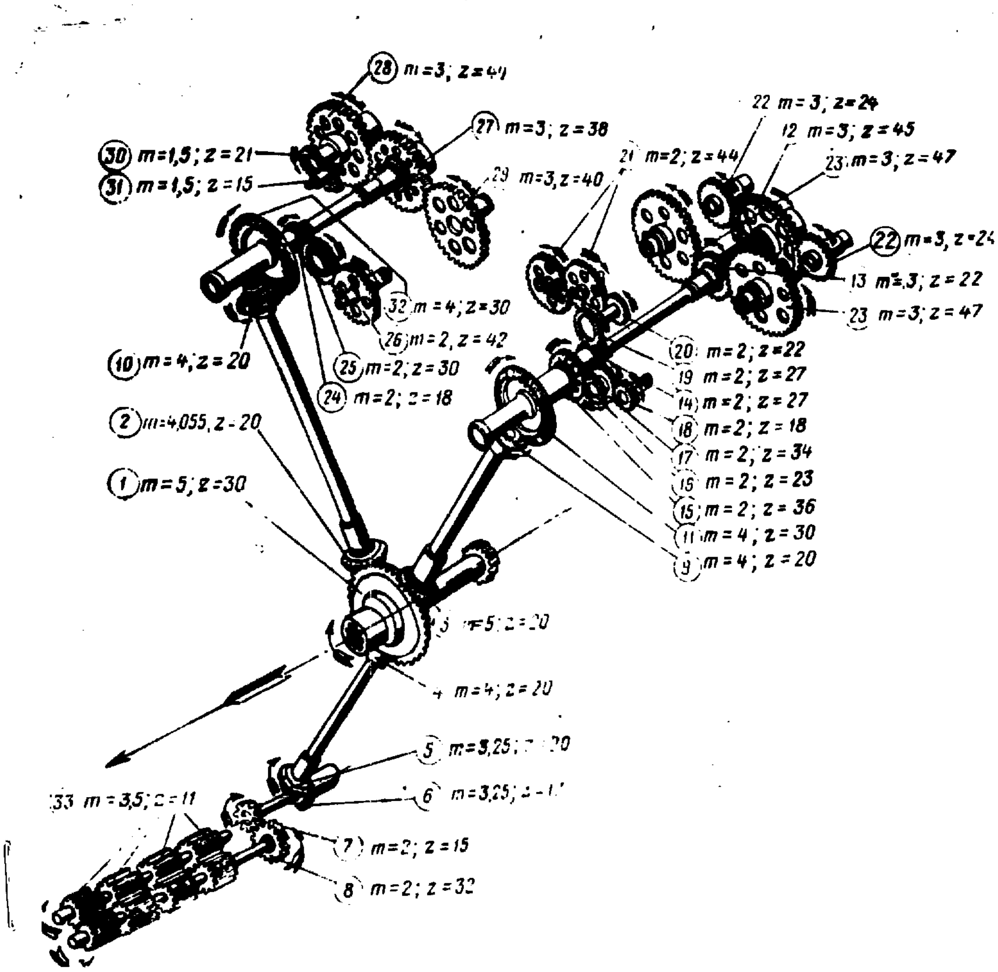

Fig. 7 Kinematic diagram of the engine

S-E-C-R-E-T
No Foreign Dissem

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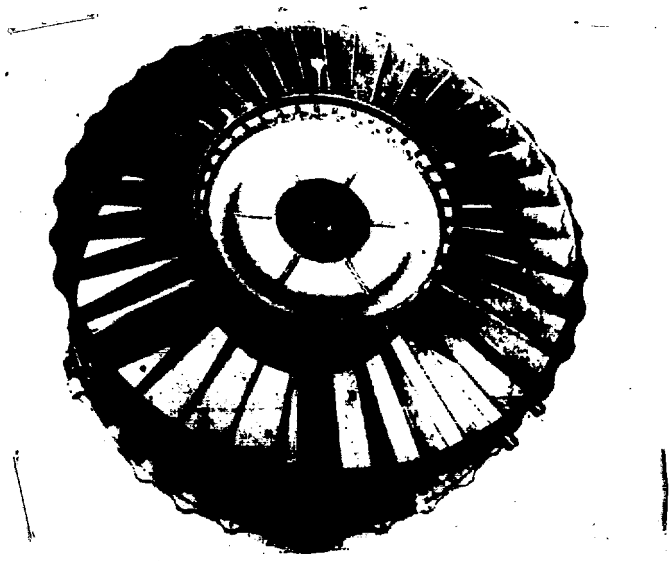

Fig. 8 Front section of compressor housing

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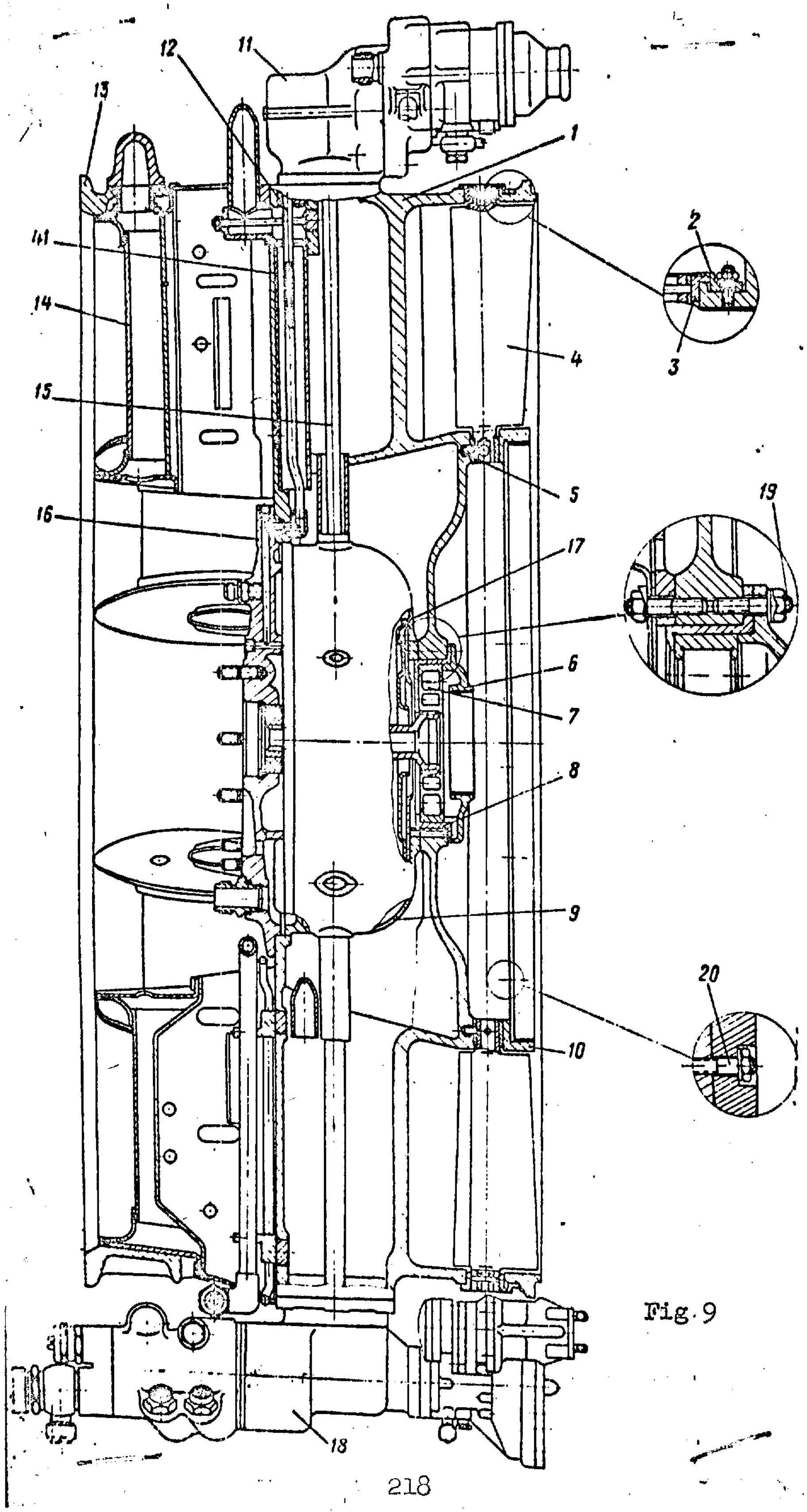

Fig. 9

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Fig. 9 Longitudinal section of front compressor housing
1. Main case 2. Guide ring [?] 3. Sleeve 4. Guide vane 5. Pin 6. Cap 7. Roller bearing 8. Front bearing housing 9. Case 10. Bearing cover 11. Left intermediate drive 12. Oil supply tube from the left intermediate drive to the main [drive] 13. Reinforcing ring 14. Reinforcing strut 15. Shaft of left intermediate drive 16. Main drive housing 17. Oil filter 18. Lower drive 19-20. Tap bolts 41. Venting tube of main compressor case

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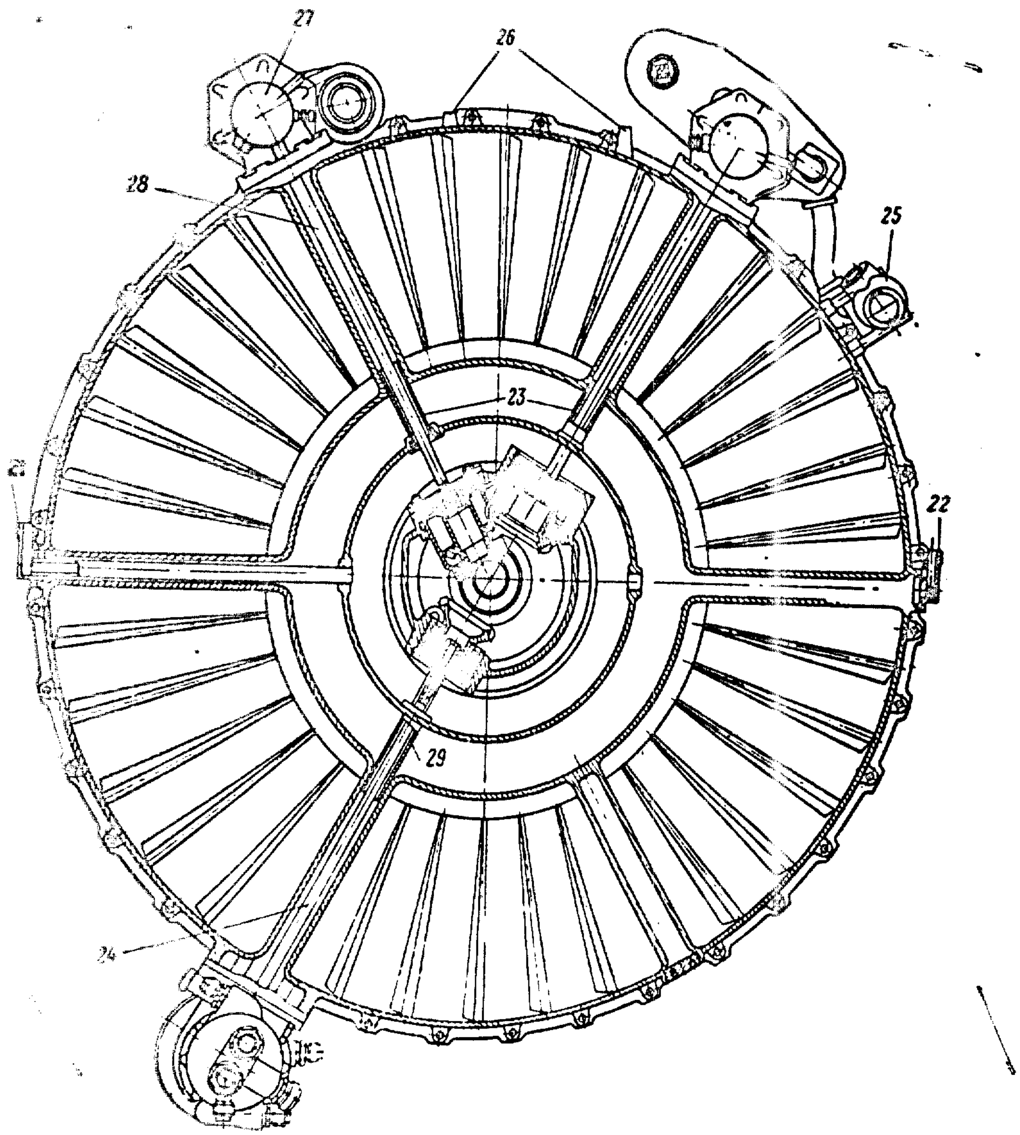

Fig. 10 Cross section of the Front compressor housing
21, 22 Elbow fittings 23. Oil return lines 24. Lower drive shaft
25. Anti-icing system fittings 26. Fastening lugs of PT-4M housing
27. Right intermediate drive 28. Right intermediate drive shaft
29. Oil return line

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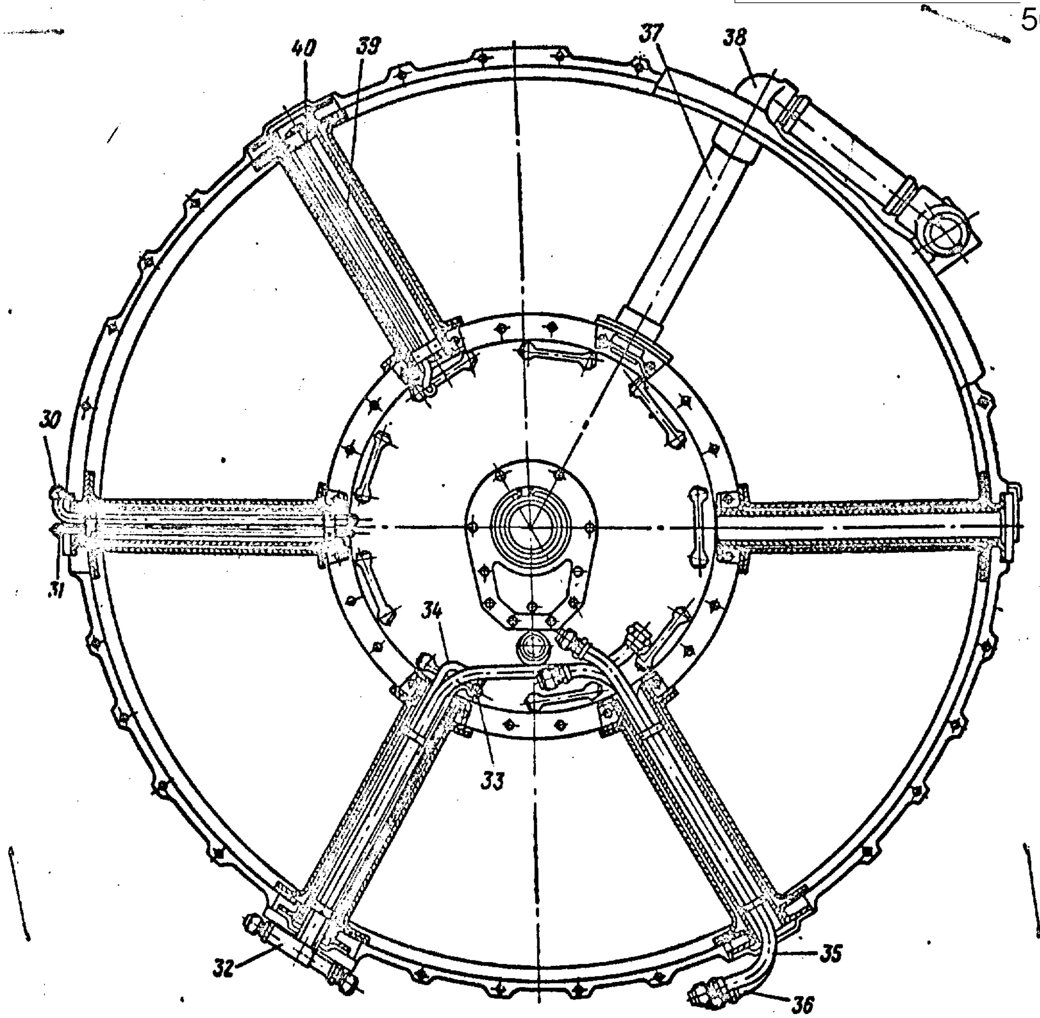

Fig. 11 Section of the front housing of the compressor along the reinforcing struts.
30. Turbostarter air line 31. Turbostarter fuel line 32. Return line to oil tank 33, 34. Starter drain lines 35. Oil line from tank to turbostarter 36. Oil line from the lower engine drive to turbostarter 37. Reinforcing strut 38. Anti-icing system fitting 39. Electrical cable 40. Oil line to SD-24A pressure indicator

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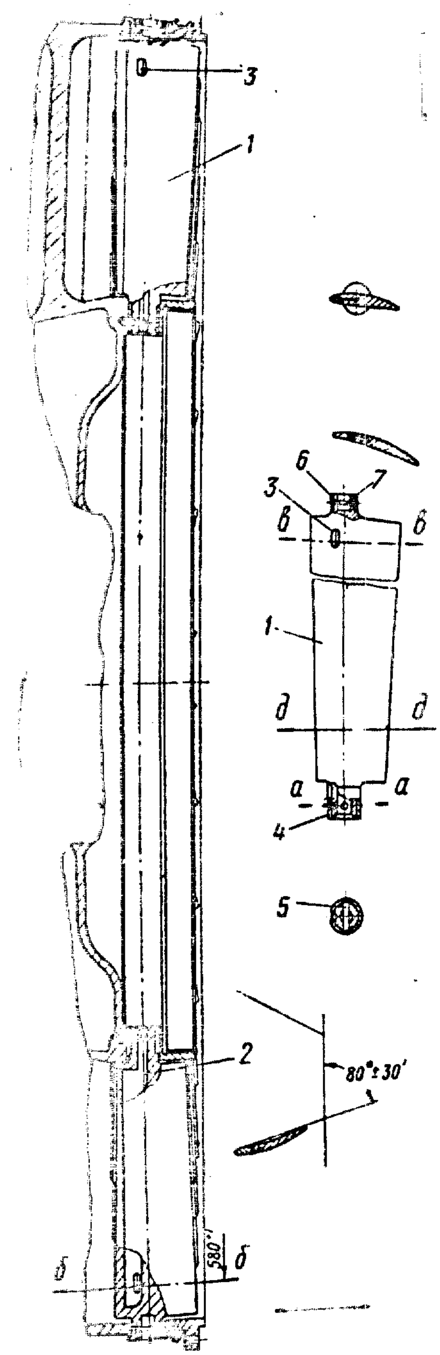

Fig. 12 Compressor [inlet] guide vane installation.
1. Vane 2. Opening for warm air supply for heating 3. Vane air exhaust opening 4, 6. Sleeves 5, 7. Pins

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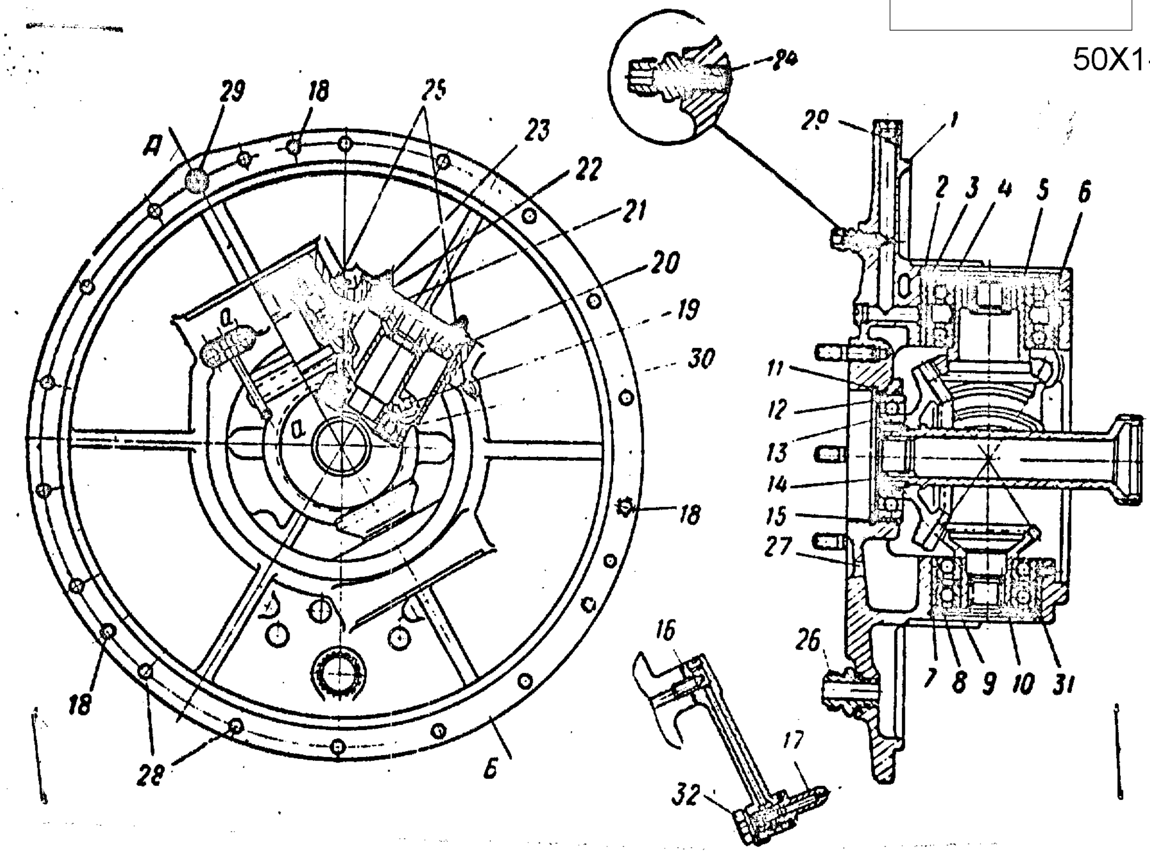

Fig. 13 Main Drive.

1. Main drive housing 2, 7, 11, 23. Retainer rings 3, 8, 12, 22. Calibrated washers 4, 9, 13, 21, 30. Ball bearings 5. Level gear to the lower drive 6, 15, 31. Sleeves 10. Level gear to the lower drive 14. Bevel gear of main drive 16. Nozzle case 17. Nozzle 18. Threaded opening 19. Bevel gear to right intermediate drive 20. Cylindrical sleeve 24. Return valve 25. Nozzles 26. Turbostarter oil return connection 27. Air breather opening of turbostarter and upper part of compressor housing 28. Openings for bolts 29. Oil inlet to housing 32. Bolt

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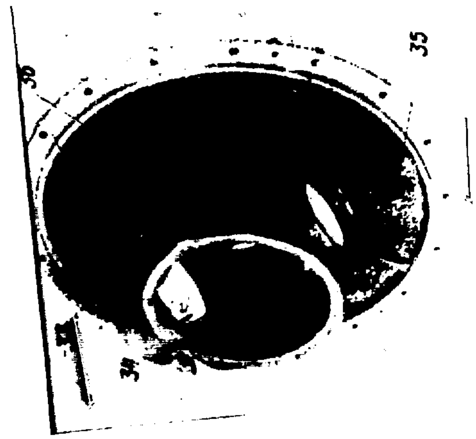

Fig. 14 Main drive housing
33. Bolt for fastening cyliner insert 34. Bolt for fastening oil inlet nozzle to roller bearing of the front support 35. Opening for draining oil from turbostarter 36. Nozzles for oil to teeth of the bevel gears

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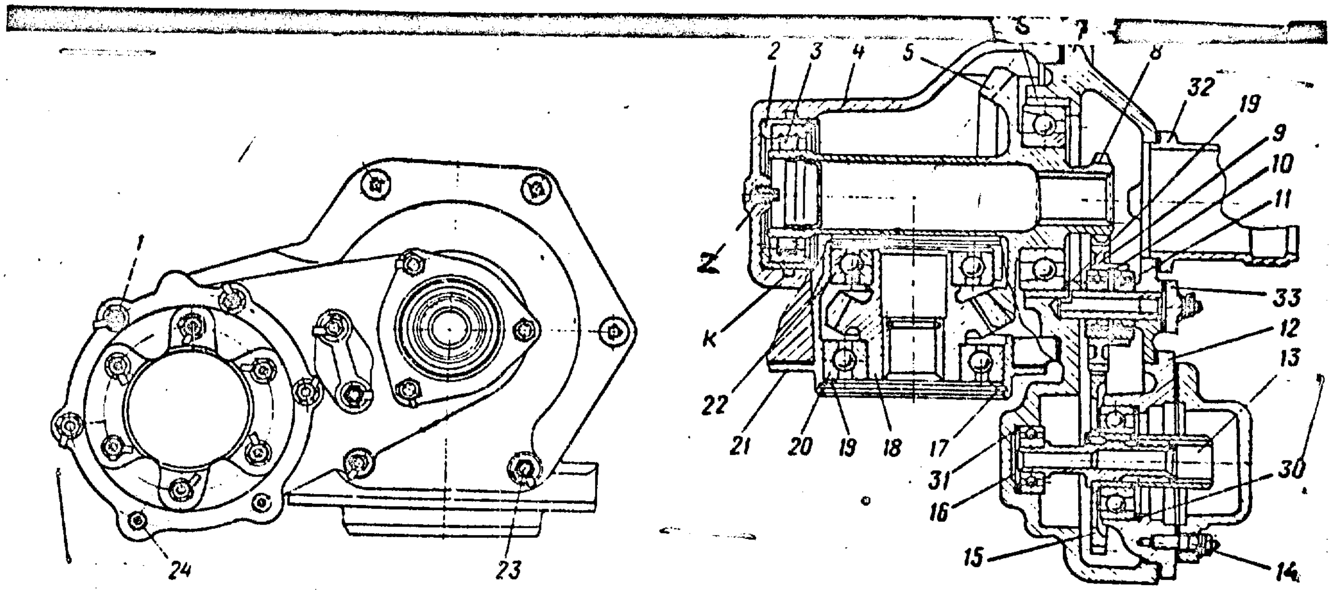

Fig. 15. Right intermediate drive
1. Bolt 2. Roller bearing case 3. Roller bearing 4. Right intermediate drive housing 5. Drive ring of bevel gear of right intermediate drive 6. Bearing sleeve 7. Compressor drive housing 8. Drive ring of gear (5) 9. Intermediate gear of left intermediate drive 10. Retainer (spacing, distance) ring 11. Ball bearing 12. Housing unit 13. Splined coupling 14. Stud bolt for fastening AK-150N compressor 15. Compressor drive gear 16. Shaft 17. Retainer (spacing, distance) ring 18. Bevel gear of the intermediate drive 19. Spacer insert 20. Ball bearing 21. Cyliner insert 22. Ball bearing 23. pin 24. Sleeve 30, 31. Spacer inserts 32. Shaft adapter unit 33. Cover Z. Nozzle for oil to the splined connection K. Annular groove

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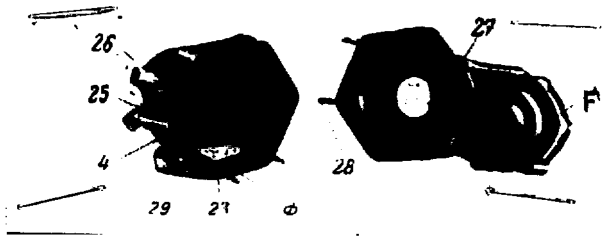

Fig. 16 Housing of right intermediate drive with compressor drive housing
4. Intermediate drive housing 7. Compressor drive housing
23. Stud bolt 25. Oil line connection 26. Opening for oil to compressor drive housing 27. Opening for oil to compressor drive housing 28. Stud bolt 29. Nozzle for lubrication of bevel gears
F. Milled channel for return of oil

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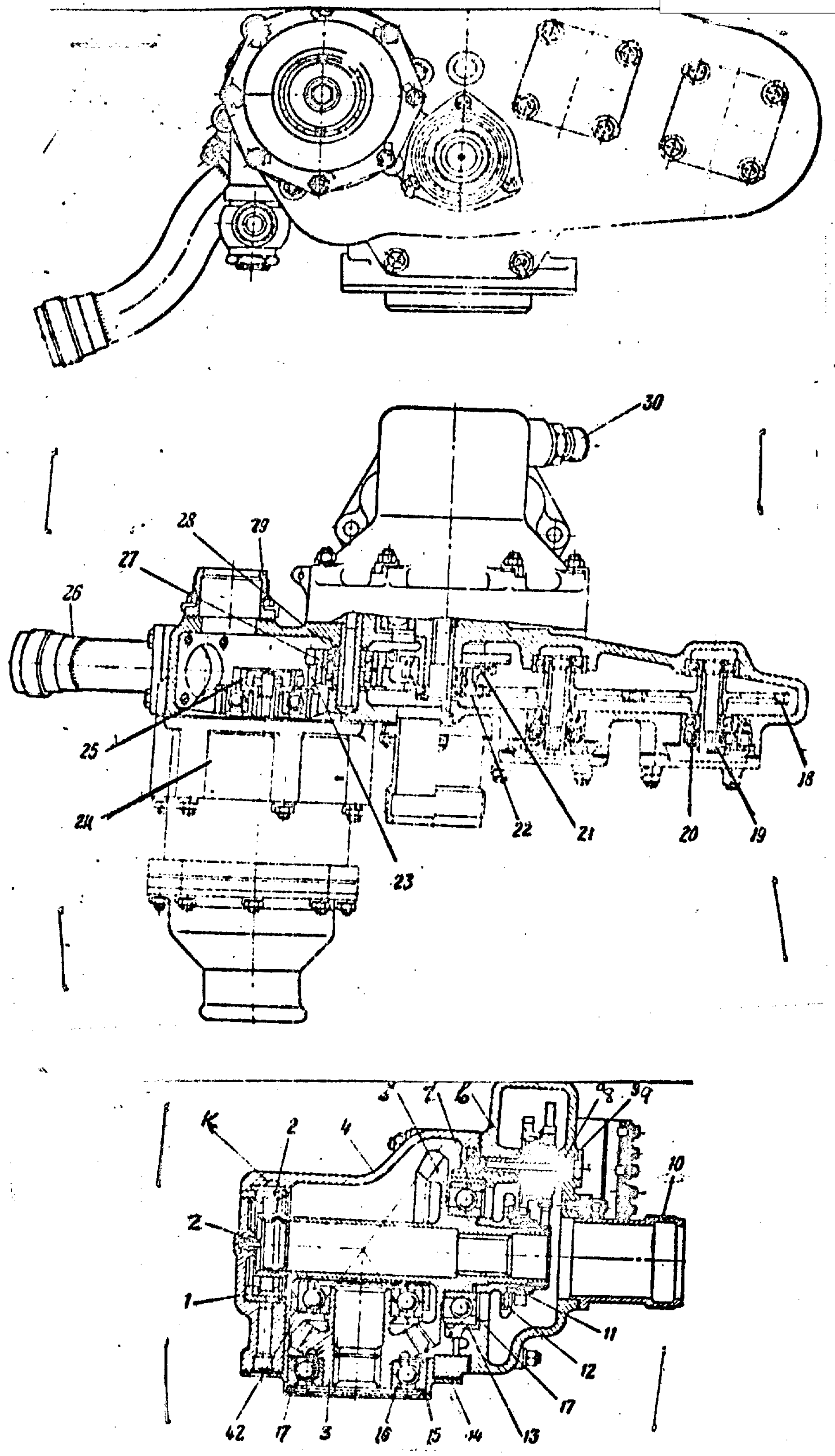

Fig. 17

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Fig. 17 Left intermediate drive

1. Roller bearing sleeve 2. Roller bearing 3. Bevel gear of left intermediate drive 4. Left intermediate drive housing 5. Bevel gear of left intermediate drive 6. Tachometer drive housing 7. Ball bearing 8. Shaft 9. Ball bearing 10. Adapter unit of spring housing 11. Tachometer drive gear 12. Centrifugal de-aerator drive gear 13. Ball bearing sleeve 14. Cyliner insert 15. Retainer ring 16. Ball bearing 17. Spacer 18. Tachometer drive gear 19. Shaft 20. Packing 21. Intermediate gear of tachometer drive 22. Intermediate gear of tachometer drive 23. Large intermediate gear of centrifugal de-aerator drive 24. Centrifugal de-aerator 25. Drive gear centrifugal de-aerator 26. Tube for venting air front transmission cavity 27. Small intermediate fear of the centrifugal de-aerator drive 28. Shaft 29. Adapter unit 30. Oil supply nozzle Z. Nozzle for oil to the spring groove K. Annular groove 42. Ball bearing

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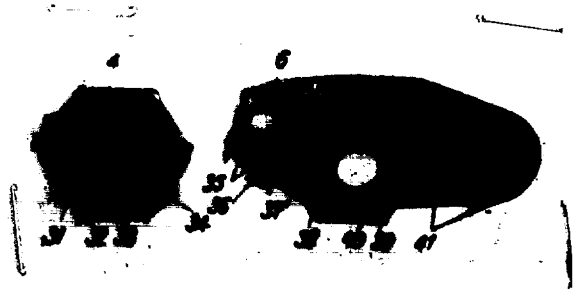

Fig. 18 Left intermediate drive housing with tachometer housing

4. Left intermediate drive housing 6. Left intermediate tachometer drive housing 31. Nozzle for oil to bevel gears 32. Bolt 33. Opening for outflow of oil 34. Lower flange 35. Bolt for fastening adapter unit 36. Bolt for fastening vent tube 37. Opening for pin 28 38. Bolt for pin 28 of the centrifugal de-aerator 39. Openings for bolts 40. Bolt for fastening adapter unit 41. Bolt for fastening tachometer transmitters

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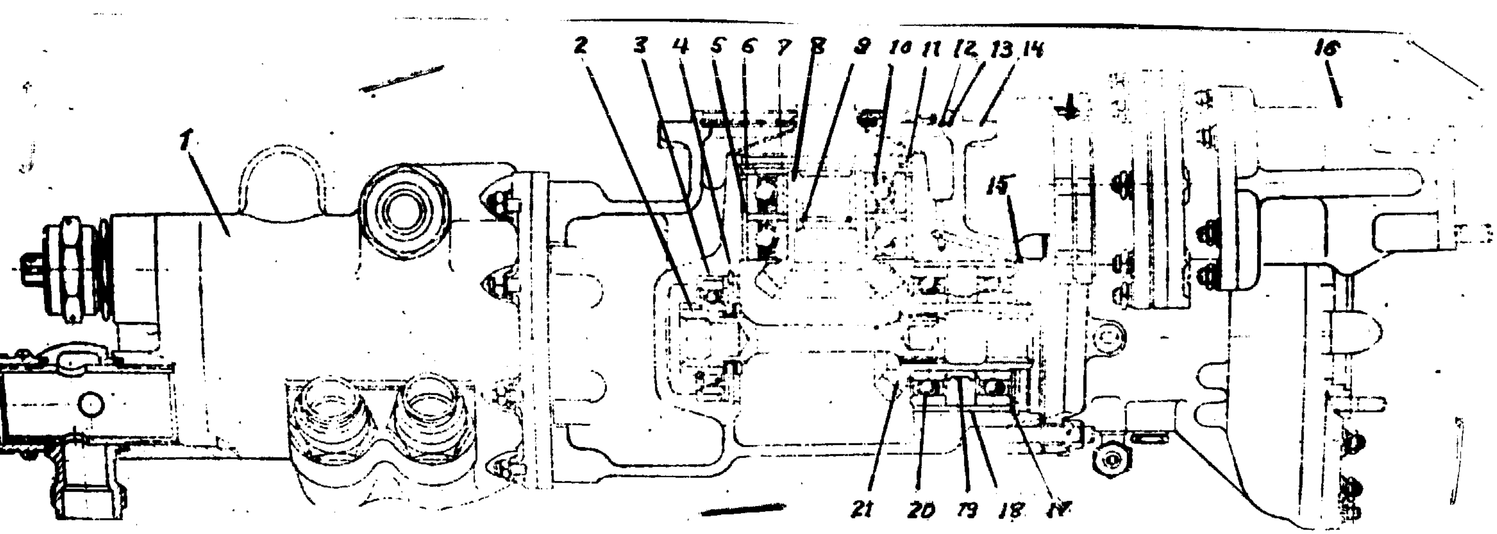

Figure [illegible]. Lower drive
1. Oil pump 2. Oil pump drive 3. Ball bearing sleeve 4. Retainer ring
5. Ball bearing sleeve 6. Retainer ring 7. Ring (spacer sleeve) 8. Drive gear
9. Retainer ring 10. Ball bearing 11. Spacer 12. Screen 13. Retainer ring
14. Lower drive housing 15. Retainer Ring 16. CN-1A fuel pump 17. Spacer
18. Ball bearing sleeve 19. Separator sleeve 20. Ball bearing 21. Bevel gear

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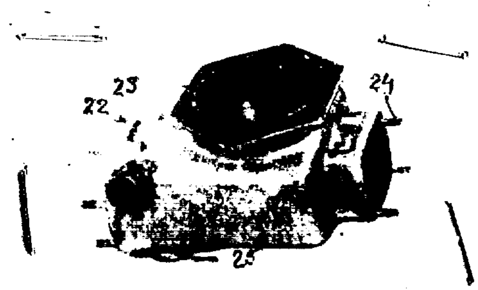

Fig. 20 Lower drive housing
22. Line connection 23. Stud bolt 24. Stud bolt 25. Threaded opening for oil drain cock

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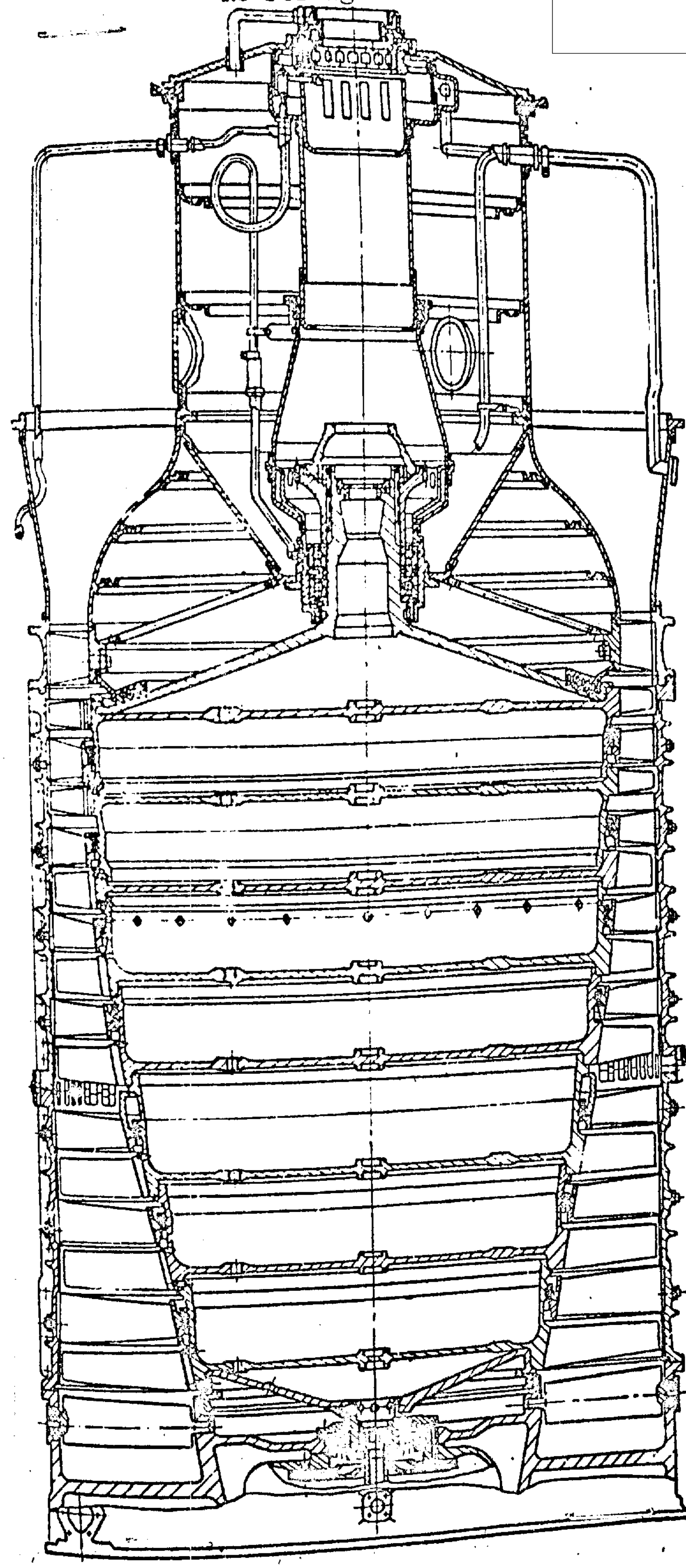

Fig. 21 Longitudinal section of compressor

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Fig. 22 General view of compressor with half of center case removed.

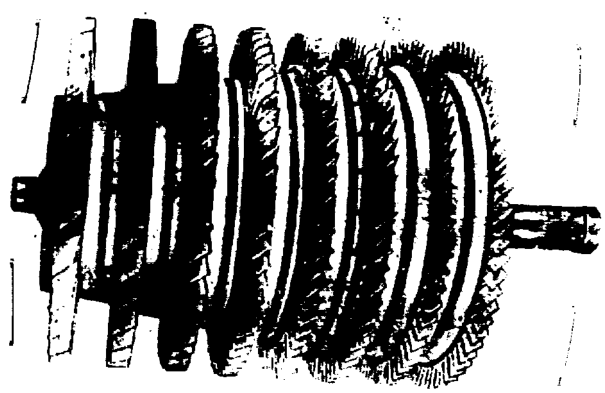

Fig. 23 Compressor rotor

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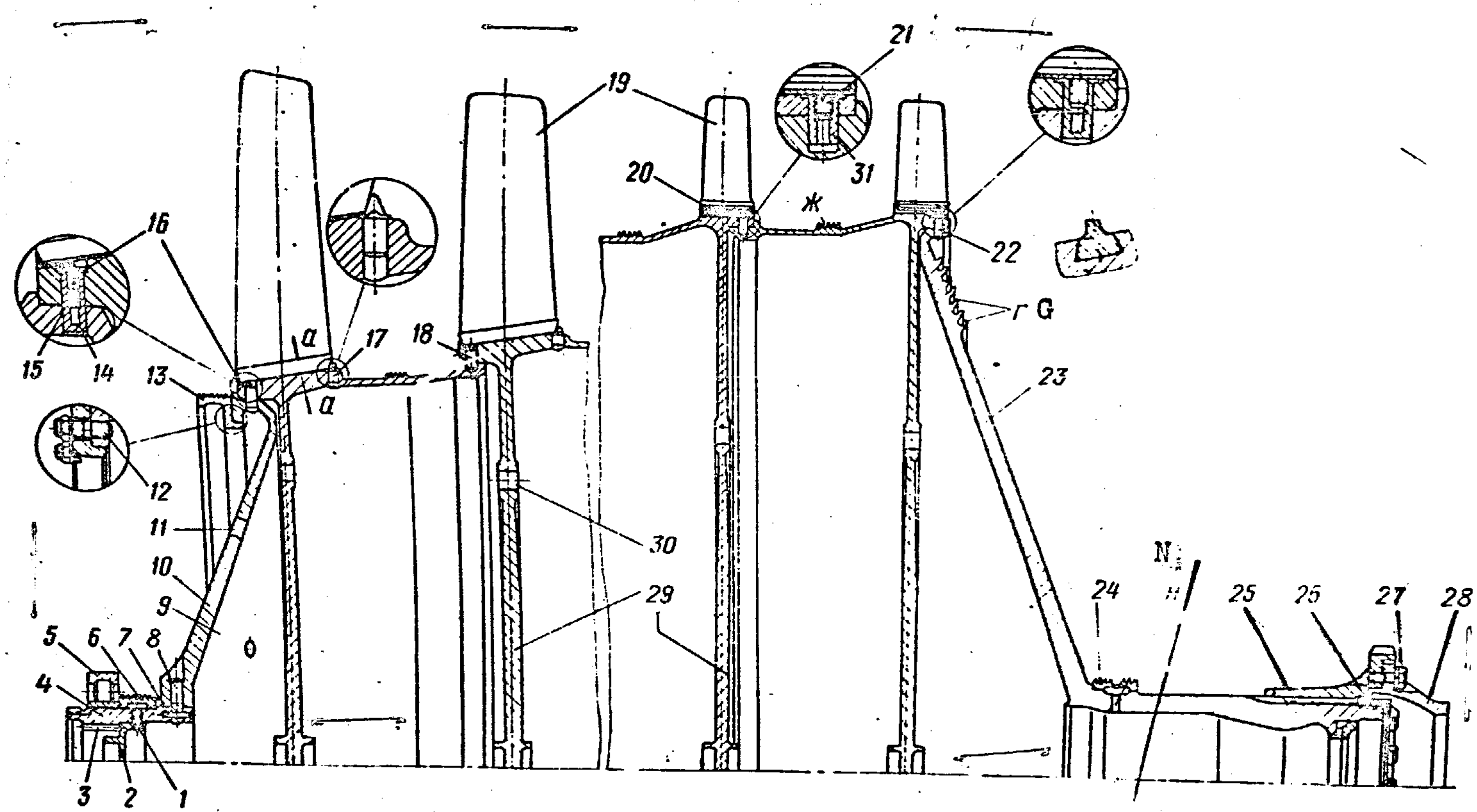

Fig. 24. Compressor rotor (section)
1. Stop 2. Blind flange 3. Splines 4. Front journal 5. Front roller bearing 6. Front bearing seal 7. Pin 8. Pin 9. Front journal assembly 10. Front journal 11. Air supply openings to the relief cavity 12. Screw 13. Front journal seal 14. Bolt 15. Bolt 16. Lock pin 17. Bevel pin 18. Bolt 19. Blades 20. Lock pin 21. Balancing weight 22. Bolt 23. Rear journal (cone) 24. Rear journal seal 25. Splined drive coupling 26. Nut 27. Bolt 28. Ball bearing cover 29. Compressor rotor disc 30. Openings in disc walls 31. Bolt

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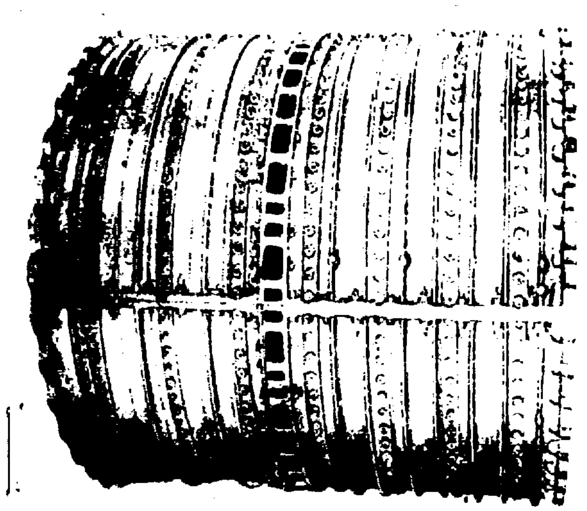

Fig. 25. Center compressor case (assembled)

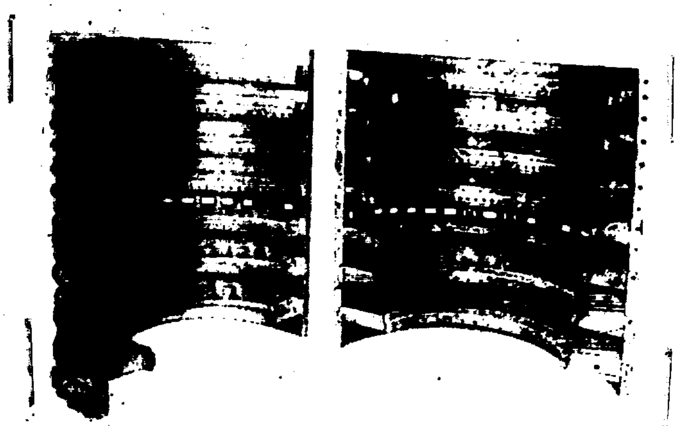

Fig. 26. Center compressor case

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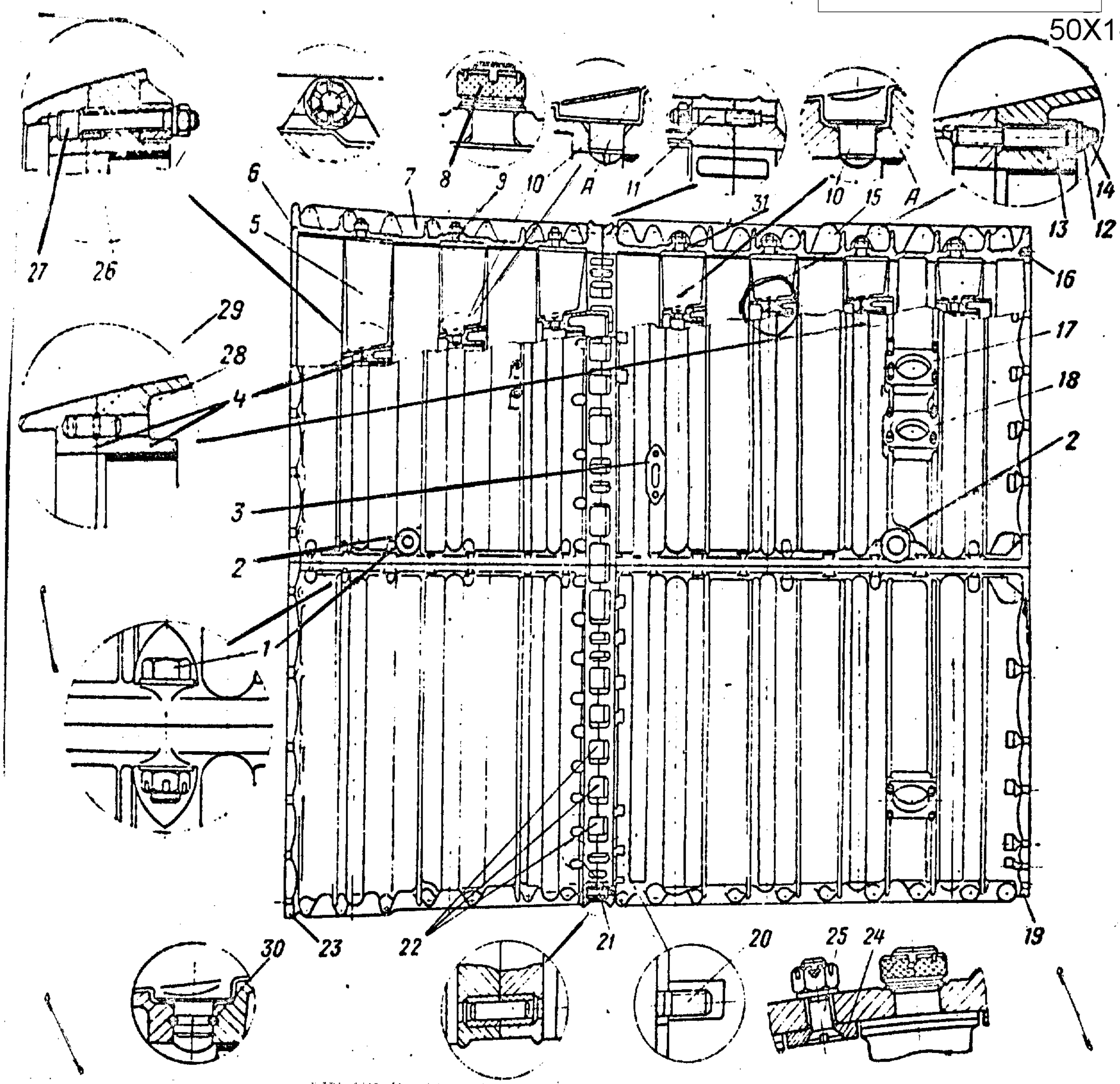

Fig. 27 Center compressor case (section)
1. Bolt 2. Lug 3. Flange [mounted unit] for bleeding air for cabin pressurization 4. Inner semi-circular [elements] of stator vanes 5. Stator vane 6. Annular recess 7. Front section of center case 8. Nut 9. Stator vane anchor bolts 10. Stator vane anchor fittings [female threads] 11. Bolt 12. Nut 13. Sleeve 14. Bolt 15. Rear section of center case 16. Round recess 17. Elbow with valve bleeding air for the anti-icing 18. Flange system fitting for bleeding air for cabin pressurization 19. Rear flange of the center case 20. Bolt 21. Pin 22. Openings for bleeding air from compressor 23. Front flange of the center case 24. [Back-up] ring 25. Bolt 26. Pin 27. Bolt 28. Pin 29. Retainer ring 30 Retainer ring 31. Seal ring

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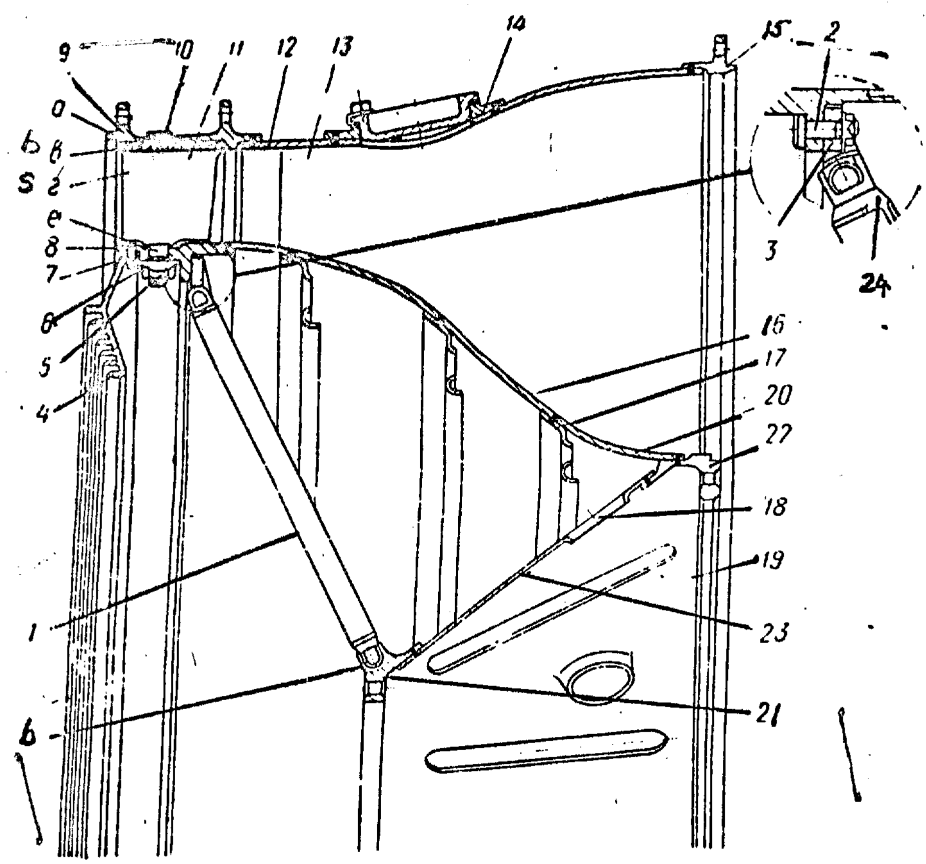

Fig. 28 Rear compressor housing

1. Strut 2. Bolt 3. Bracket 4. Rear seal 5. Nut
6. Lock washer 7. Pin 8. Inner ring of rear housing
9. Rear housing flange 10. Pin 11. Stator vane of state VIII of the compressor 12. Outer liner 13. Combustion chamber
14. Flange 15. Flange, securing combustion chamber case
16. Inner liner of diffuser 17. Flange 18. Opening for air release 19. Center bearing cone 20. Inner liner of the diffuser 21. Flange for securing the center bearing
22. Flange for securing the turbine shaft housing 23. Case
24. Eye b.. Eye

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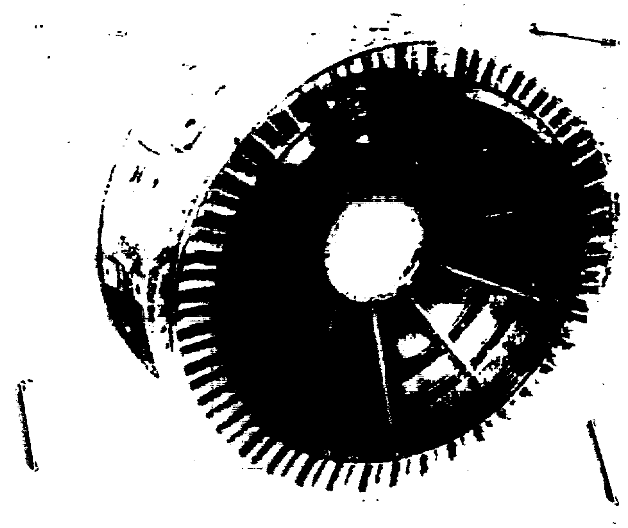

Fig. 29
25. Flange for fastening nozzles 26. Flange

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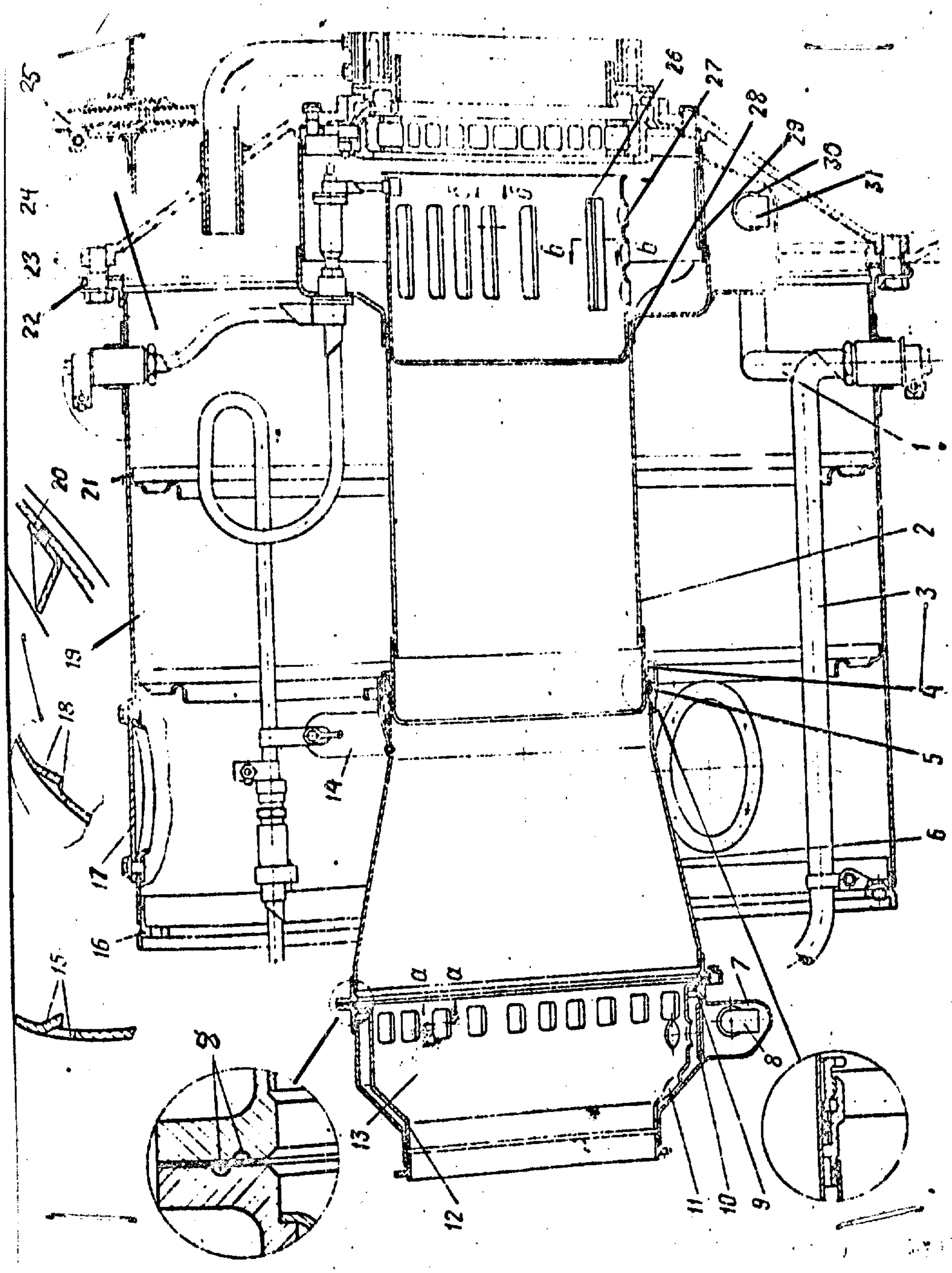

Fig. 30

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Fig. [illegible] Turbine shaft housing and inner section of the shaft case
1. Oil return line from rear bearing cavity 2. Rear shaft case
3. Oil return line from the center bearing cavity 4. Nut
5. Packing 6. Center shaft case 7. Oil collector
8, 31. Traps 9, 11. Oil return openings from the Front and rear shaft cases 10, 29. Screen-foam filter 12, 26. Case
13. Front shaft case 14. Support 15, 18. Cross-sections with bent edges 16. Front flange 17. Cover plate
19. Turbine shaft housing 20. Spacer 21. Reinforcing rings
22. Rear flange 23. Frame for the guide assembly of Stage I of the turbine 24. Sleeve 25. Oil inlet line
27, 28. Oil return openings 30. Oil collector g. Annular recesses

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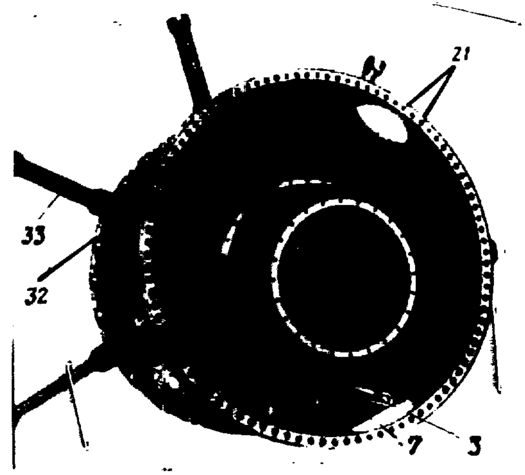

Fig. 31 Turbine shaft housing
[Number illegible] Oil return line from the front bearing housing 7. Oil collector [Number illegible] ring reinforcing elements made of steel sheet [Number illegible] flange for fastening lines 33. Air bleeder tube

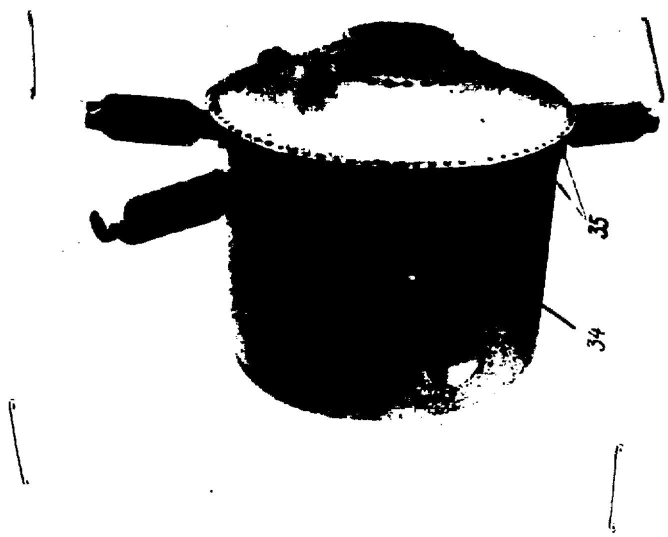

Fig. 32 Turbine shaft housing (general view)
34, 35. Openings with sleeve, for telescoping tube fitting

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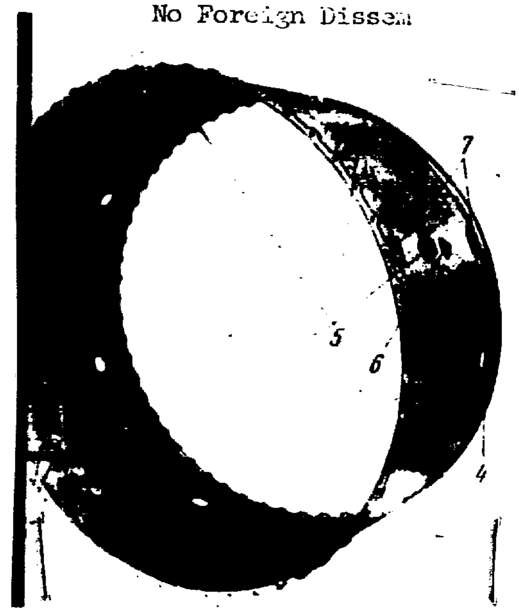

Fig. 33 Combustion chamber case
(Numbers correspond to those on Fig. 34)

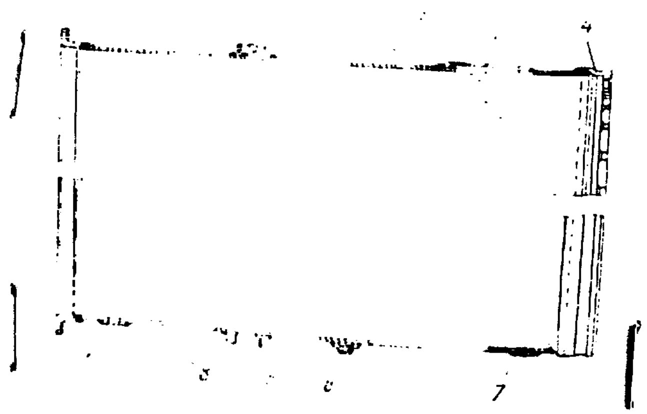

Fig. 34 Combustion chamber case
1. Front flange 2. Wall of the case 3. Flange for line fittings 4. Rear flange 5. Threaded lug for fastening oil lines 6. Lug for fastening line 7. Flange fitting with openings for fuel drain lines 8. Fastening eye

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Figure 35. Components of the Front Bearing

2. Inner ring
6. Rollers
8. Separator
9. Outer ring
10. Housing
11. cover
B. Oil outlet opening
K. Retainer
O. Race

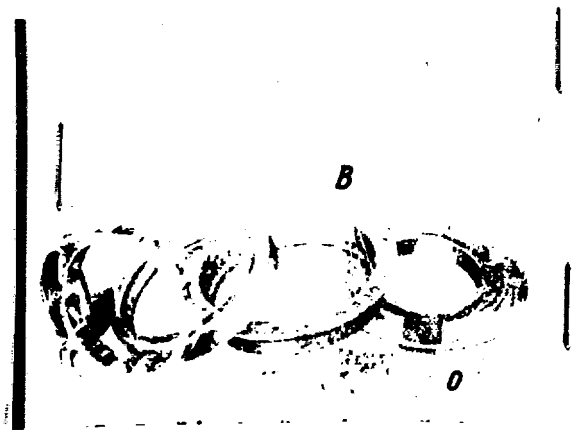

Figure 37. Components of the Center Bearing

6. Oil outlet openings
9. Cover
11. Housing
13. Oil nozzle
14. Adapter

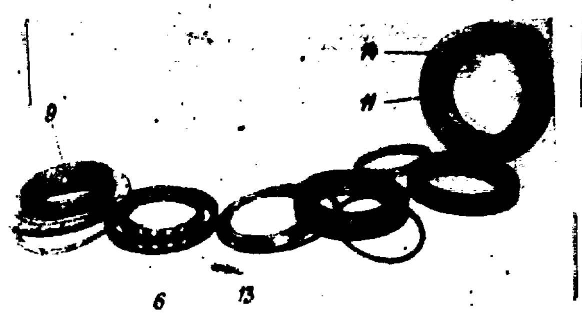

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Figure 36. Front Seal Bearing

1. /Labyrinth seal
2. Inner ring
3. Front journal of the compressor rotor
4. Nut
5. Oil collection ring
6. Roller
7. Nozzle
8. Separator
9. Outer ring
10. Housing
11. Cover
12. Flange
13. Retainer
14. Outer ring race
15. Cover flange
16. Annular
17. Talc layer

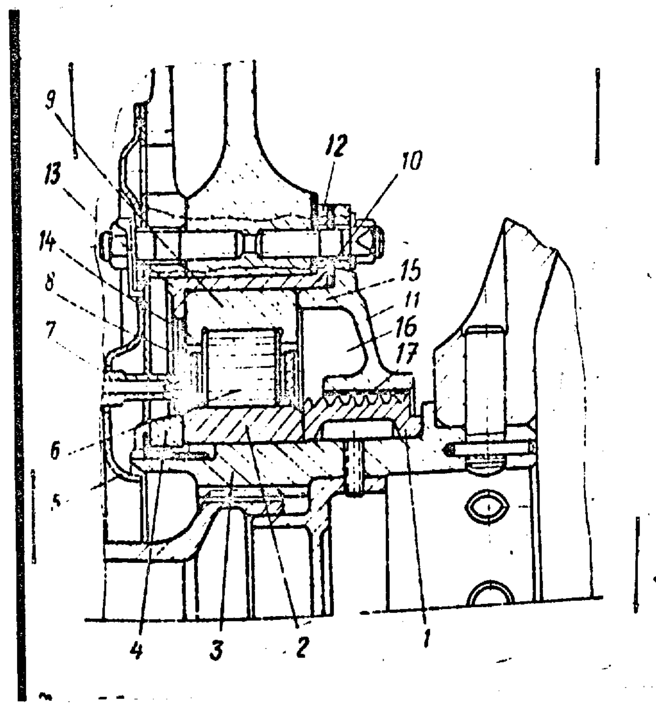

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Figure 38. Center Bearing

1, 2. Inner rings
3. Spacers
4. Ball bearing
5. Oil collector
6. Oil outlet openings
7. Rear Journal seal
8. Talc layer
9. Cover
10. Seal
11. Bushing
12. Separator
13. Oil nozzles
14. Adapter
15. Lug for securing ring
16. Cover flange

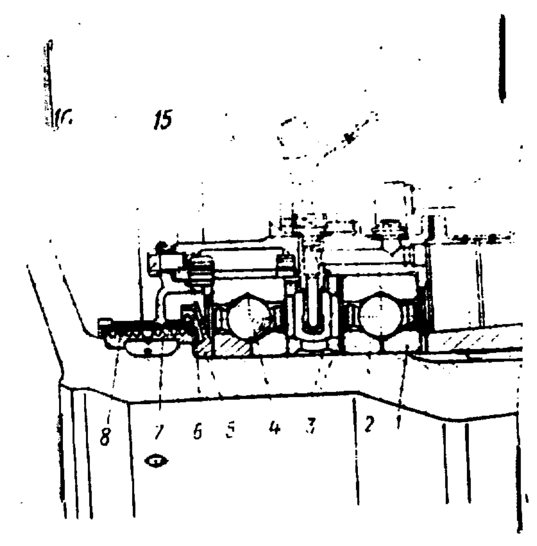

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Figure 39. Components of the Front Bearing

1. Flange
2. Pin
3. Pin
4. Threaded openings in flange
5. Longitudinal channels
6. Threaded opening
7. Ring grooves
8. Housing of the central bearing
9. Longitudinal openings
10. Adapter of the central bearing
11. Opening for the oil nozzle
12. Threaded openings in flange
13. Blind flange
14. Oil inlet opening to the nozzle
a. Adapter flange

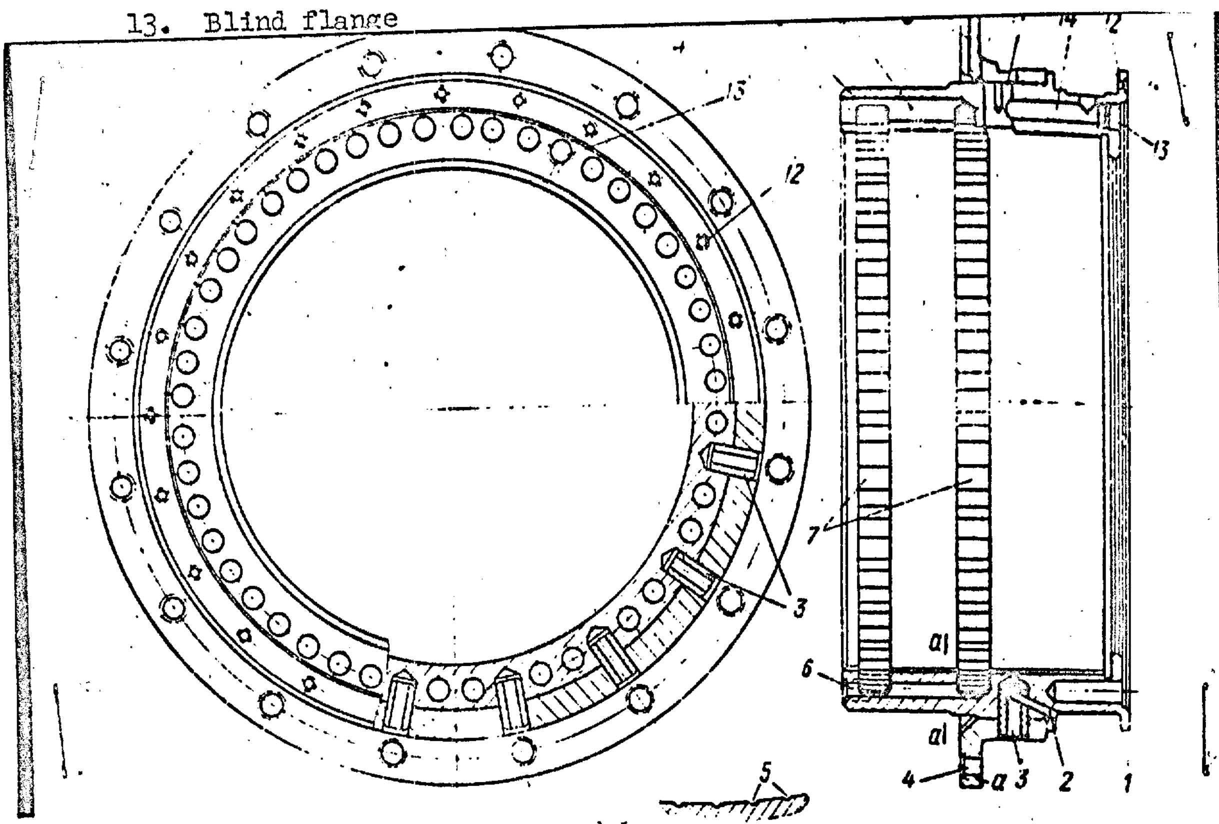

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Figure 86. Rear Bearing

1. Talc layer
2. Nozzle
3. Separator
4. Roller
5. Inner ring
6. Flange of the turbine shaft
7. Nut
8. Nozzle
9. Oil Lines
10. Outer ring
11. Housing of rear bearing
12. Opening
13. Rear cover (inner)
14. Air discharge line
15. Cover of rear bearing (outer)
16. Screen filter

a. Lug
b. Opening for line
c. Cavity between the inner and outer covers

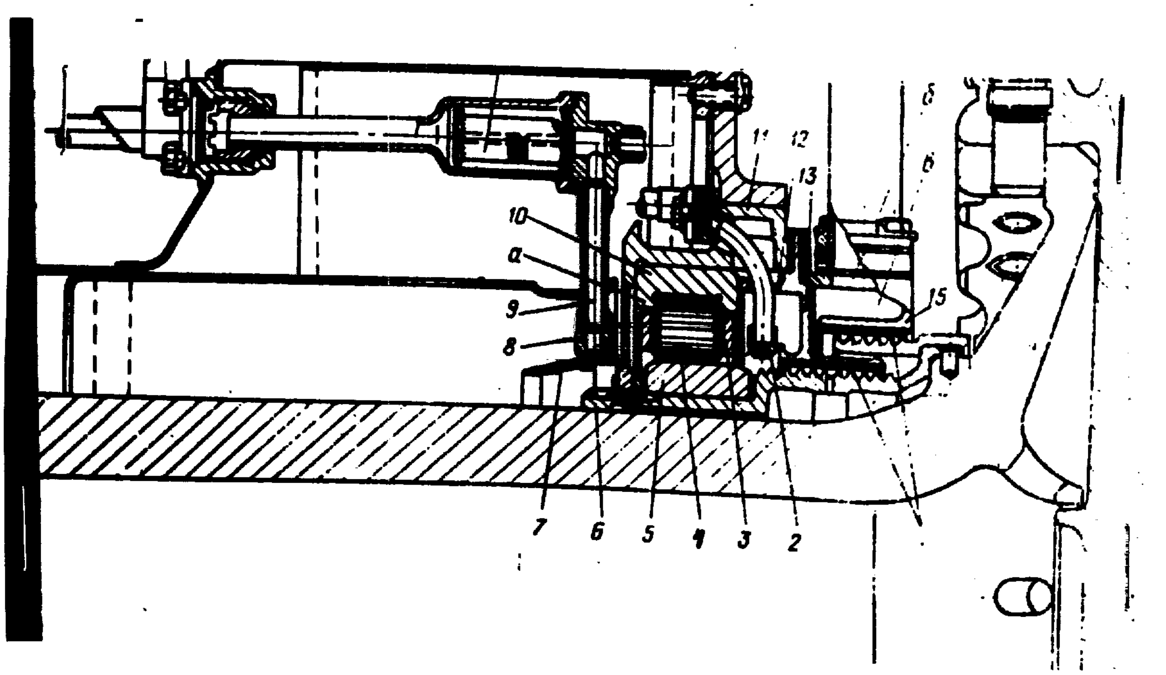

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Fig. 41 Components of the rear bearing.
1. roller bearing 2. pin 3. housing 4. case 5. rear cover (inner) 6. rear cover (outer) 7. case [rear of shaft housing] 8. openings for lines 9. openings for fastening rear cover

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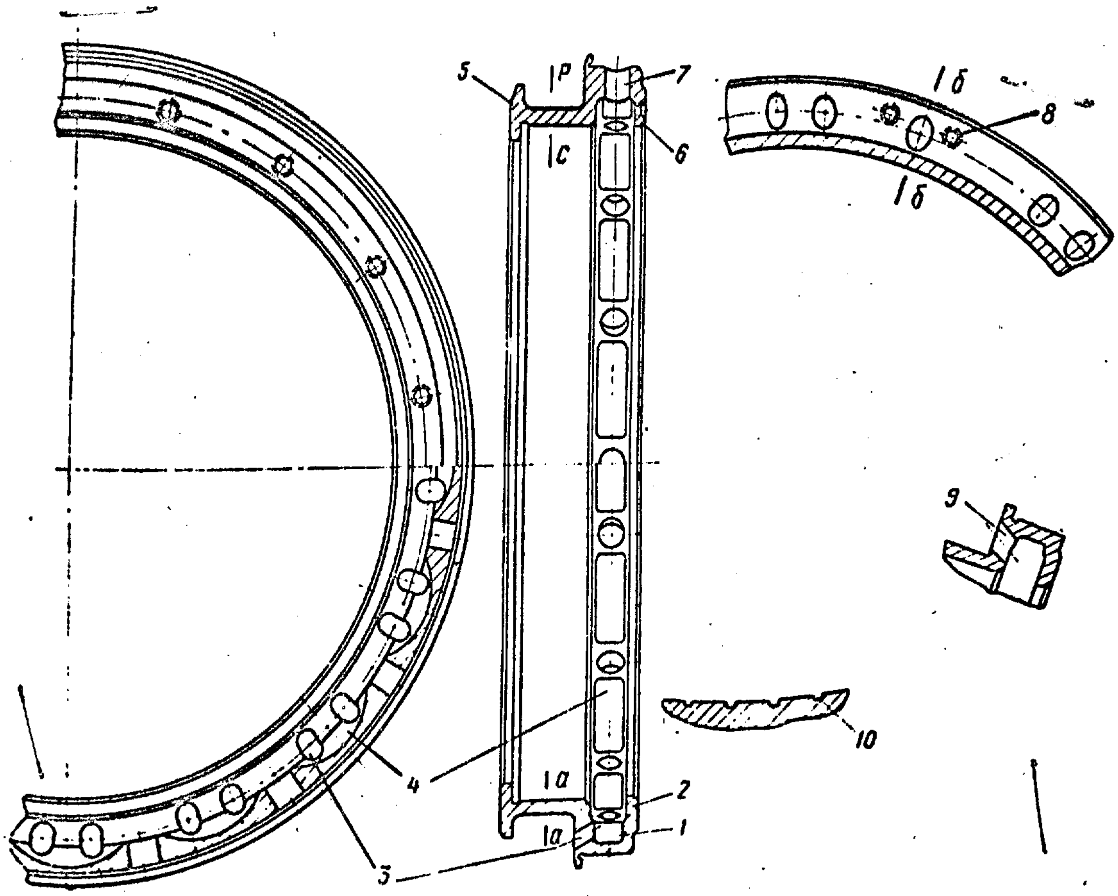

Fig. 42. Housing of rear bearing.
1. Annual channel 2. flange 3. oil outlet opening 4. recess 5. flange 6. centering band 7. opening for radial pin 8, 9. openings for lines and attachment of oil nozzle 10. axial channels.

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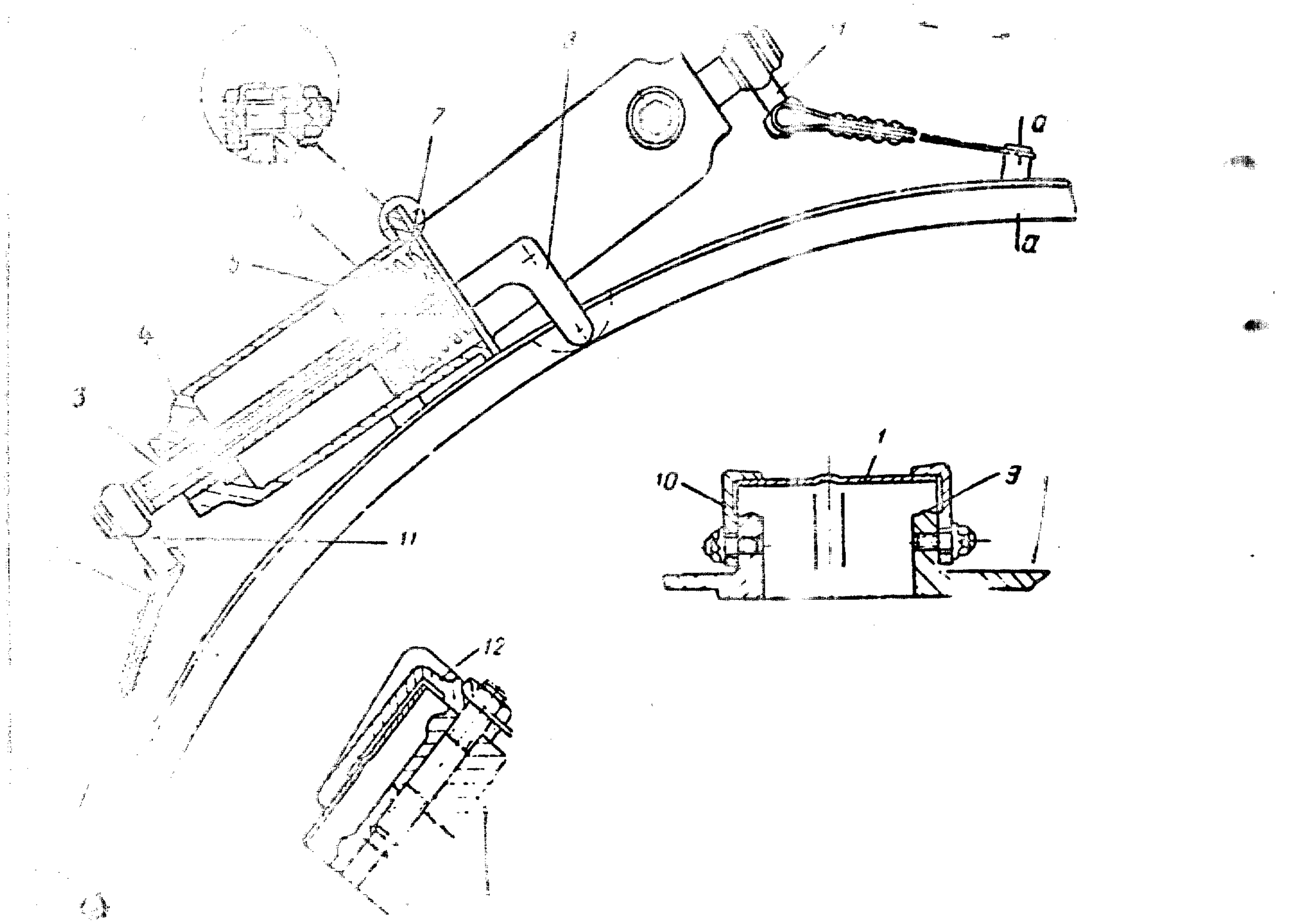

13 [Compressor] bleed mechanism.
1. Band bleed valve 2. eye of band bleed valve 3. piston rod
4. cylinder 5. rubber gasket 6. piston 7. spring 8. frame
9. center case flange 10. retainer 11. lever 12. retainer

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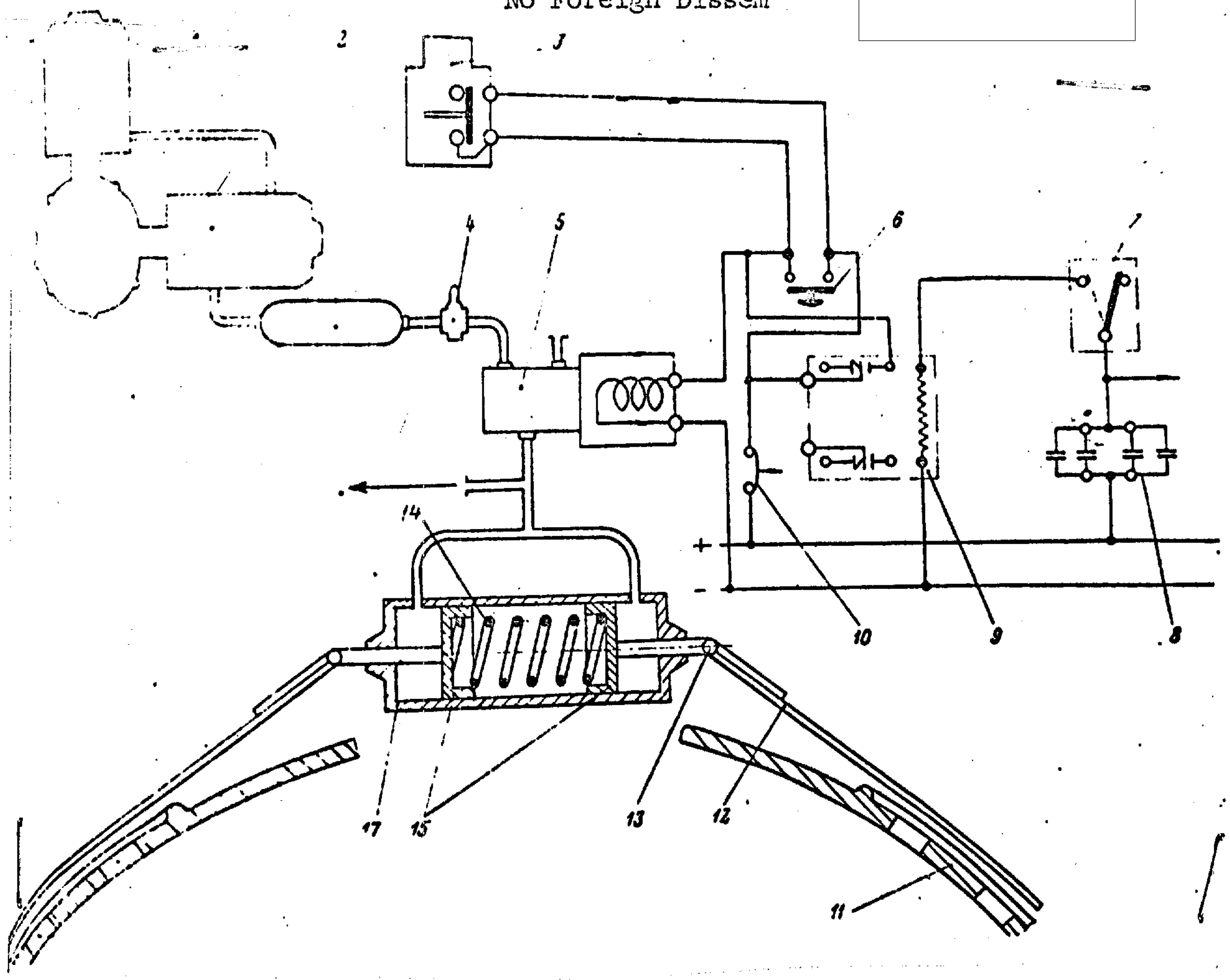

Fig. 44 Compressor bleed valve control.
1. Compressor pistons 2. Compressed air tank 3. Air pressure reduction valve PV-40 4. Electromagnetic air valve 5. Centrifugal transducer CD-3 6. Push button 7. Terminal switch 8. Temperature fire indicator 9. Relay RP-2 10. Circuit breaker (AZS-5) 11. Compressor case 12. Band bleed valve 13. piston rod 14. Spring 15. Pistons 16. Air bleed openings 17. Compressor bleed mechanism.

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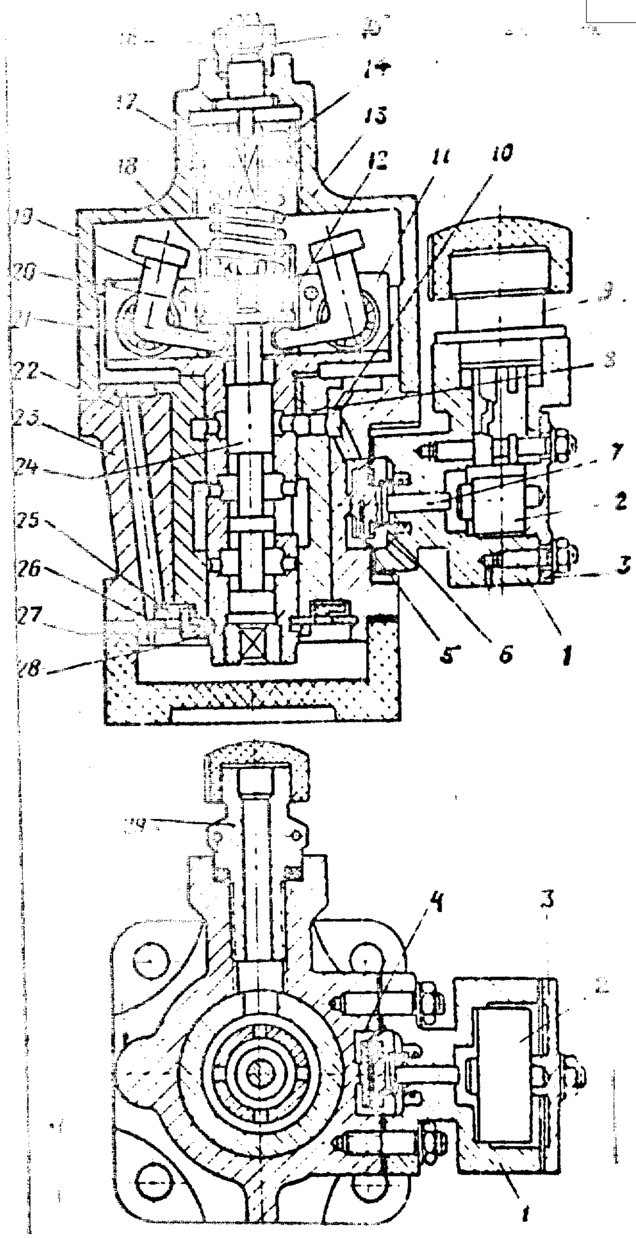

Fig. 45 Centrifugal transducer
1. Housing of diaphragm amplifier 2. Terminal switch 3. Cover diaphragm amplifier 4. Cavity of diaphragm type amplifier; [magnetic?] air tap [?] 5. Diaphragm 6. Spring 7. Slide shaft [bronze] 8. Bushing 9. Slide connection 10. Opening 11. Rotor 12. Disc 13. Cap 14. Adjustment nut 15. Nut 16. Bolt 17. Spring 18. Cupped disc 19. Centrifugal weight 20. Radial ball bearing 21. Radial ball bearing 22. Oil channel 23. Housing 24. Slide valve barrel 25. Spacer 26. Lock ring 27. Retainer ring 28. Seat 29. Line coupling

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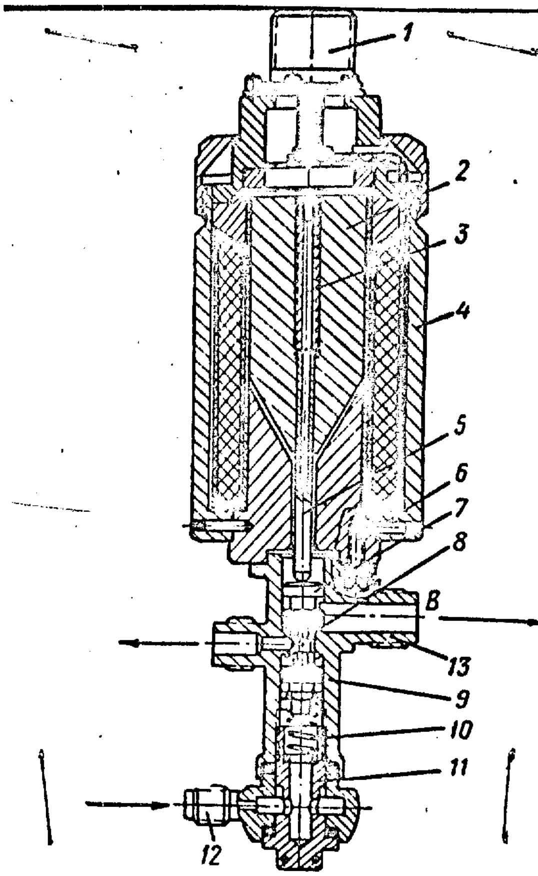

Fig. 46 Electromagnetic air valve.
1. Connector 2. Movable core 3. Adjustment screw 4. Housing of the electromagnet 5. Contact 6. Screw 7. Valve 8. Lifter 9. Housing 10. Spring 11. Fitting 12. Line couping 13. Outlet line coupling.

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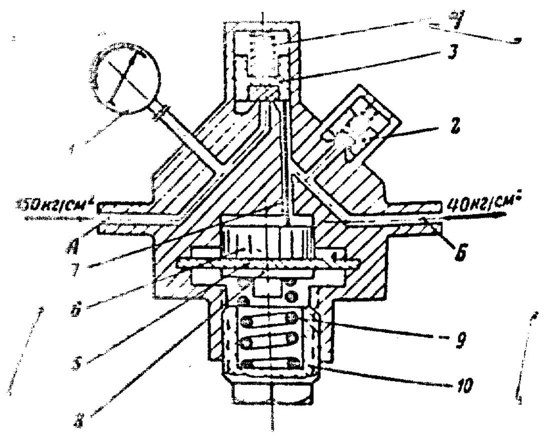

Fig. 17 Diagram of the operation of air pressure reduction valve RV-40.
1. Manometer 2. Safety valve 3. Slide valve 4. Spring
5. Diaphragm 6. Piston 7. Push rod 8. Washer 9. Spring
10. Adjustment screw A. High pressure line Б. Low pressure line.

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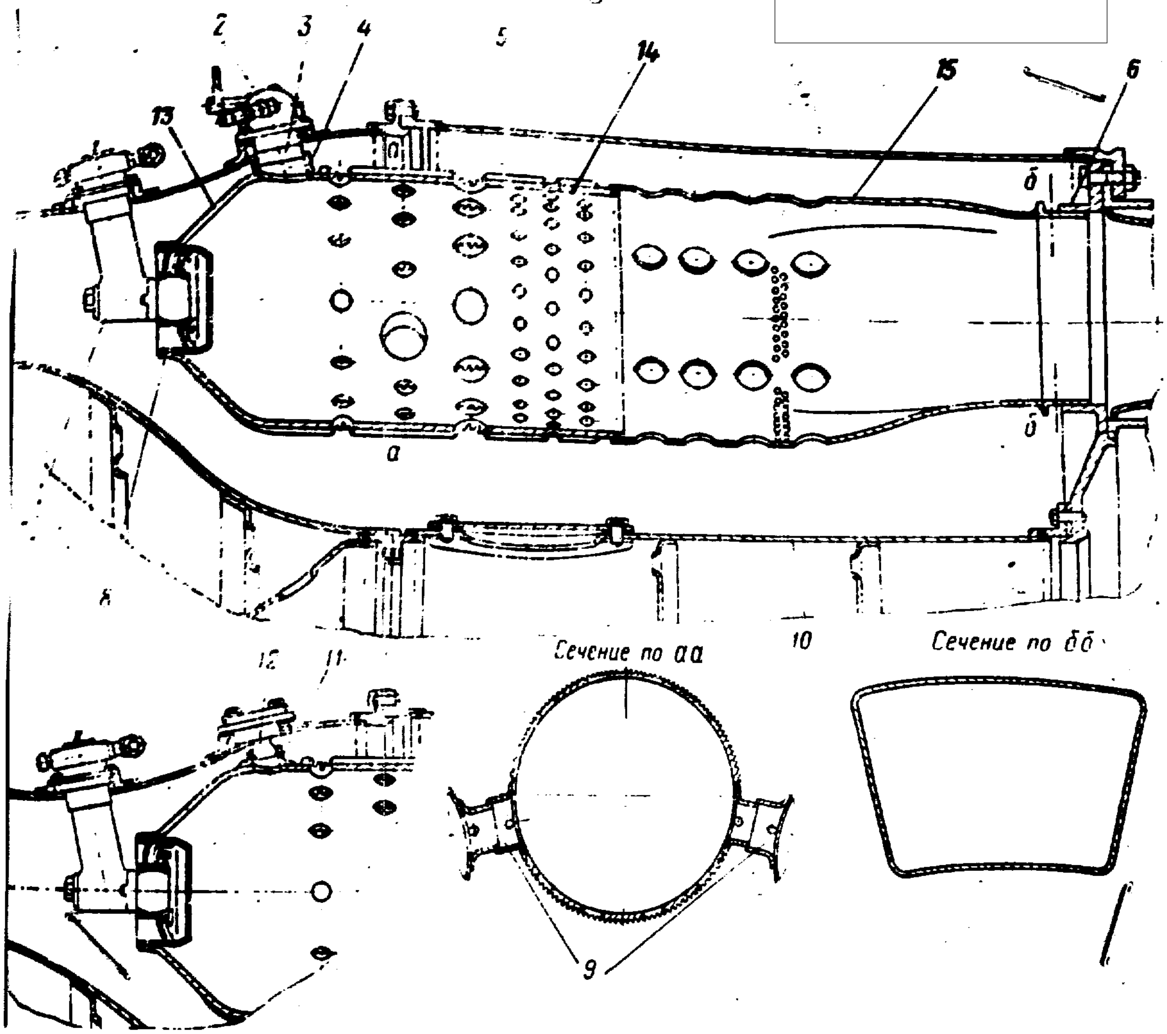

Fig. 48 Burner installation
1. Rear case of diffuser [?] 2. Igniter 3. Attach member
4. Igniter sleeve 5. Outer combustio n chamber case 6. Frame of the Stage I turbine stator vane [exhaust nozzle vane] assembly: generator 7. Fuel nozzle 8. Vortex 9. Crossover tubes
10. Turbine shaft housing [?] 11. Attach bushing 12. Lock
13. Dome 14. Inner liner 15. Rear section of flame tube.

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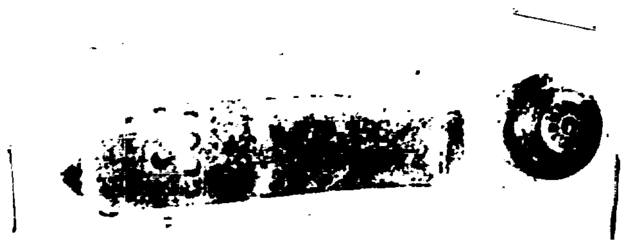

Fig. 49 Flame tube. [Number illegible]
1. Vortex generator 2. Flame tube dome 3. Crossover [flashover] tube coupling 4. Cylinder [?] 5. Rear section of flame tube 6. Nozzle of flame tube [?] 7. Igniter sleeve [?]

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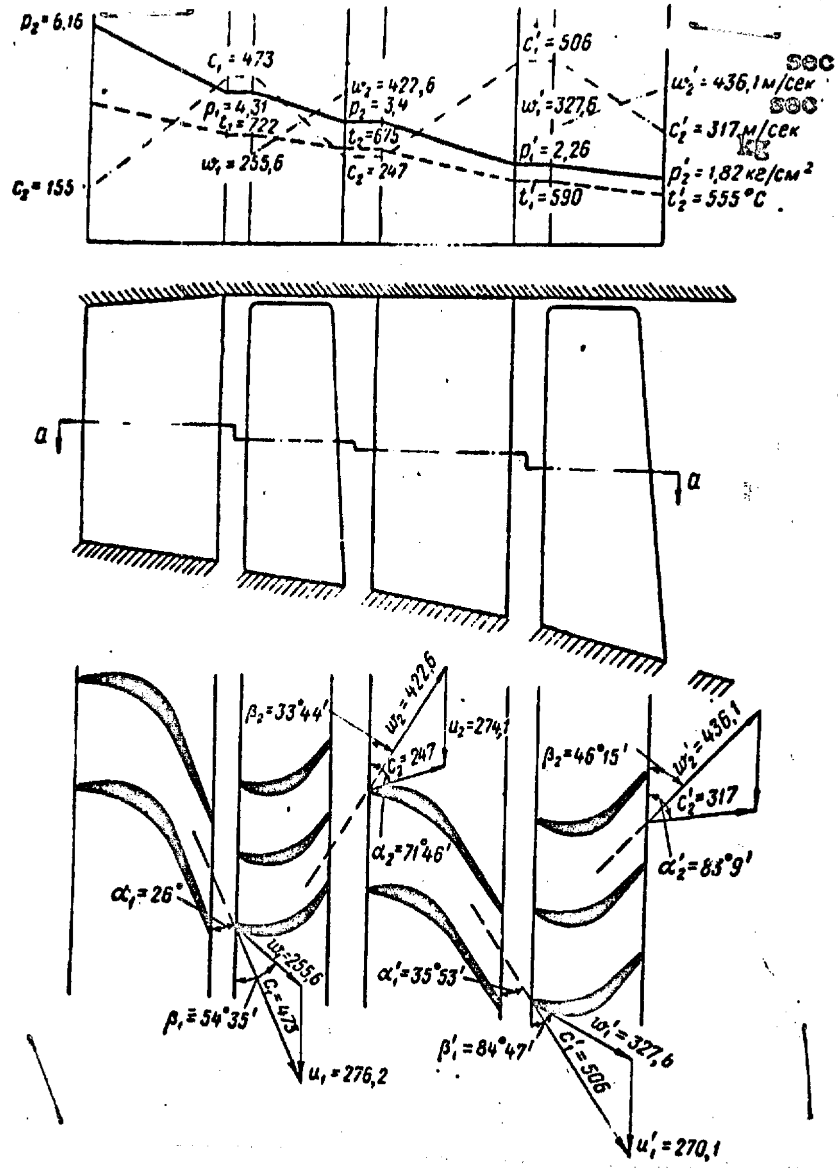

Fig. 50 Diagram of flow section of the turbine; changes in gas parameters and the velocity triangles [rectors] in central section.

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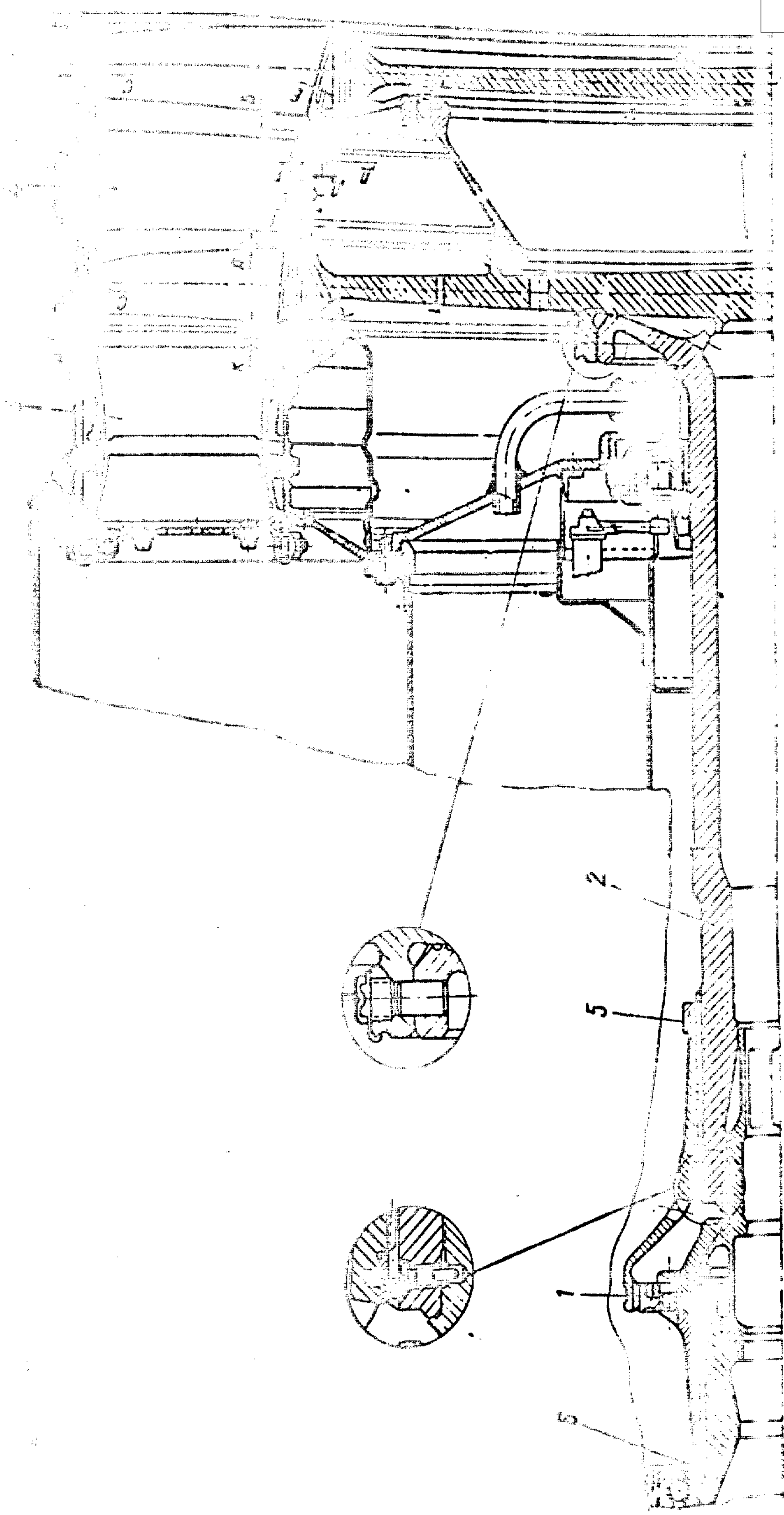

Figure 51. Turbine

1. Splined coupling 2. Turbine shaft 3. Stator vane of Stage I
4. Stator vane of Stage II 5. Locking collar 6. Sized ring

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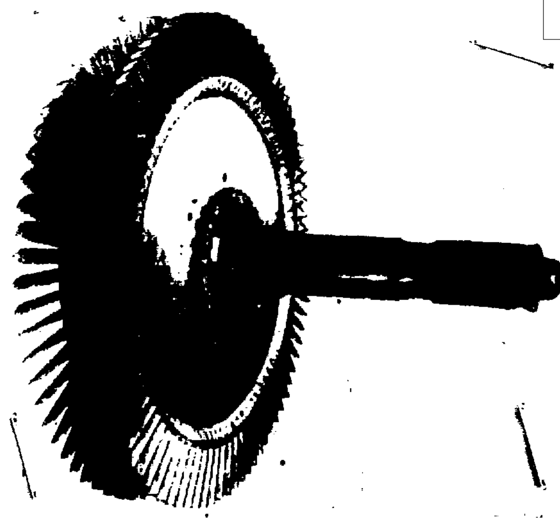

Fig. 52 Turbine rotor (general view)

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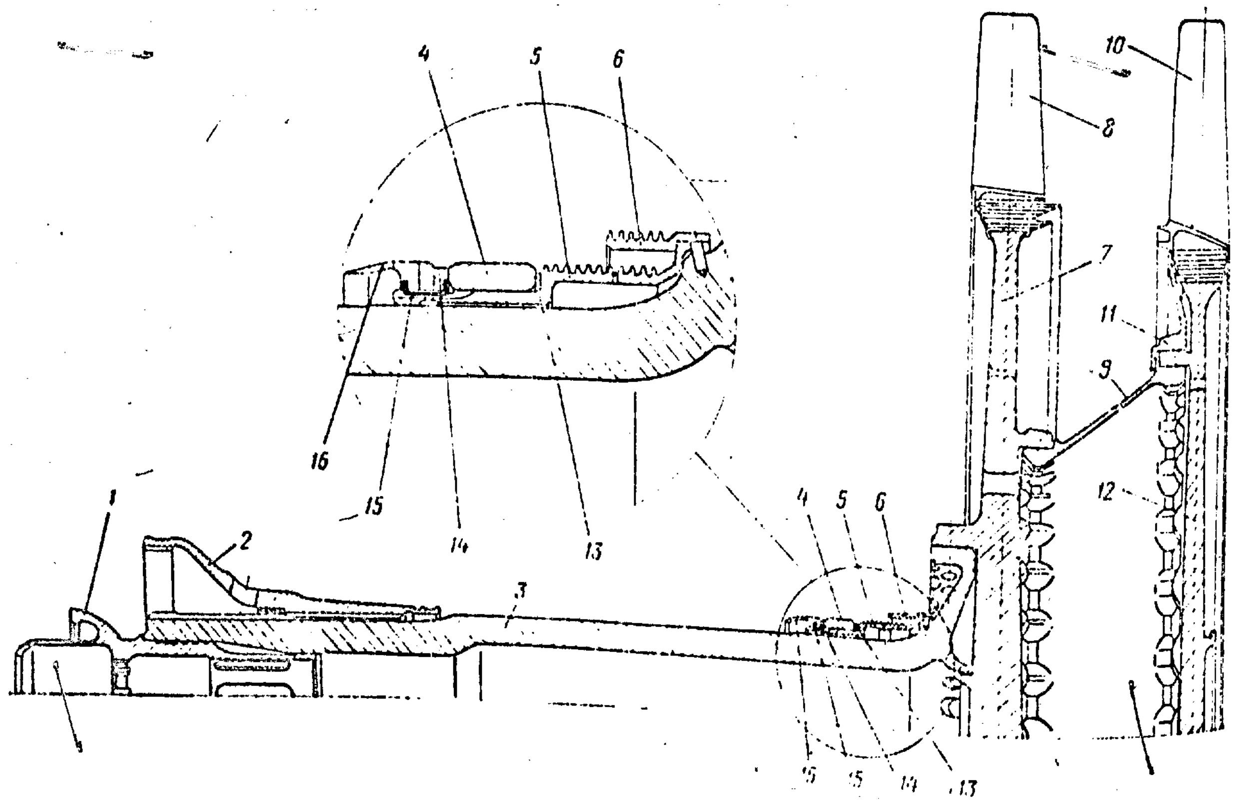

Fig. 53 Turbine rotor (cross section).
1. Ball coupling of shaft 2. Splined drive sleeve 3. Turbine shaft 4. Inner ring of roller bearing 5. Seal sleeve 6. Seal 7. Disc of Stage I 9. Separator 10. Bucket of Stage II 11. Flange 12. Disc of Stage II 13. Spacer ring 14. Ring 15. Lock washer 16. Nut.

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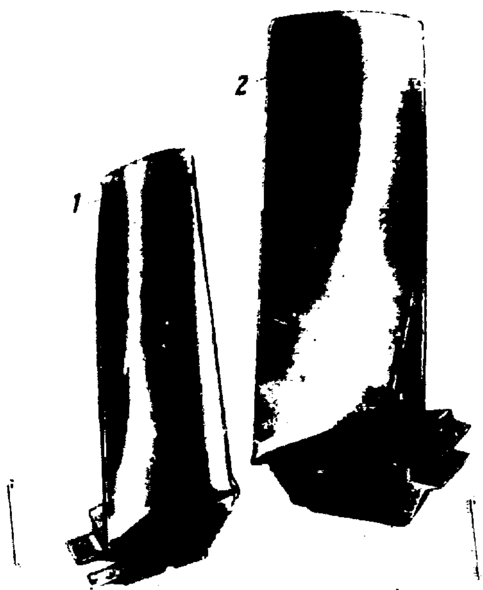

Fig. 54 Turbine buckets.
1. Bucket of stage I 2. Bucket of Stage II.

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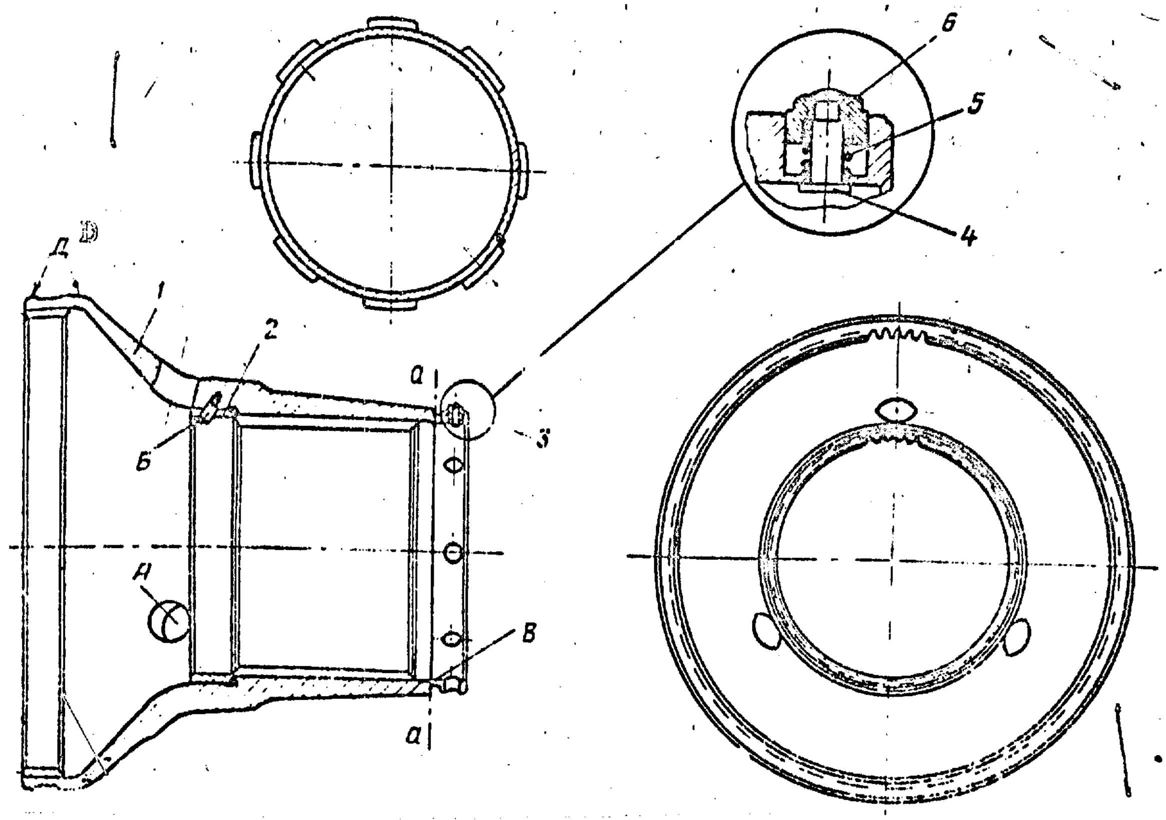

Fig. 55 Splined drive sleeve.
1. Splined drive sleeve 2. Center ring 3. Spring lock nut
4. Bolt 5. Spring 6. Lock sleeve

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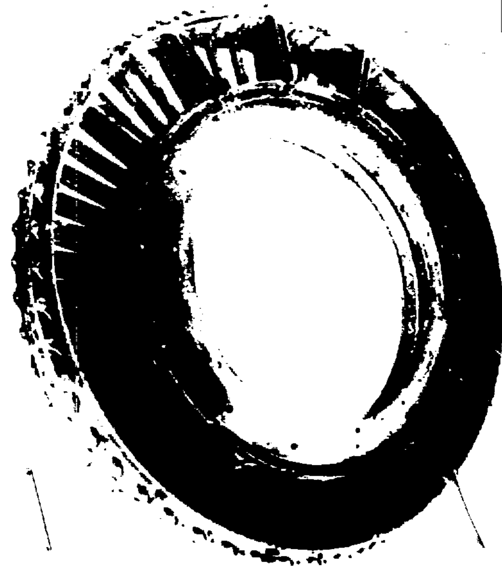

Fig. 56 Stator assembly of stage I (front view).

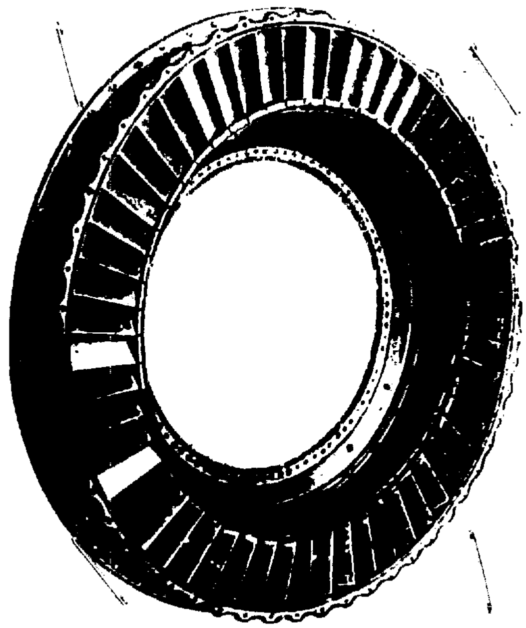

Fig. 57 Stator assembly of stage I (rear view)

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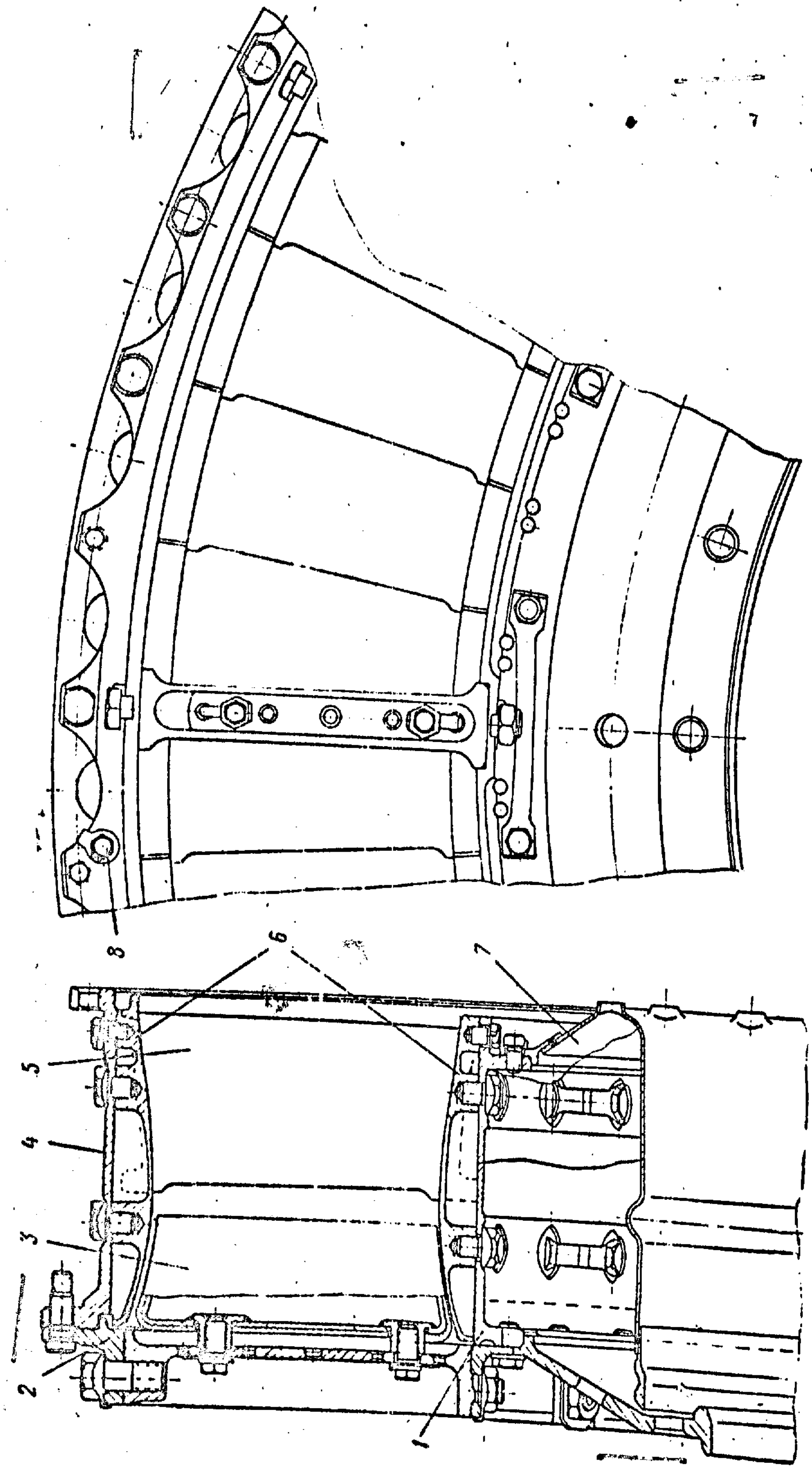

Fig. 58. Stator assembly of stage I.
1. Inner casing 2. Stator assembly frame 3. Cover 4. Outer casing
5. Stator vanes of stage I 6. Upper and lower supports [mounts]
7. Flange 8. "Lock" bolt

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Fig. 59 Support strut.

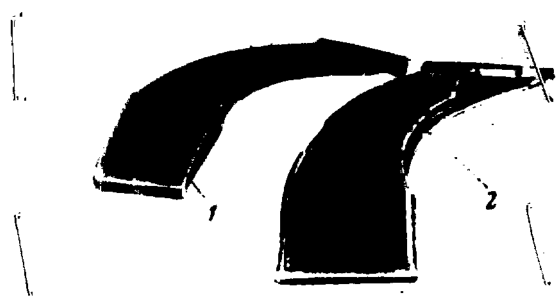

Fig. 60 Mounts.
1. Lower 2. Upper

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Fig. 61 Stator vane of stage I assembly.

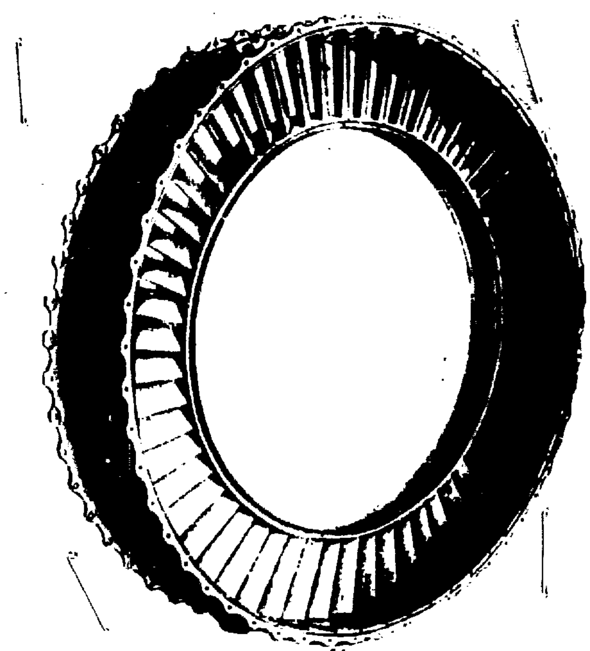

Fig. 62 Stator vane of stage II assembly.

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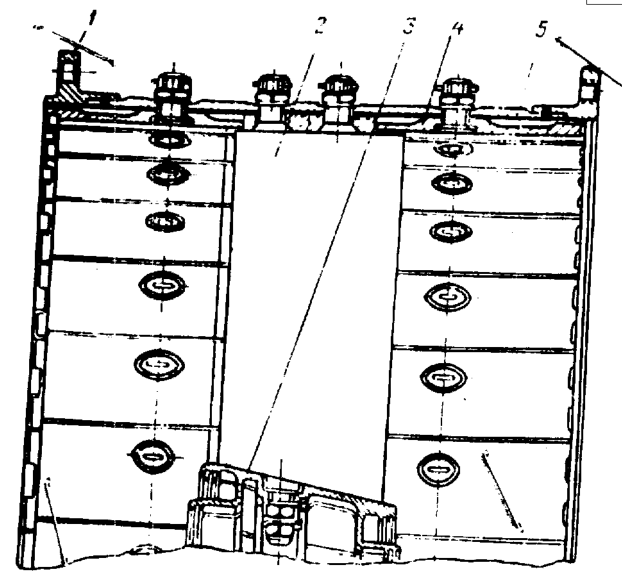

Fig. 63 Stator assembly of stage II.
1. Housing 2. Stator vane 3. Mount 4. Stator assembly ring
5. Support [outer case].

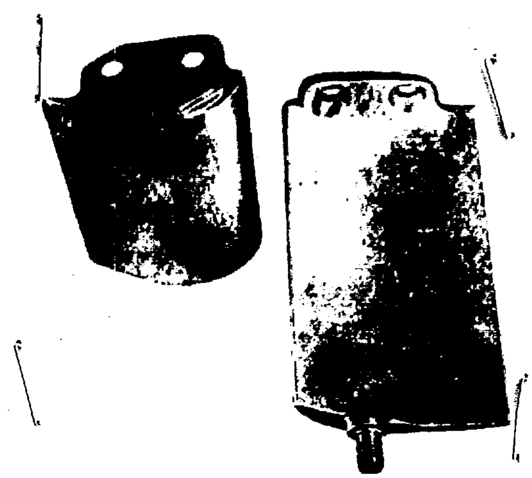

Fig. 64 Stator vane of stage II.

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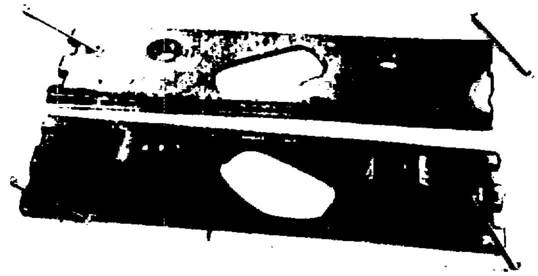

Fig. 65 Stator vane mount [inner] of stage II.

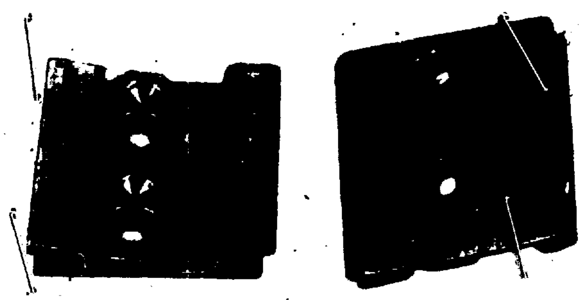

Fig. 66. Stator vane mount [outer] of stage II.

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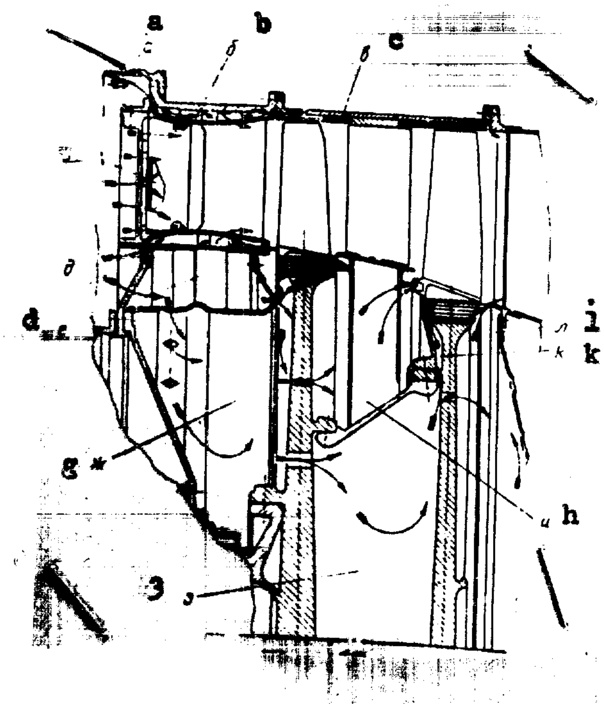

Fig. 67 [Caption not included in photo].

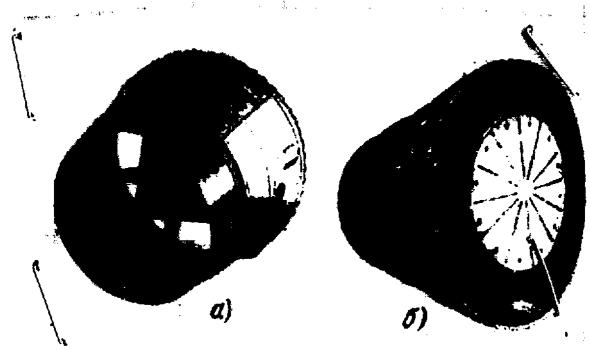

Fig. 68 Exhaust nozzle.

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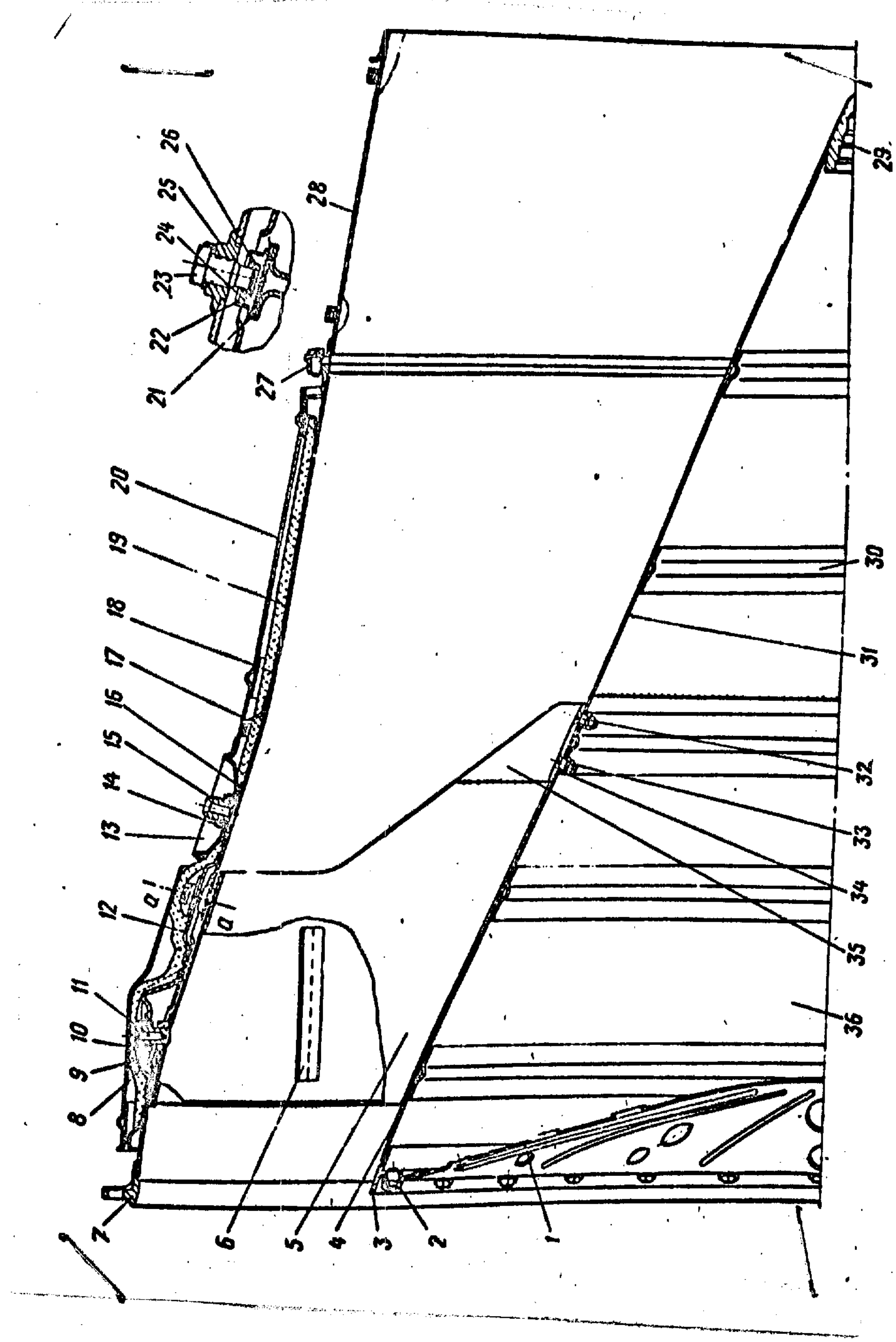

Fig. 69

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Fig. 69 Exhaust nozzle.
1. Front closure 2. Screw 3. Cone flange 4. Front of [exhaust] cone case 5. Turbine exhaust strut 6. Reinforcement [?] 7. Front flange 8. Projection 9. Support 10. Boss 11. Radial screw 12. Retainer plate 13. Cupped insert 14. Anchor nut 15. Thermocouple receptacle 16. Support 17. Separator assembly ring 18. Inner case of exhaust nozzle 19. Heat insulation 20. Outer case 21. Upper face of the turbine exhaust strut 22. Ring 23. Screw 24. Centering busing 25. Cover plate 26. Insert 27. Flange 28. Nozzle extension 29. Cone tip element 30. Ring 31. Rear case assembly of exhaust cone 32. Bolt 33. Castellated nut 34. Mounting plate a35. aft edge [of guide vane] 36. Nozzle cone case.

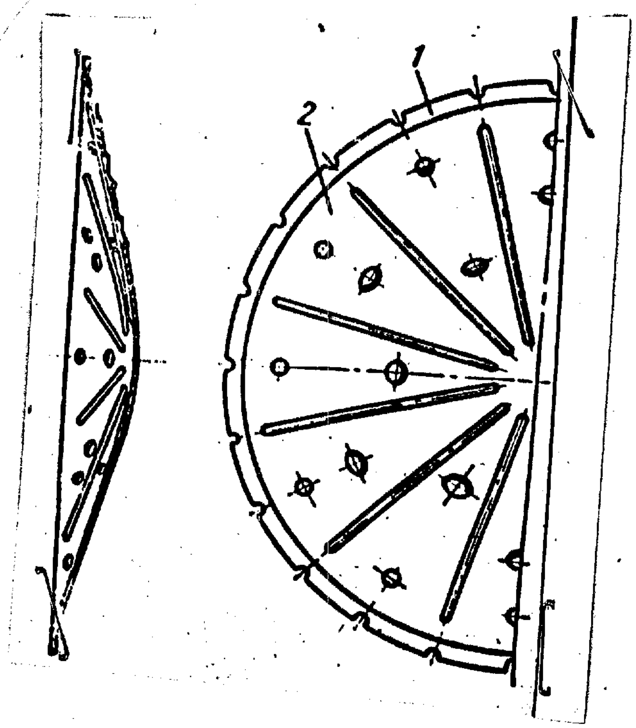

Fig. 70 Closure.
1. Closure flange 2. Closure case

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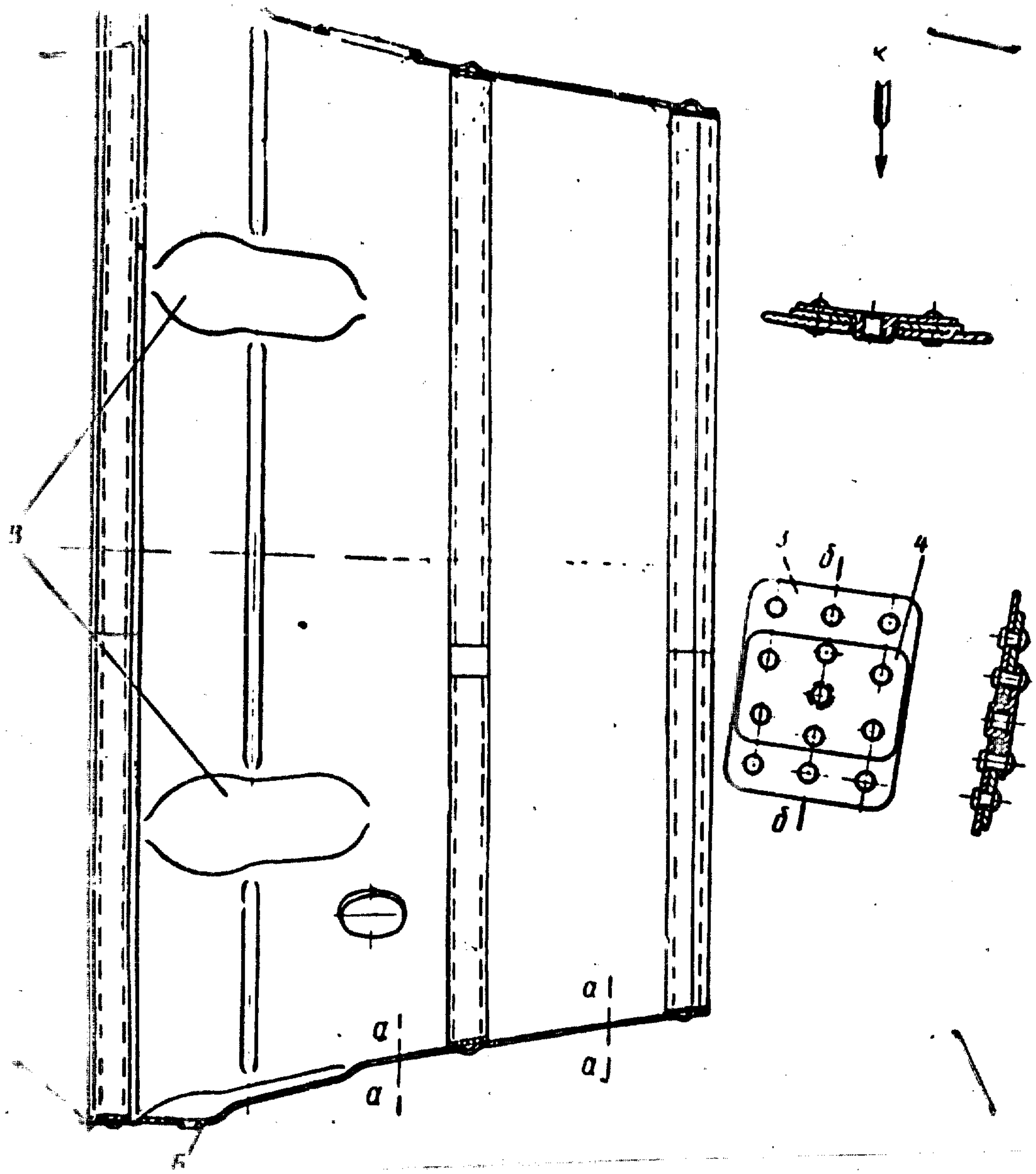

Fig. 71 Outer [nozzle] case.
1, 2. Ring frames [?] 3. Back-up plate 4. Riveted reinforcement; A.and B openings

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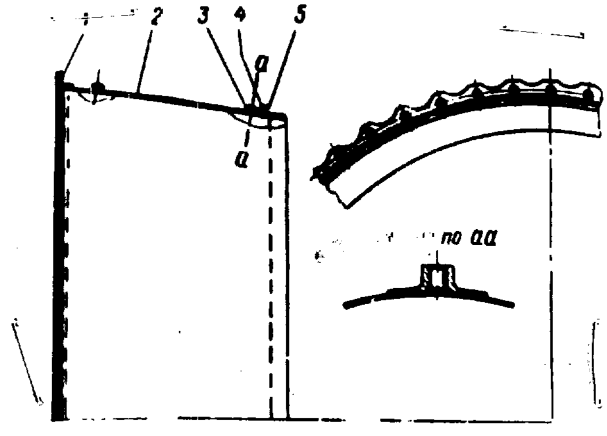

Fig. 72 Nozzle extension
1. Flange 2. Extension case 3. Anchor nut 4. Ring 5. Eye

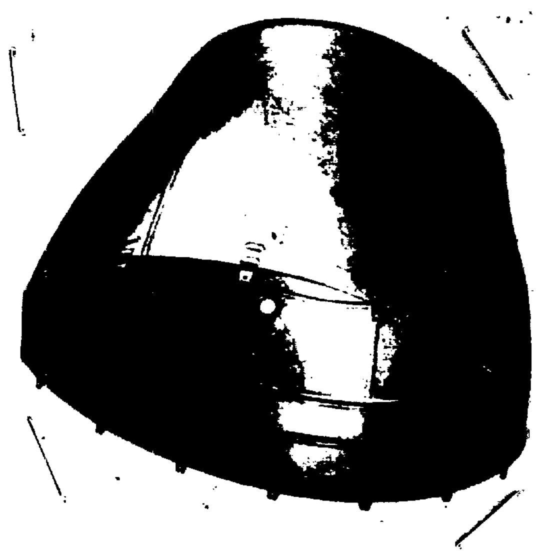

Fig. 73 Nozzle shroud. (General view)

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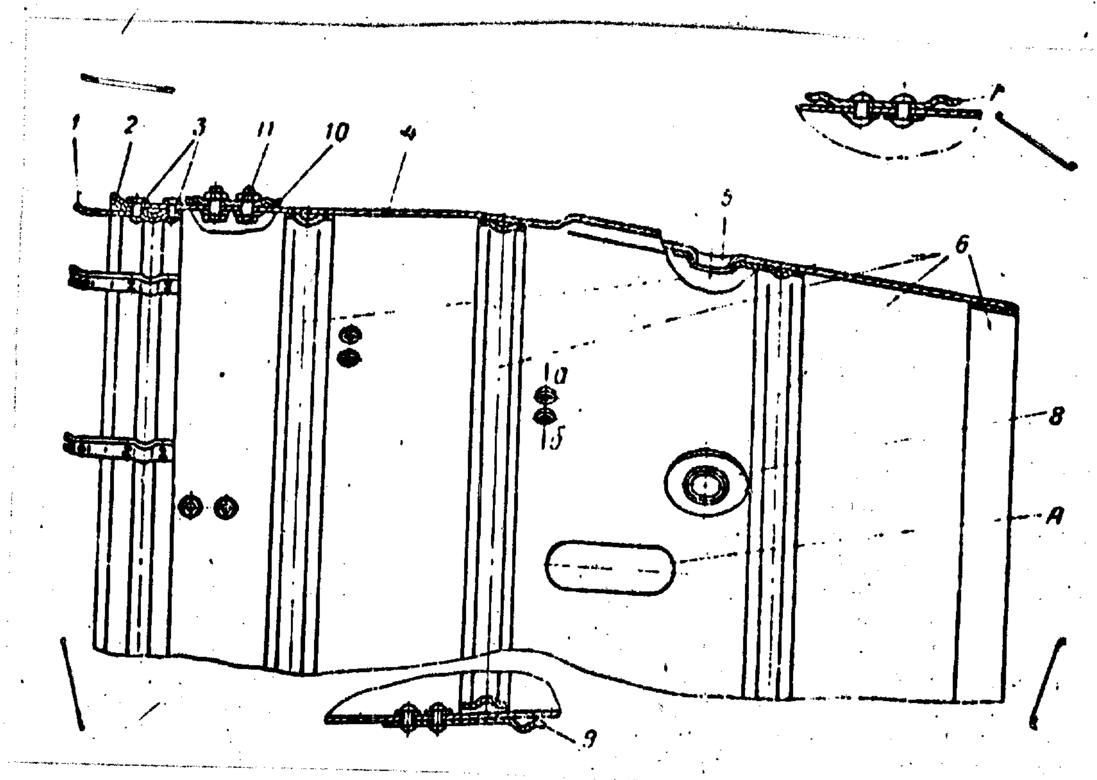

Fig. 74 Nozzle shroud
1. Attach 2. Air scoop 3. Plates 4. Shroud case 5. Flanged openings 6. Aluminium rings 7. Clamp 8. Back-up plates 9. Clamp 10. Clamps 11. screw A. Lugs.

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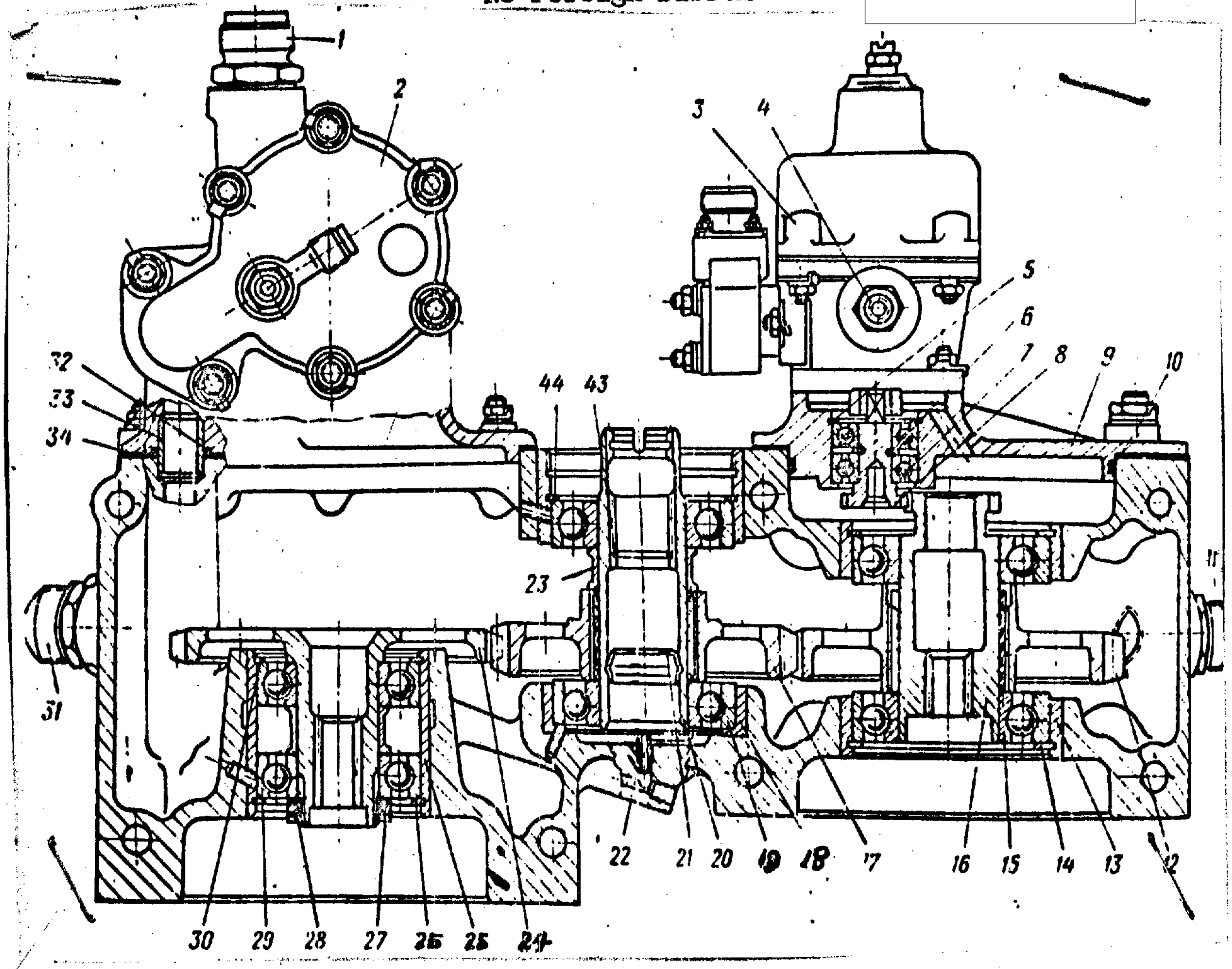

Fig. 75 Housing of engine accessories.
1. Oil intake coupling to oil filter 2. Oil filter 3. Centrifugal transducer 4. Oil intake coupling for centrifugal transducer 5. Retainer ring 6. Retainer ring 7. Ball bearing 8. Driver gear of centrifugal transducer 9. Mounting of centrifugal transducer 10. Seal ring 11. Oil outlet coupling 12. Gear of PN-15B fuel pump drive 13. Bearing bush 14. Retainer ring 15. Ball bearing 16. Shaft of fuel pump drive gear 17. Gear of fuel pump drive 18. Ball bearing bush 19. Ball bearing 20. Drive shaft 21. Blind flange 22. Nozzle 23. Separator 24. Gear of PN-28B fuel pump drive 25. Ball bearing bush 26. Retainer ring 27. Nut 28. Lock washer 29. Ball bearing 30. Retainer 31. Line coupling 32. Seal ring 33. Bushing 34. Seal 43. Retainer ring 44. Retainer ring.

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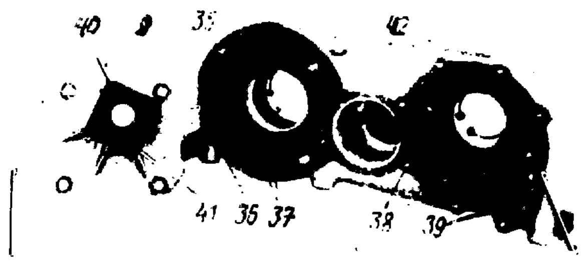

Fig. 76 Accessory housing with mount for the centrifugal transducer
9. Mount of the centrifugal transducer drive 35. Engine accessory housing 36. Stud bolt 37. Oil return opening 38. Stud 39. Oil intake opening 40. Bolt 41. Oil outlet 42. Oil nozzle for gears of the PN-B drive

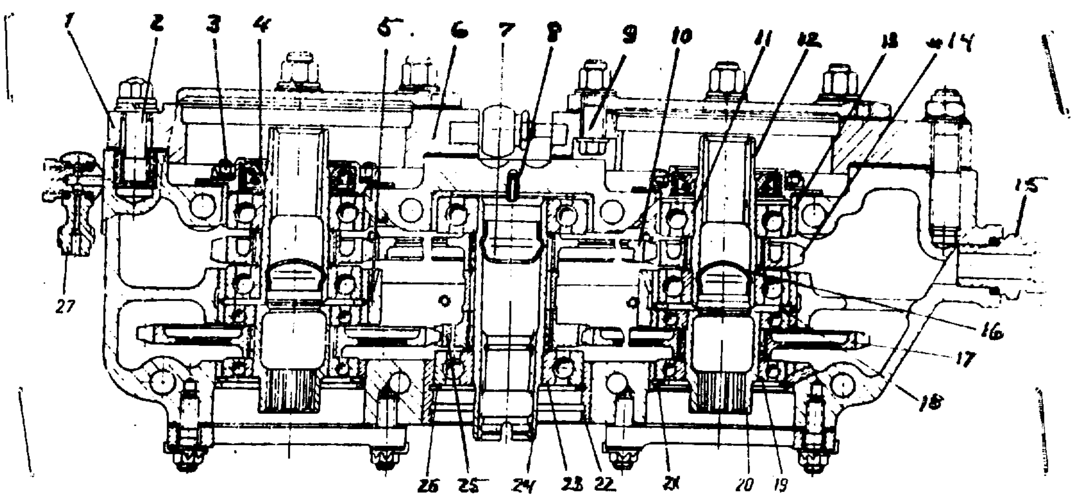

Fig. 77 Housing of aircraft accessories
1. Housing of aircraft accessories 2. Bolt 3. Nut 4. Packing box 5. Annular recess 6. Attach member 7. Blind flange 8. Nozzle 9. Bolt 10. Gear of generator drive 11. Ball bearing 12. Shaft 13. Ball bearing bush 14. gear 15. Oil outlet coupling 16. Blind flange 17. Gear of the hydraulic pump drive 18. Retainer ring 19. Ball bearing 20. Drive shaft hydraulic pump 21. Retainer ring 22. Housing 23. Ball bearing 24. Drive shaft 25. Gear of the hydraulic pump drive 26. Retainer 27. Oil inlet coupling.

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Fig. 79 Diagram of the lubricating system.
1. Oil tank 2. Oil fuel cooler 3. Oil tank fill cap 4. Drive (rignt) 5. Air compressor 6. Oil filter 7. Oil pressure guage 8. Check valve 9. Filter 10. Centrifugal transducer CD-3 11. Housing of engine accessories 12. Fuel pump 13. D.C. generator 15. Nozzles 16. Center bearing 17. Oil collector 18. Foam filter 19. Ball coupling 20. Filter 21. Foam filter 22. Filter 23. Rear bearing 24. Nozzle 25. Oil collector 26. Oil flow divider 27. Engine tachometer transmitter 28. Housing of aircraft accessories 29. Oil temperature guage 30. Drive (left) 31. Hydraulic pump 32. Centrifugal separator 33. Nozzle with filter 34. Front bearing 35. Check valve 36. Oil pump 37. Reduction valve 38. Delivery stage 39. Pump off stage of the rear bearing 40. Pump-off stage of center bearing 41. Pump-off stage of the front section compressor case 42. Lower drive 43. Supply pump 44. Oil collector of front compressor case 45. Oil drain (plug) 46. Oil drain (plug) 47. Oil drain (draincock) 48. Check valve.

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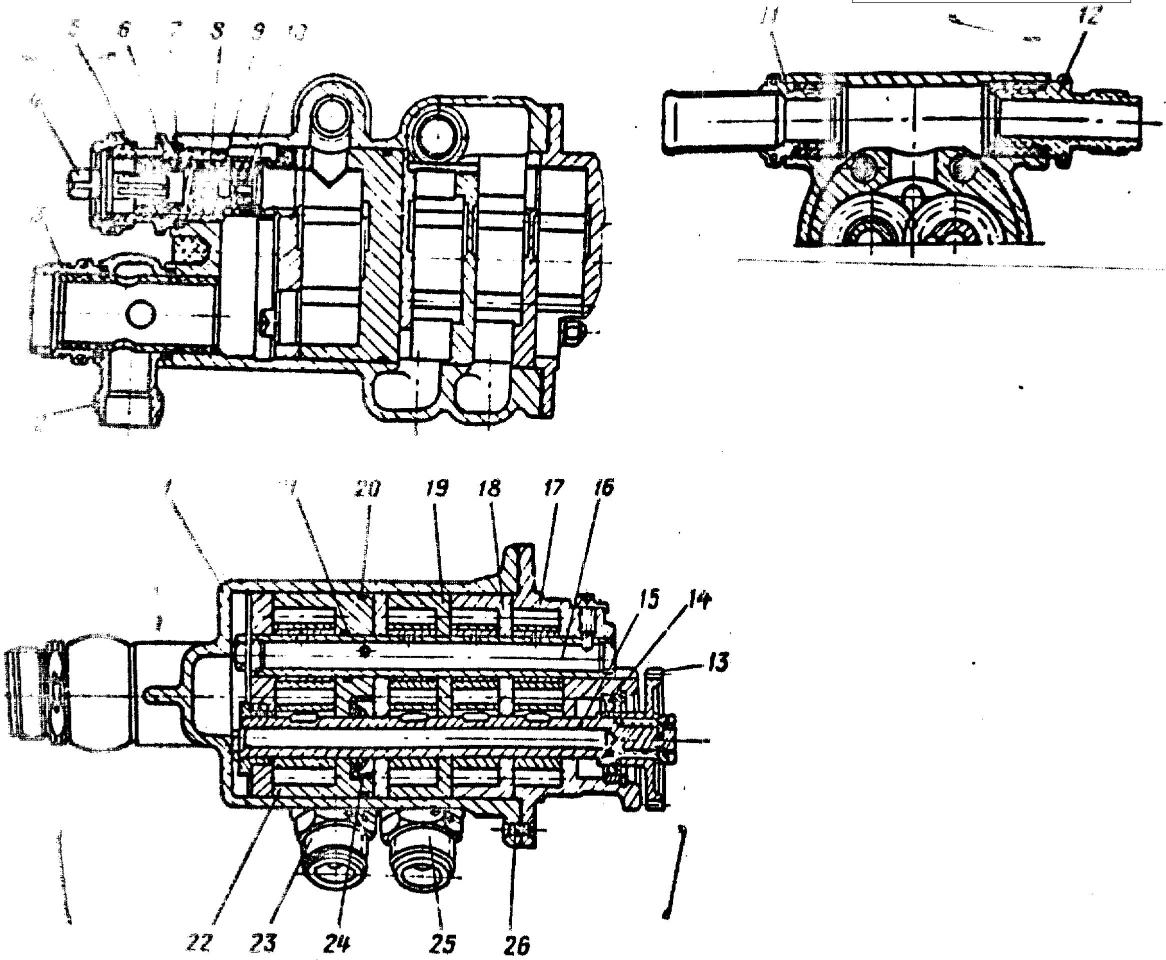

Fig. 80 Oil pump
1. Housing 2. Adapter 3. Line coupling 4. Adjustment screw 5. Nut 6. Line coupling 7. Valve spring 8. Slide valve 9. Valve 10. Slide valve 11. Line coupling 12. Line coupling 13. Gear 14. Bearing 15. Oil assembly shaft 16. Shaft of drive gears 17, 18, 19. Pumping stages 20 and 21. Seal rings 22. Delivery stage 23. Coupling for oil line from rear bearing 24. Rubber packing 25. Coupling for oil line from center bearing 26. Screw

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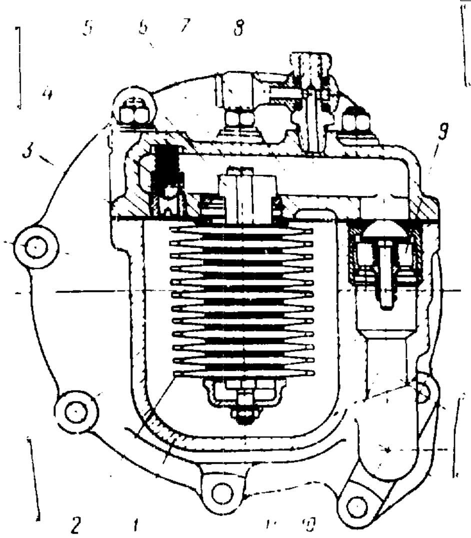

Fig. 81 Oil filter
1. Housing 2. Filter disc 3. Cover 4. Safety valve
5. Shaft 6. Tightening screw 7. Cover cavity 8. Oil outlet coupling to pressure guage 9. Check valve 10. Cavity
11. Filter cavity.

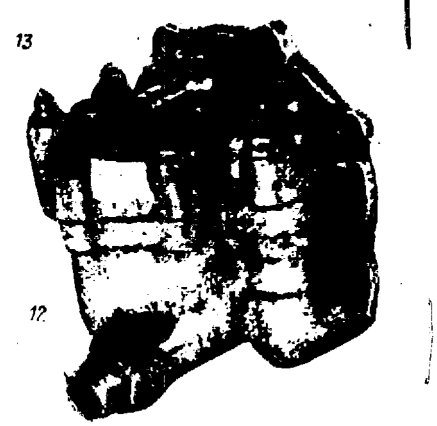

Fig. 82 Oil filter (general view).
12. Line coupling 13. Bolt.

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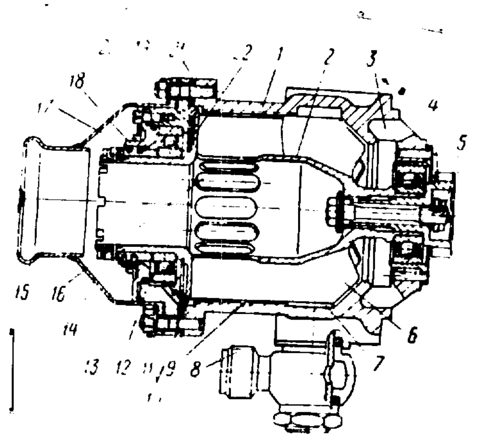

Fig. 83 Centrifugal separator.
1. Housing 2. Rotor 3. Oil deaerator intake opening 4. Drive gear 5. Bolt for fastening the drive gear 6. Drum 7. Cavity 8. Oil discharge coupling 9. Oil collection channel 10. Washer 11. Bolt for fastening housing and cover 12. Cover 13. Ring 14. Housing 15. Air discharge coupling 16. Air release opening 17. Bronze ring 18. Bushing 19. Rubber gasket 20. Screws for fastening the bush 21. Calibrated washer 22. Groove

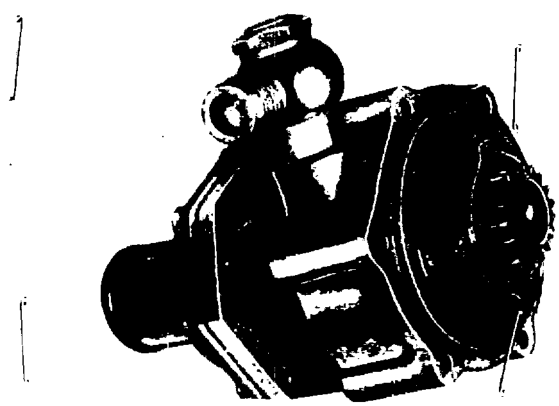

Fig. 84 Centrifugal separator.

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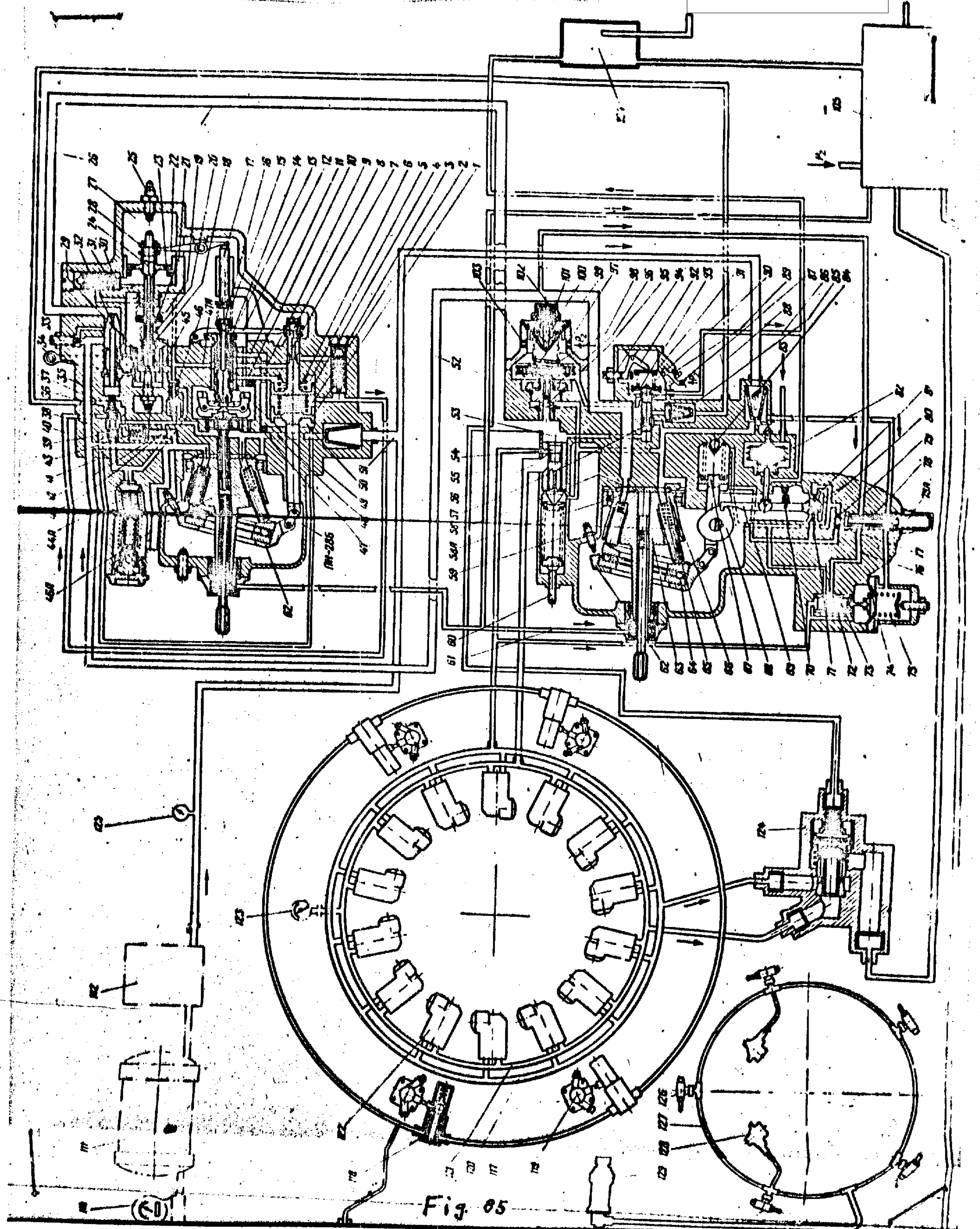

Fig. 85

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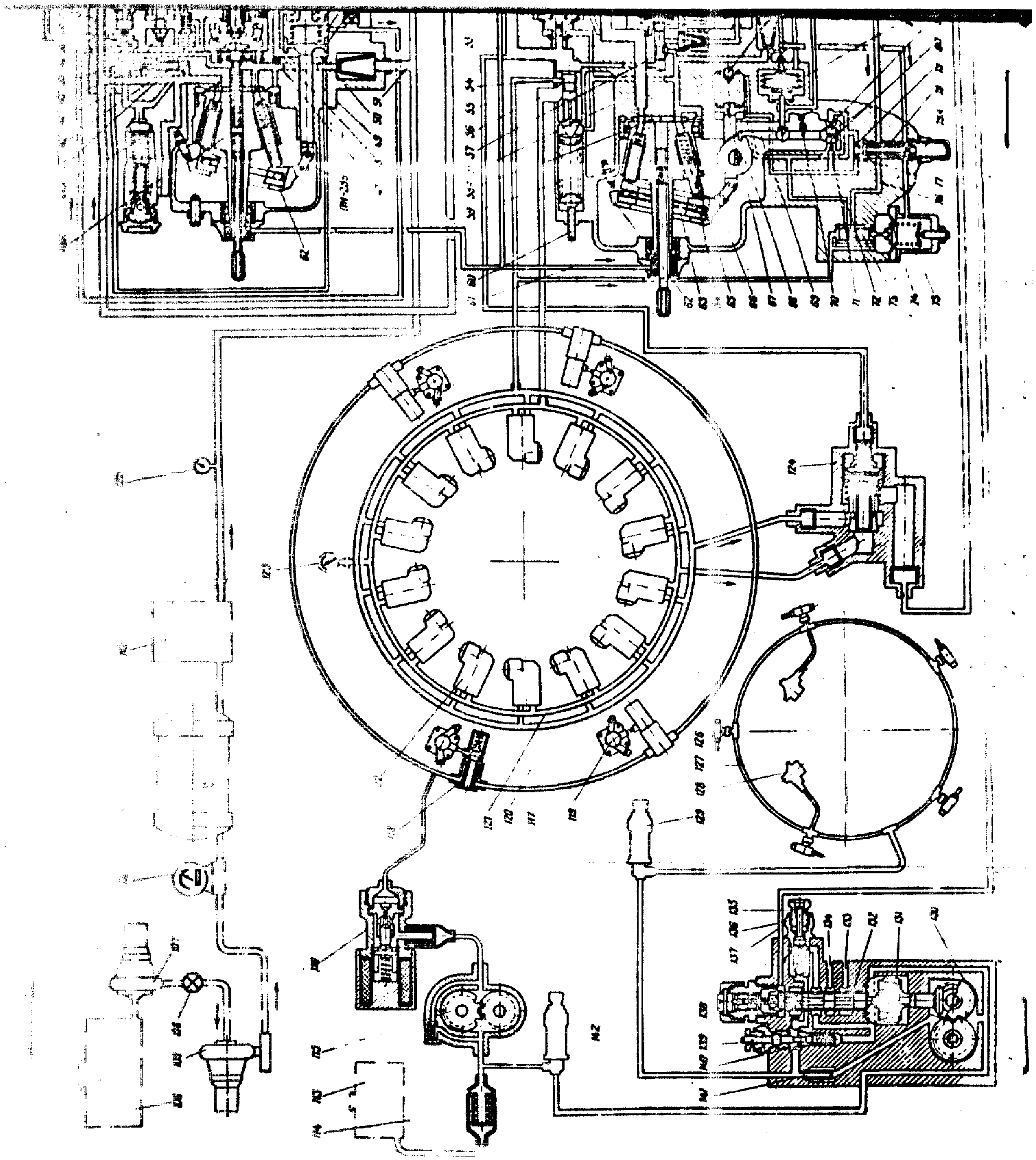

Fig. 86

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Figure 85. Fuel System of Engine

1. Piston of inclined thrust bearing
2. Inter-piston chamber
3. Throttle packing of regulator
4. Servo-piston of slide valve of control mechanism
5. Chamber of servo-piston
6. Spring of servo-piston of control mechanism
7. Passage channel of fuel from the inter-piston chamber
8. Slide valve of control mechanism
9. Channel for feeding fuel to the chamber inter-piston
10. Channel for feeding fuel to the chamber of piston 1
11. Channel for feeding fuel to the chamber of piston 1
12. Lever of control system
13. Slide valve of automatic revolution governor
14. Axial bearing of slide valve 13
15. Spring of slide valve 13
16. Axial pin of slide valve 13
17. Connecting rod of spring

18, 19. Springs

20. Opening for discharge of fuel
21. Disc of spring
22. Connecting lever of retarder and connecting rod 17
23. Piston of retarder
24. Piston retarder

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25. Stop screw of retarder

26. Channel for feeding fuel to the distribution valve

27. Channel for low-pressure fuel

28. Joint of lever 22

29. Bolt

30. Filter

31. Throttle packing of retarder

32. Throttle valve

33. Regulation screw for idling

34. Control lever

35. Entrance nozzle of fuel to valve chamber or constant pressure distribution

36. Spring for admission of fuel to valve chamber for constant pressure distribution

37. Chamber for entrance of fuel to valve chamber for constant pressure distribution

38. Channel for feeding high-pressure fuel to the throttle valve

39. Valve for constant pressure distribution

40. Channel for delivery of fuel from the inter-piston chamber

41. Channel for feeding high-pressure fuel to chamber 50

42. Regulating screw for beginning of automatic action

43. Spring of safety valve

44. [word missing?] safety valve; fine filter

45. Bushing of control lever of throttle valve

46. Valve for constant pressure of fuel

47. Nozzle for passage of fuel from chamber of piston

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48. Centrifugal revolution governor

49. Bushing of slide valve

50. Chamber of servo-piston of control system

51. Channel for fuel feeding

52. Channel for drainage of fuel

53. Channel for feeding high-pressure fuel to the slide valve of the automatic acceleration device

54. Distribution valve

55. Channel for feeding fuel to the idling manifold

56. Channel for feeding fuel to the main manifold

57. Slide valve of automatic acceleration device

58. Displacement opening in rotor

58A. Distribution panel of rotor

59. Stop for maximum supply of fuel

60. Regulation screw of distribution valve

61. Drainage of shaft sealing of high-pressure pumps

62. Inclined thrust bearing body of plunger bearing

63. Rotor

64. Axial bearing of plungers

65. Plunger

66. Suction opening in distribution panel of rotor

67. Piston of inclined thrust bearing

68. Cam of altitude-speed manifold

69. Lever of altitude-speed manifold

70. Spring of lever

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71, 81 - Nozzles of variable section of altitude-speed corrector

72. Channel for feeding high-pressure fuel to piston of inclined thrust bearing

73. Slide-valve of minimum-pressure valve

74. Membrane of minimum-pressure valve

75. Spring of minimum-pressure valve

76. Channel for feeding high-pressure fuel to slide valve for minimum-pressure

77, 79. Nozzles for feeding air to the automatic acceleration device

78. Slide valve for constant pressure

78-A. Spring of constant-pressure valve

80. Pivoting slabs of lever 69 of altitude-speed manifold

82. Aneroids of altitude-speed manifold

83. Feeding of air to altitude-speed manifold

84. Stop for minimum supply

85. Filter

86. Drainage channel fo membrane chamber of automatic acceleration device

87. Nozzle for feeding air to automatic acceleration device

88. Channel for letting out fuel from chamber

89. Nozzle for passage of air

90. Spring of automatic acceleration device

91. Disc of automatic device

92. Lever

93. Membrane of automatic acceleration device

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94. Regulation screw of spring of automatic acceleration device

95. Slide valve of automatic starter device

96. Piston spring

97. Nozzle for feeding air to the starter device

98. Spring

99. Membrane

100. Disc of spring

101. Regulation screw of spring of automatic starter device

102. Cap

103. Variable nozzle for passage of air

104. Drainage tank, small

105. Drainage tank, large.

106. Main fuel tank

107. Aircraft auxiliary fuel pump

108. Fire cock

109. Auxiliary fuel pump CN-1

110. Flowmeter

111. Oil-fuel cooler

112. Low-pressure filter (screen)

113. Tank for starter fuel

114. Filter for starter fuel

115. Pump for starter fuel PNR10-3M

116. Electromagnetic fuel valve

117. Manifold of starter nozzles

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118. Filter with valve

119. Igniter

120. Main manifold for nozzles

121. Idle manifold for nozzles

122. Main nozzle

123. Manometer, measuring pressure of fuel in the idle manifold of the nozzles

124. Outlet valve

125. Manometer, measuring fuel pressure in front of pumps PN-28B and PN-15B

126. Starter nozzle

127. Fuel manifold of starter

128. Igniter of starter

129. Auxiliary electromagnetic valve of starter

130. Fuel pump

131. Centrifugal governor

132. Slide valve of centrifugal governor

133. Feed of oil to pump TNR-3R

134. Outlet of oil to hydraulic connecting pipe

135. Regulation screw of reduction valve

136. Reduction valve

137. Drainage channel from hollow of centrifugal governor to drainage tank 105

138. Screw of centrifugal governor

139. Regulating screw for starting

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140. Ball valve

141. Filter

142. Main electromagnetic fuel valve of starter

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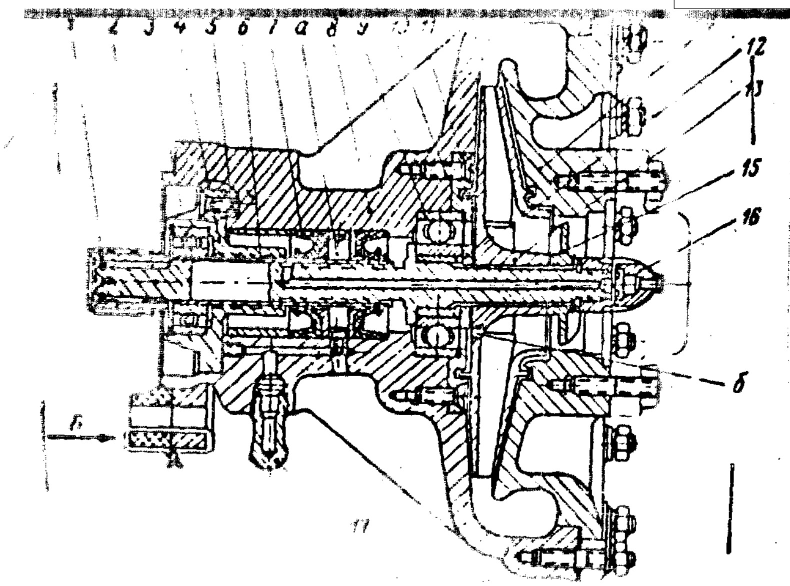

Figure 86. Pump CN-1A

1. Coupling; 2. shaft; 3. bearing; 4. center case; 5. screw; 6. bushing; 7. cup; 8. Case; 9. bearing; 10. screw; 11. lid; 12. regulartion ring; 13. impeller; 14. lid; 15. guide vanes; 16. cup; 17. waste pipe.

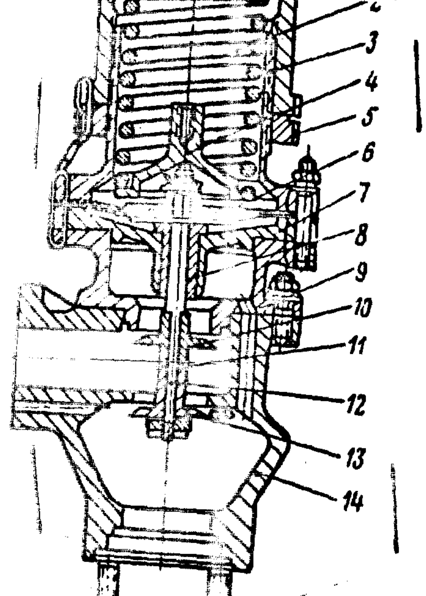

Figure 87. Valve of Fuel Pump CN-1A

1. Cap; 2. spring; 3. bushing; 4. disc; 5. bolt; 6. membrane; 7. guide equipment; 8. bushing; 9. center body; 10. valve; 11. regulating washer; 12. connecting rod; 13. valve; 14. body.

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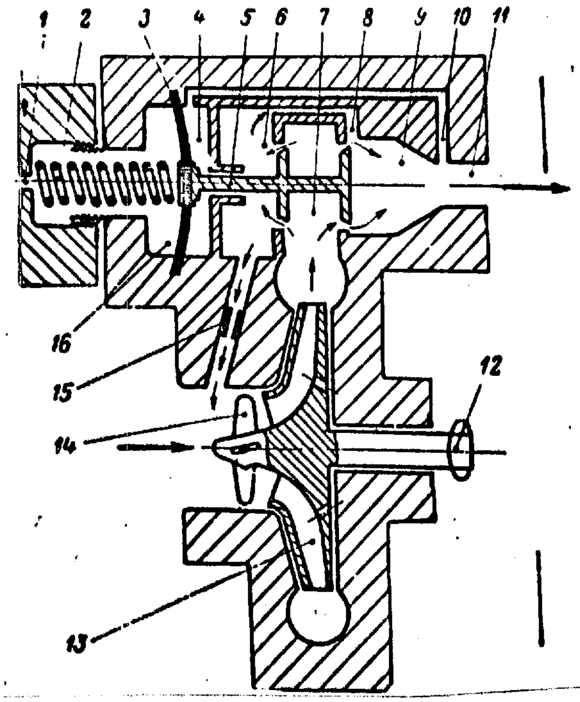

Figure 88. Diagram of Operation of Pump CN-1A

1. Opening for connection with atmosphere; 2. spring; 3. membrane; 4. hollow of membrane chamber; 5. valve; 6. hollow in front of valve; 7. hollow for feeding fuel; 8. passage valve; 9. hollow for valve outlet; 10. channel connecting hollow 4 with outlet pipe; 11. outlet pipe; 12. shaft; 13. impeller; 14. guide vanes; 15. nozzle; 16. hollow in which 2 of the membrane chamber is placed.

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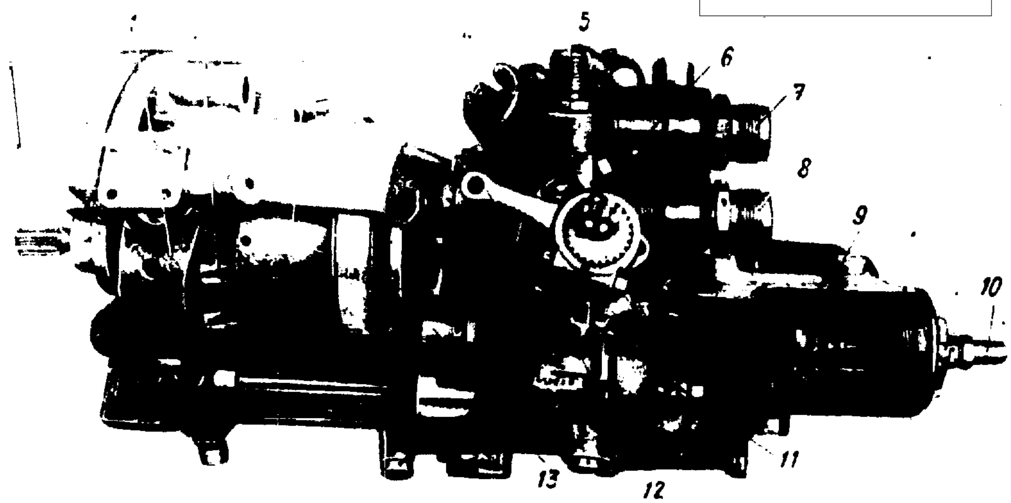

Figure 89. Fuel Pump PN-28B

1. Slanting thrust bearing; 2. plunger; 3. impeller; 4. spring of central filter; 5. idle needle; 6. support screw of control lever; 7. pipe for carrying fuel from the throttle cock; 8. pipe for feeding fuel from the PN-156 pump; 9. piston of hydraulic retarder; 10. regulation screw of maximum revolutions; 11. support screw; 12. control lever; 13. regulation screw for beginning of automatic operation.

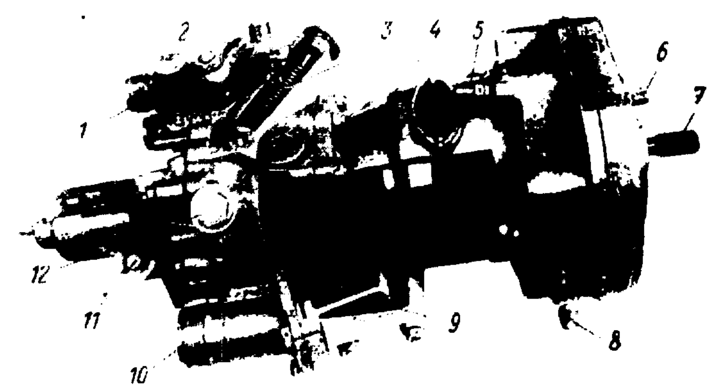

Figure 90. Fuel Pump PN-28B

1. minimum-pressure valve; 2. pipe for feeding tube from automatic acceleration device PN-15B; 3. center filter; 4. centrifugal governor; 5. maximum-output regulation screw; 6. regulation screw for minimum feed; 7. shaft for drive of pump rotor; 8. drainage pipe under the pump; 9. filter; 10. pipe for fuel supply; 11. stopper for throttle regulator; 12. throttle valve.

Figure 92. Fuel Pump PN-15B

1. Pipe for feeding air P_2; 2. drainage pipe; 3. pipe for connecting automatic acceleration device with valve for constant

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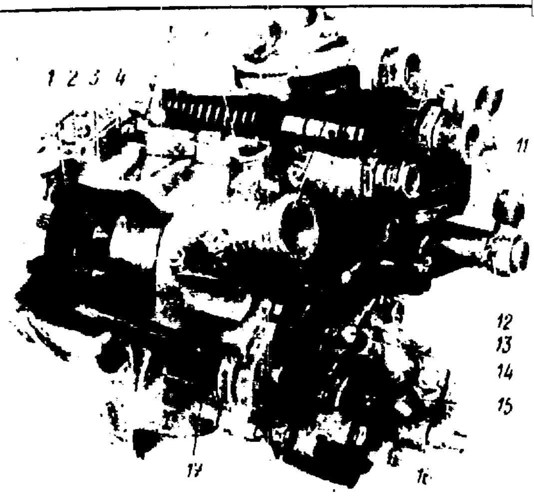

Figure 91. Fuel Pump PN-15B

1. Impeller; 2. drainage pipe below pump; 3. plunger; 4. rotor; 5. spring of distribution valve; 6. pipe for feeding fuel to PN-28B; 7. pipe for feeding fuel; 8. pipe for feeding fuel to the main manifold; 9. pipe for feeding fuel to idling manifold; 10. pipe for feeding fuel to the distribution valve from the PN-28B; 11. pipe for feeding air P_2; 12. variable nozzle for passage of air; 13. regulation screw of automatic acceleration device; 14. regulation screw for minimum-pressure valve; 15. minimum-output regulation screw; 16. regulation screw of initial position of aneroids VSK; 17. piston.

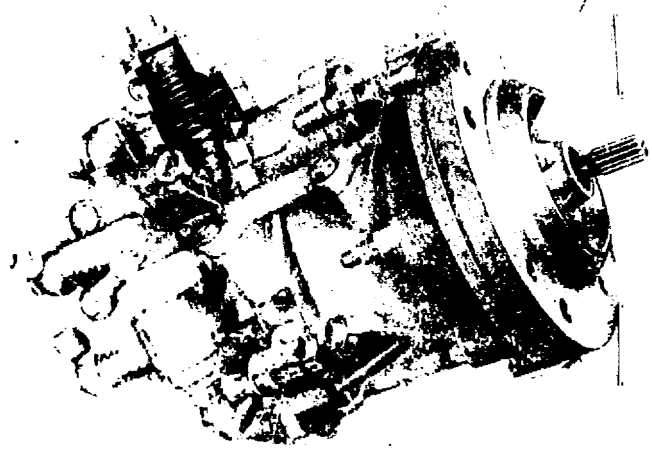

Figure 92. Fuel Pump PN-15B

1. Pipe for feeding air P_2; 2. drainage pipe; 3. pipe for connecting automatic acceleration device with valve for constant pressure distribution of PN-28B; 4. regulation screw of automatic starting device; 5. regulation screw of distributing valve; 6. maximum-output regulation screw; 7. shaft for pump drive. 8; constant pressure valve.

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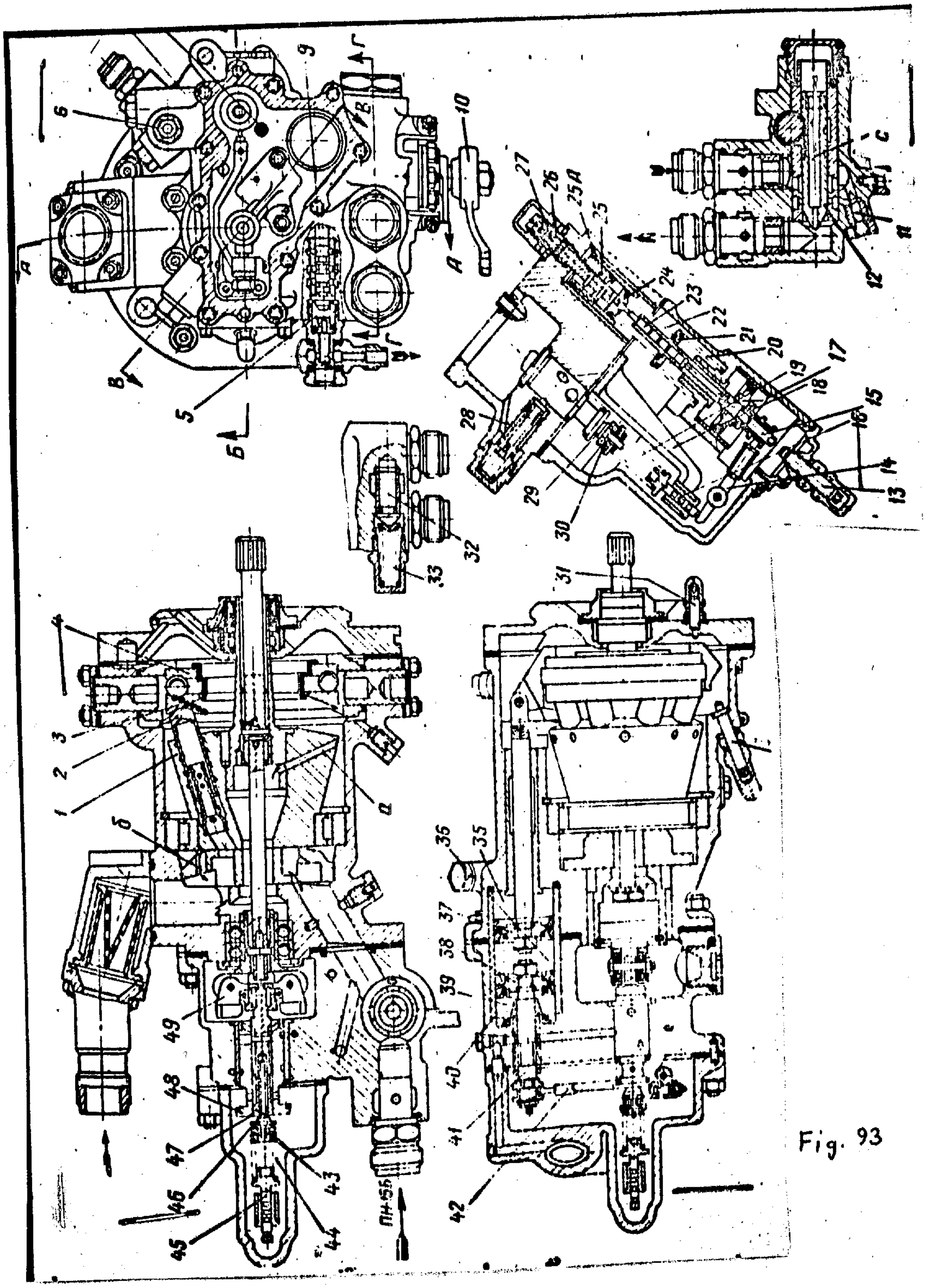

Fig. 93

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Figure 93. Structure of PN-28B Fuel Pump

1. Rotor
2. Plunger
3. Bearing
4. Bearing body
5. Spring of constant-pressure distribution valve
6. Throttle section
7. Reverse connection lever
8. Nozzle
9. Constant-pressure distribution valve
10. Control lever
11. Idle pin
12. Throttle valve
13. Regulation screw for maximum revolutions
14. Lever
15. Piston rod
16. Spring rod
17. Piston of retarder
18. Brace
19. Spring of transmitter slide valve
20. Spring
21. Disc
22. Spring
23. Slide valve of hydraulic retarder

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24. Disc

25. Bushing

25A. Rod

26. Safety bushing

27. Regulation screw

28. Constant-pressure valve

29. Needle of slide valve of revolution transmitter

30. Thrust bearing of transmitter slide valve

31. Regulating screw for minimum output

32. Safety valve

33. Spring of safety valve

34. Regulation screw for minimum output

35. Chamber of servo-piston of inclined plate

36. Space between pistons

37. Servo-piston of inclined thrust bearing

38. Piston of slide valve for reverse connection

39. Spring

40. Chamber of piston of slide valve for reverse connection

41. Slide valve for reverse connection

42. Lever

43. Thrust bearing of transmitter slide valve

44. Spring of control slide valve

45. Rod of spring of control valve

46. Needle of control slide valve

47. Control slide valve

48. Bushing of slide valve

49. Centrifugal weights

a. Opening

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Figure 94. Fuel Pump PN-15B

1. Distributing valve
2. Pin of bearing
3. Lid of pin
4. Bolt
5. Regulating screw
6. Spring
7. Piston of servo-mechanism
8. Bushing
9. Screw
10. Gear wheel of cam
11. Distribution panel for slide and displacement
12. Connecting rod
13. Body
14. Rotor
15. Bearing of inclined thrust bearing
16. Lid of pump
17. "Gufero" (packing)
18. Drive shaft of pump
19. Slide valve of minimum-pressure valve
20. Membrane
21. Spring
22. Regulating screw of minimum-pressure valve
23. Screen of filter

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24. Bushing of distribution valve

25. Slide valve of distribution valve

26. Spring

27. Spring

28. Bolt

29. Stopper

30. Regulating screw

31. Spring

32. Lid

33. Membrane

34. Spring

35. Seat of valve

36. Piston

37. Slide valve

38. Bushing

39. Membrane

40. Spring

41. Nozzle of acceleration device

41A. Nozzle of automatic starting device

42. Regulation screw for maximum delivery of fuel

43. Lid of acceleration device

44. Regulation screw of automatic regulation device

45. Lever

46. Regulation screw of altitude-speed corrector

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47. Aneroid

48. Washer of spring

49. Spring

50. Stick

51. Lever of control system

52. Cam of control system

53. Filter

54, 55. Nozzles

56. Spring

57. Filter

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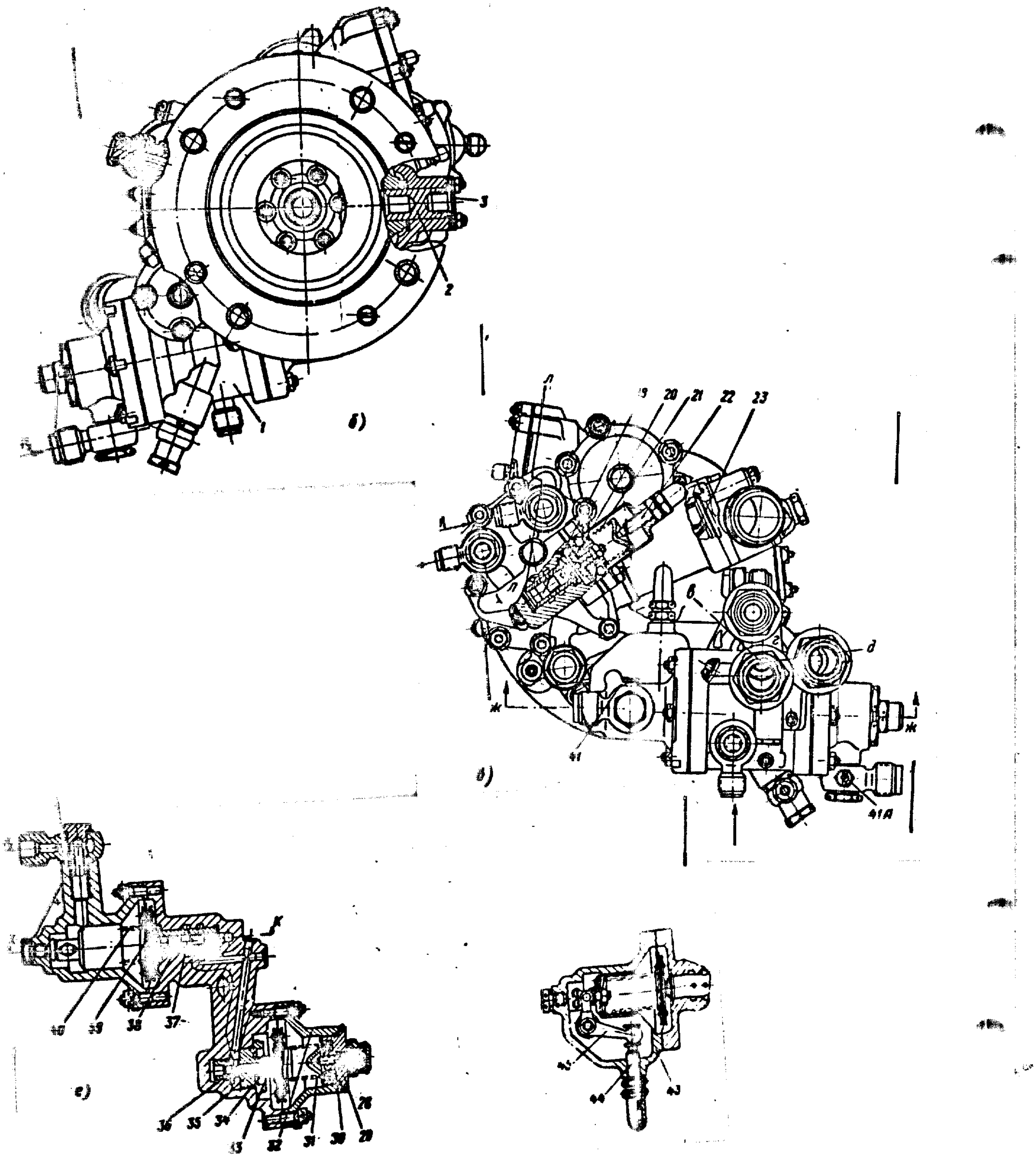

Fig. 99

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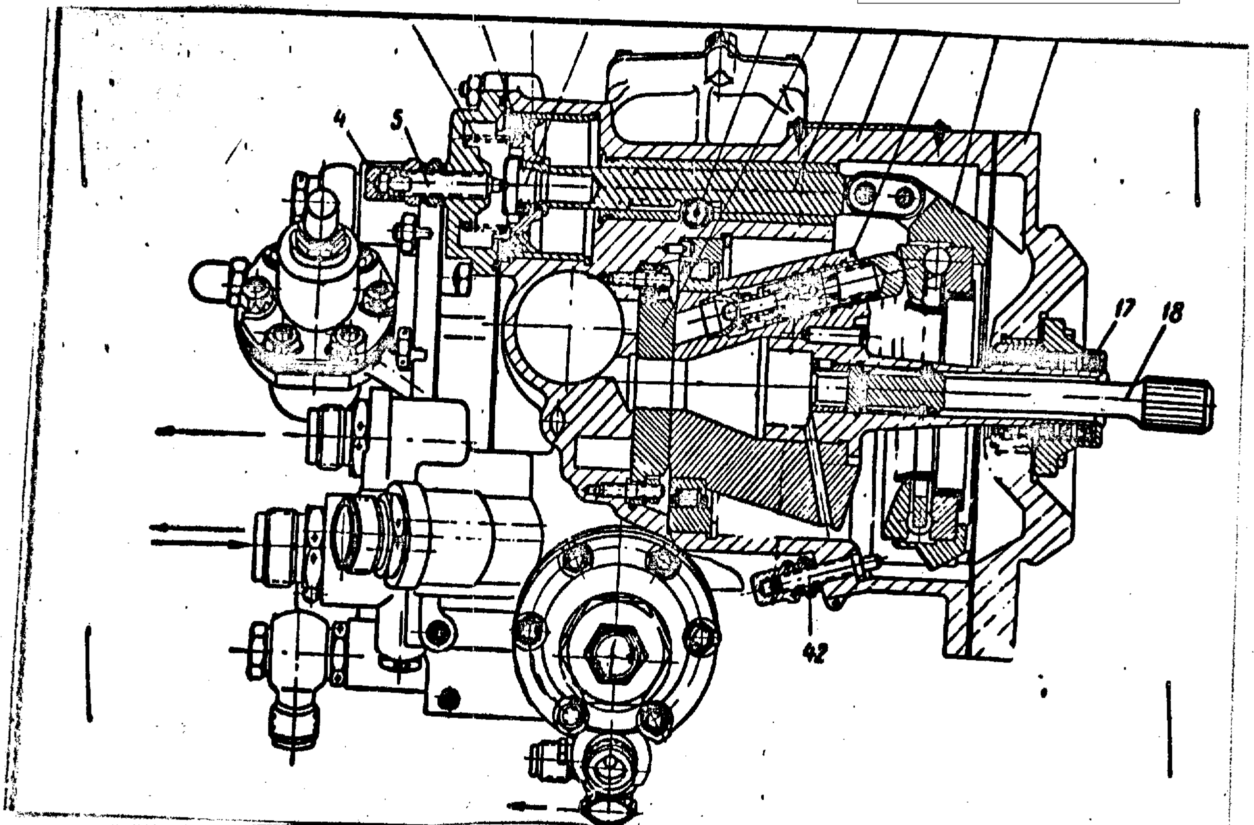

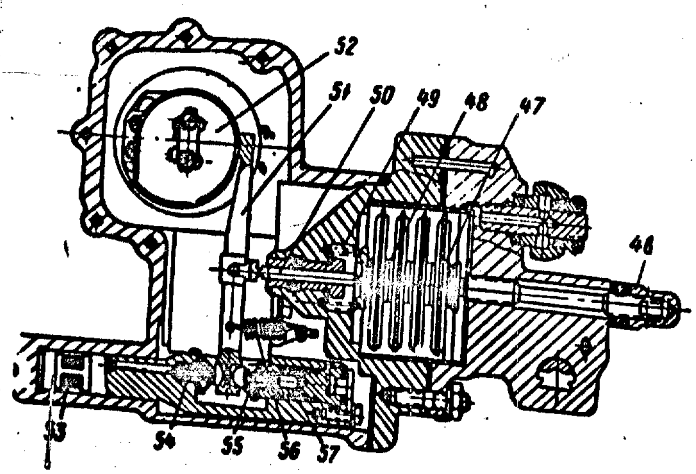

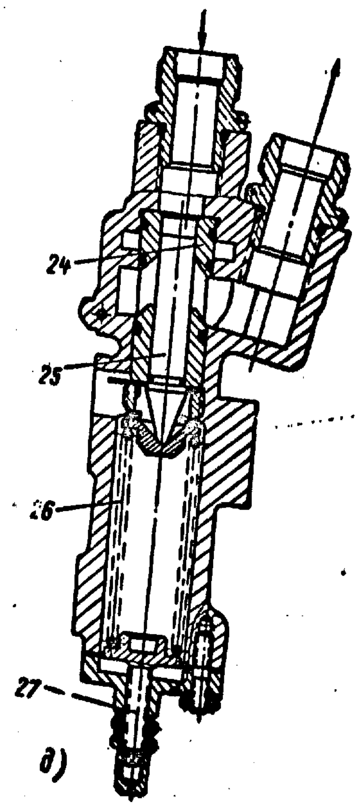

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Fig. 94

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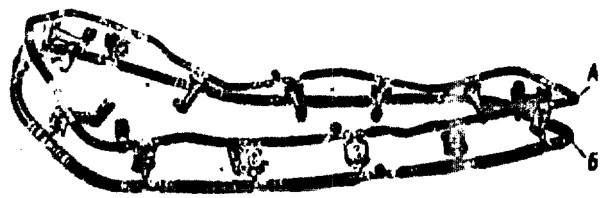

Figure 95. Fuel Manifold

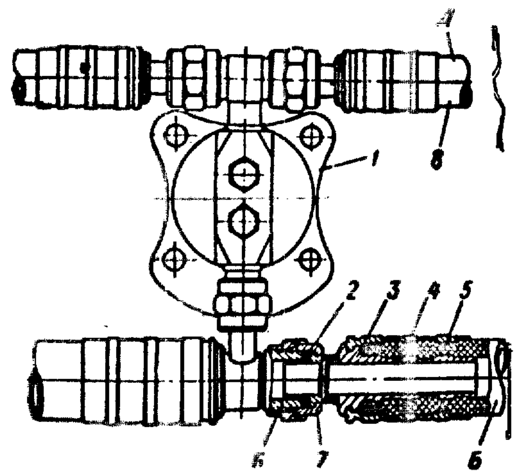

Figure 96. Grouping of Fuel Manifold

1. Main nozzle; 2. ring; 3. insert; 4. cup; 5. hoses of main manifold; 6. angle bracket; 7. reverse bolt; 8. hose of idle manifold; A. idle manifold; B. main manifold

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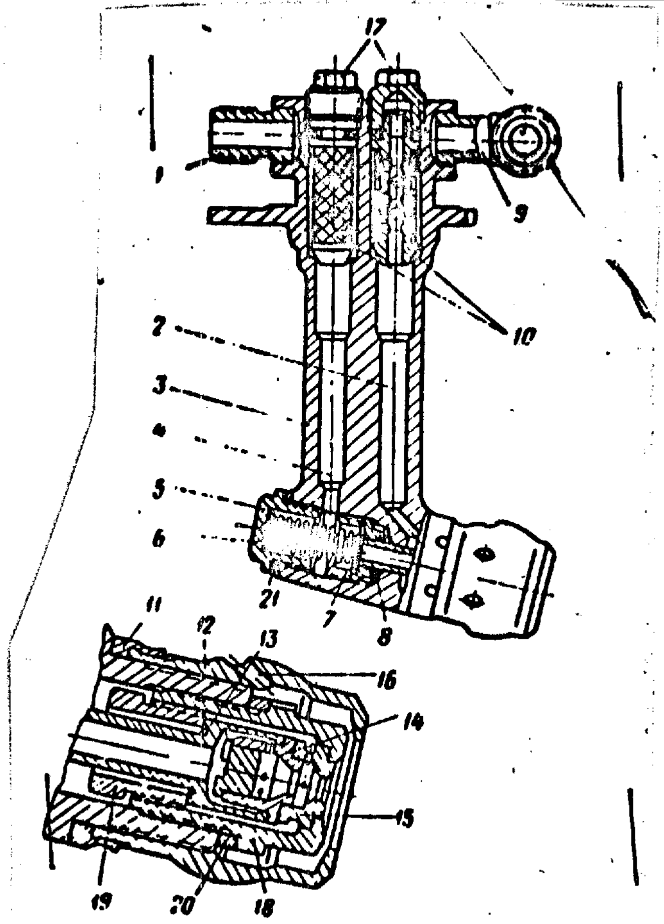

Figure 97. Main Nozzle (cross-section)

1. Screw joint; 2. idling channel; 3. nozzle body; 4. main fuel channel; 5. bolt; 6. spring; 7. screw joint; 8. sealing ring; 9. T-piece; 10. screen filters; 11. catch; 12. bushing of nozzle; 13. distribution bushing; 14. orifice; 15. orifice; 16. openings of nozzle; 17. bolt; 18. body; 19. connecting pipe; 20. washer; 21. sealing ring.

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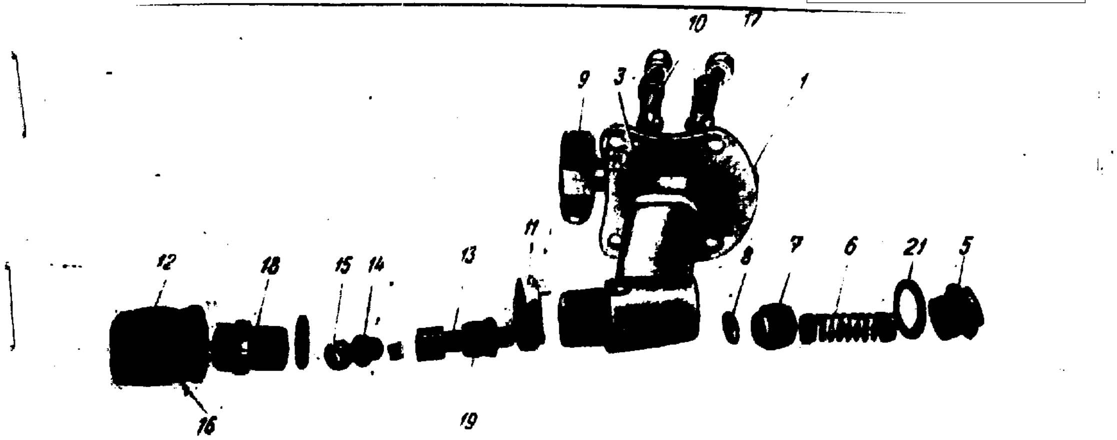

Figure 98. Parts of Nozzle

1. Screw joint; 2. idling channel; 3. nozzle body; 4. main fuel channel; 5. bolt; 6. spring; 7. screw joint; 8. sealing ring; 9. T-piece; 10. screen filters; 11. catch; 12. bushing of nozzle; 13. distribution bushing; 14. orifice; 15. orifice; 16. openings of nozzle; 17. bolt; 18. body; 19. connecting pipe; 20. washer; 21. sealing ring.

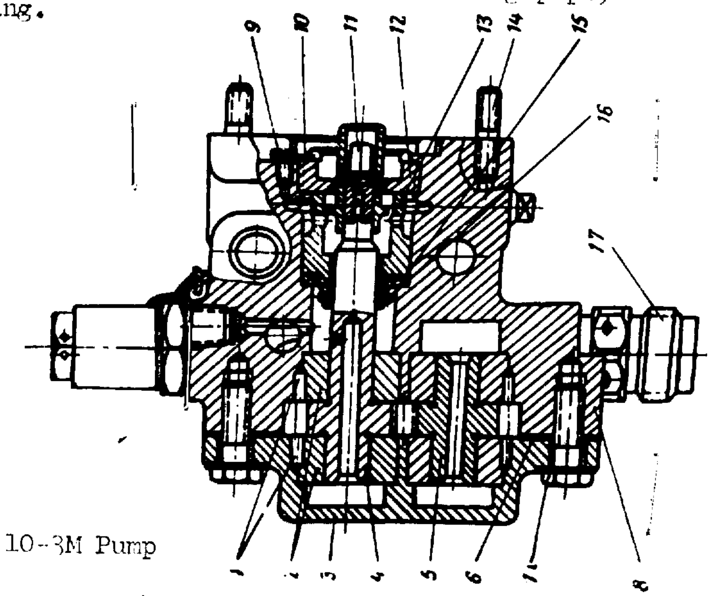

Figure 99. Structure of PNR 10-3M Pump

1. pins; 2. bushings; 3. lid; 4. drive gear; 5. drive gear; 6. washer; 7. clamping screw; 8. case; 9. screw; 10. safety sh[illegible]; 11. connecting piece; 12. bolt for packing; 13. bushing for packing; 14. stud bolt; 15. sealing cap; 16. spring; 17. connecting pipe for fuel feed.

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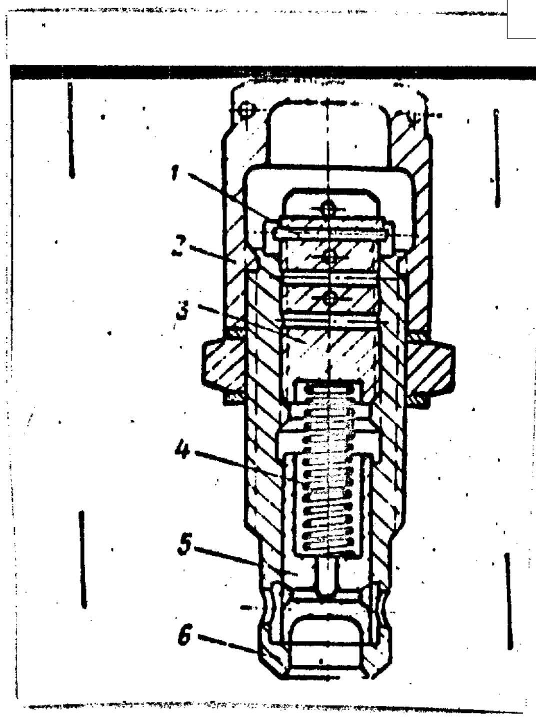

Figure 100. Reduction Valve of PNR 10-3M

1. Pin; 2. cap; 3. regulating screw; 4. spring; 5. valve; 6. body.

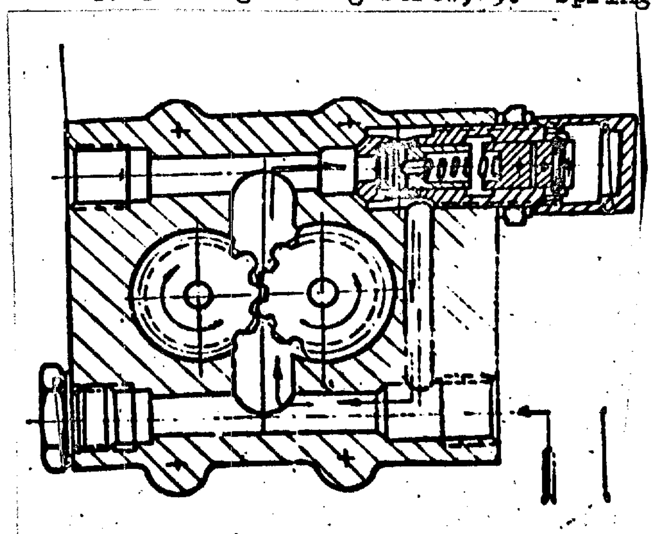

Figure 101. Schemat of Action of PNR 10-3M Unit

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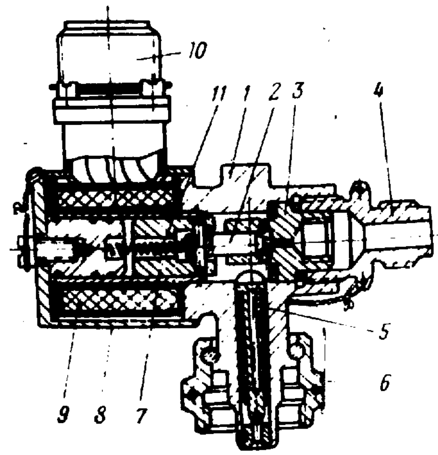

Figure 102. Electromagnetic Valve

1. Body; 2. pins; 3. valve bushing; 4. screw [illegible]
5. filter, 6. bolt; 7. solenoid core; 8. bushing [illegible]
9. solenoid; 10. plug; 11. spring.

Figure 103. Manifold of Starter Fuel

1. Screw joints for measuring fuel; 2. [illegible] feeding fuel; 3. igniter; 4. pipe feeding [illegible]

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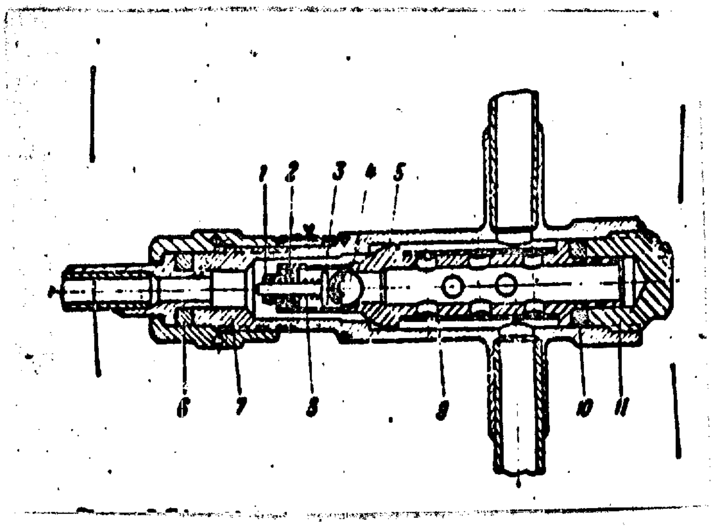

Figure 104. Grouping of Starter Fuel Manifold

1. Guide bushing; 2. safety ring; 3. cone; 4. ball; 5. body; 6. sealing ring; 7. screw joints; 8. spring; 9. screen; 10. sealing ring; 11. bolt.

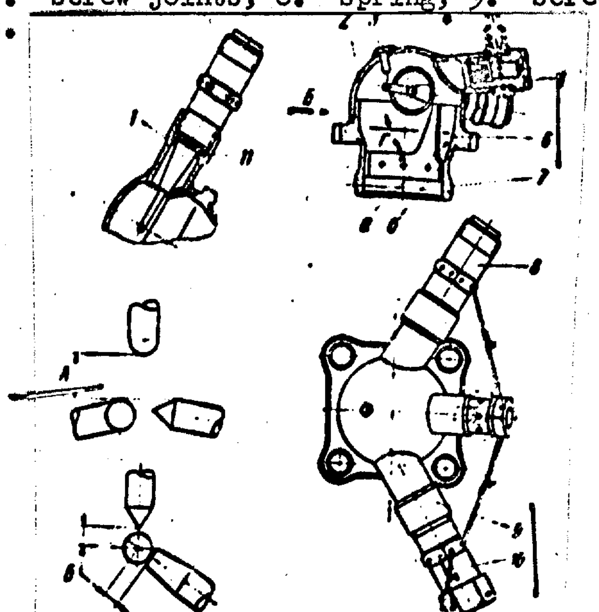

Figure 105. Igniter

1. Bushing for spark igniter plug; 2. lid of igniter; 3. discharger; 4. screw joint for nozzle; 5. nozzle; 6. flange; 7. safety device; 8. spark igniter; 9. bushing for ionizer; 10. ionizer; 11. regulation washer; a. and b. openings for feeding air.

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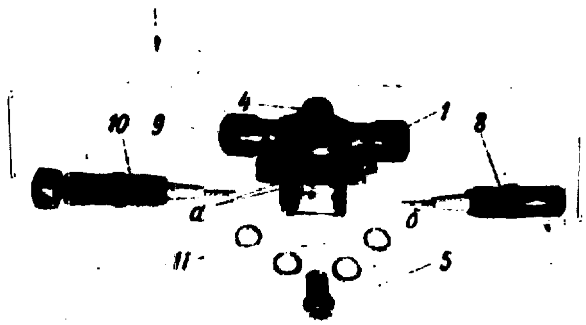

Figure 106. Parts of Igniter

1. bushing on spark igniter plug; 2. lid of igniter; 3. discharger; 4. screw joint for nozzle; 5. nozzle; 6. flange; 7. safety device; 8. spark igniter plug SD-96A; 9. bushing on ionizer; 10. ionizer SD-96M; 11. regulation washer; a. and b. openings for feeding air

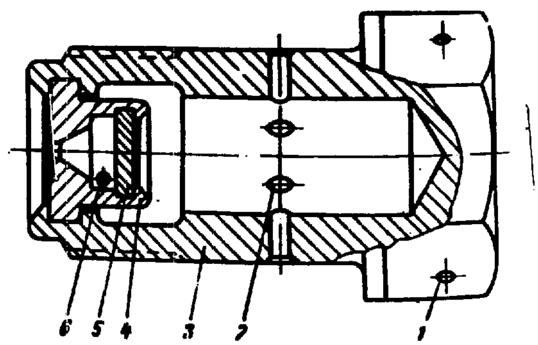

Figure 107. Starter Nozzle

1. safety opening; 2. opening for feeding of fuel; 3. connecting pipe; 4. atomizer; 5. bottom of vortex chamber; 6. openings in orifice.

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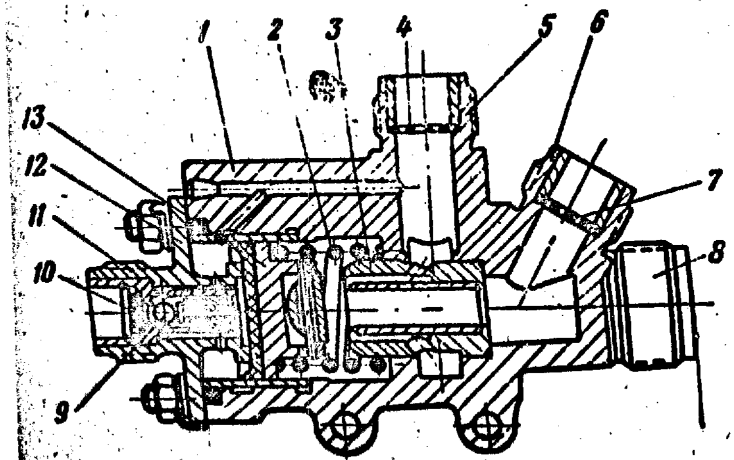

Figure 108. Discharge Valve

1. body; 2. spring; 3. stop of valve; 4, 7, 10. filters; 5. screwed joint for feeding fuel from auxiliary manifold; 6. screwed joint for feeding fuel from main manifold; 8. screwed joint for discharging fuel to drain tank; 9. check valve; 11. screwed joint for feeding fuel from high-pressure pipe; 12. lid; 13. valve.

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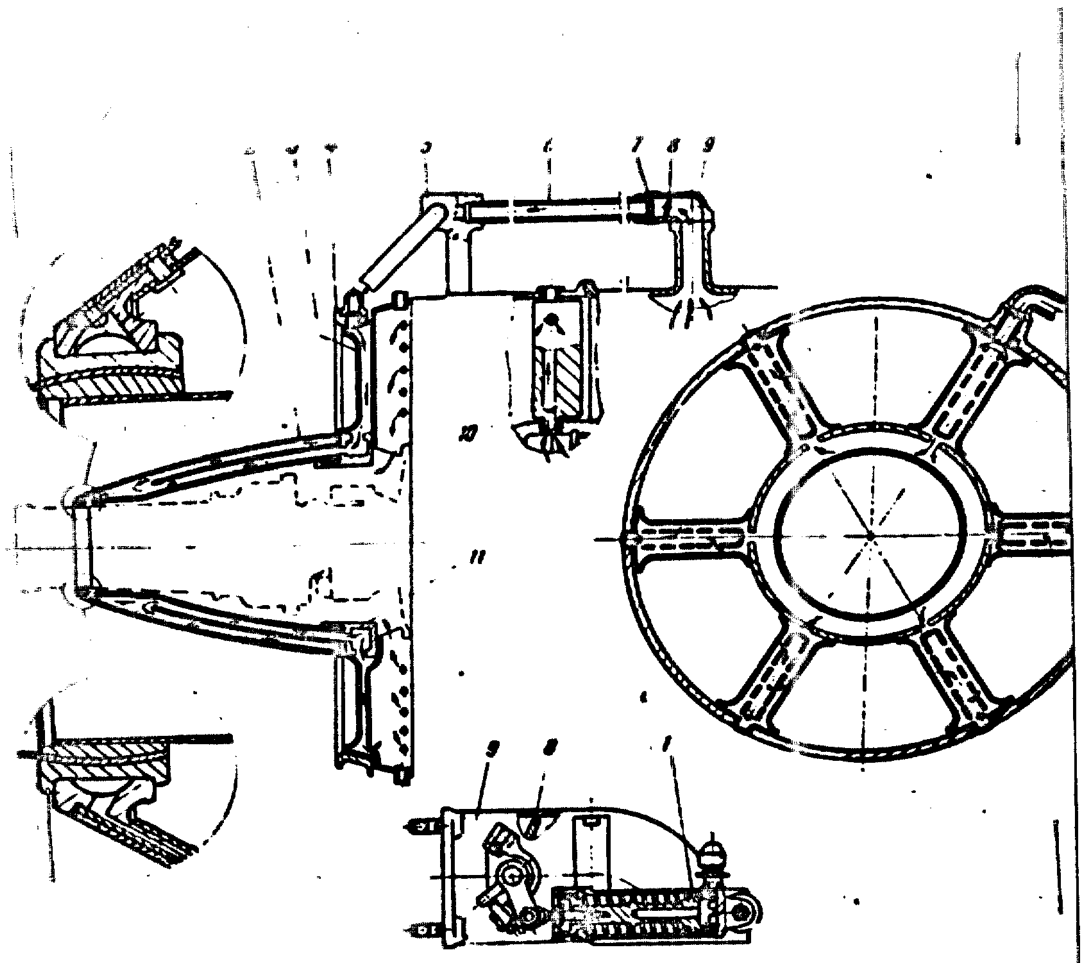

Figure 109. Schemat of Anti-Icing Equipment

1. mechanism for control of flap for intake of air; 2. cover of turbo starter; 3. reinforcing ribs; 4. external strut; 5. fitting; 6. pipe for carrying air; 7. diaphragm; 8. flap; 9. intake knee pipe; 10. guide vanes; 11. internal struts.

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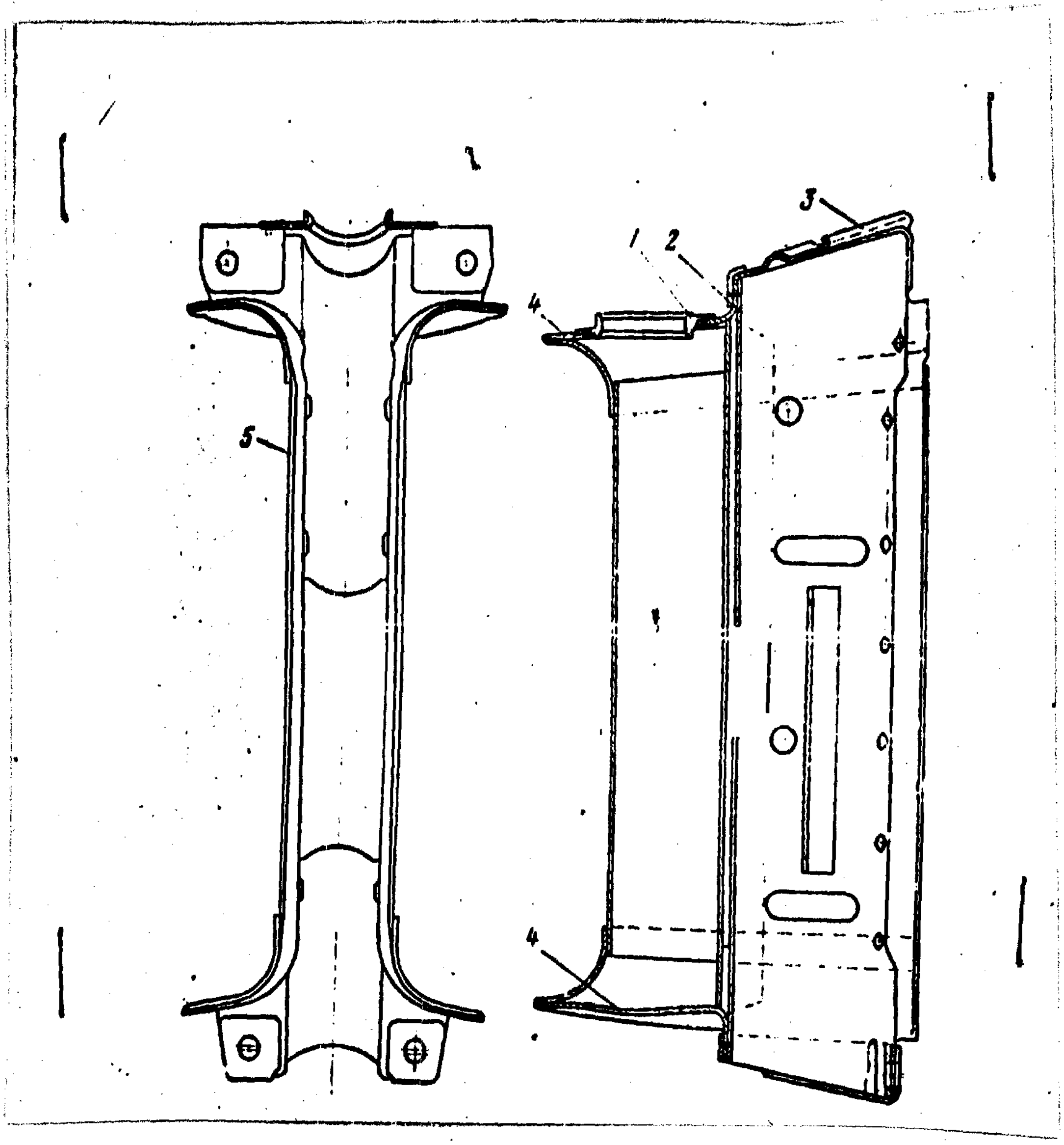

Figure 110. Reinforcing Ribs

1. bushing; 2. inside wall; 3. lid; 4. floor; 5. outside wall.

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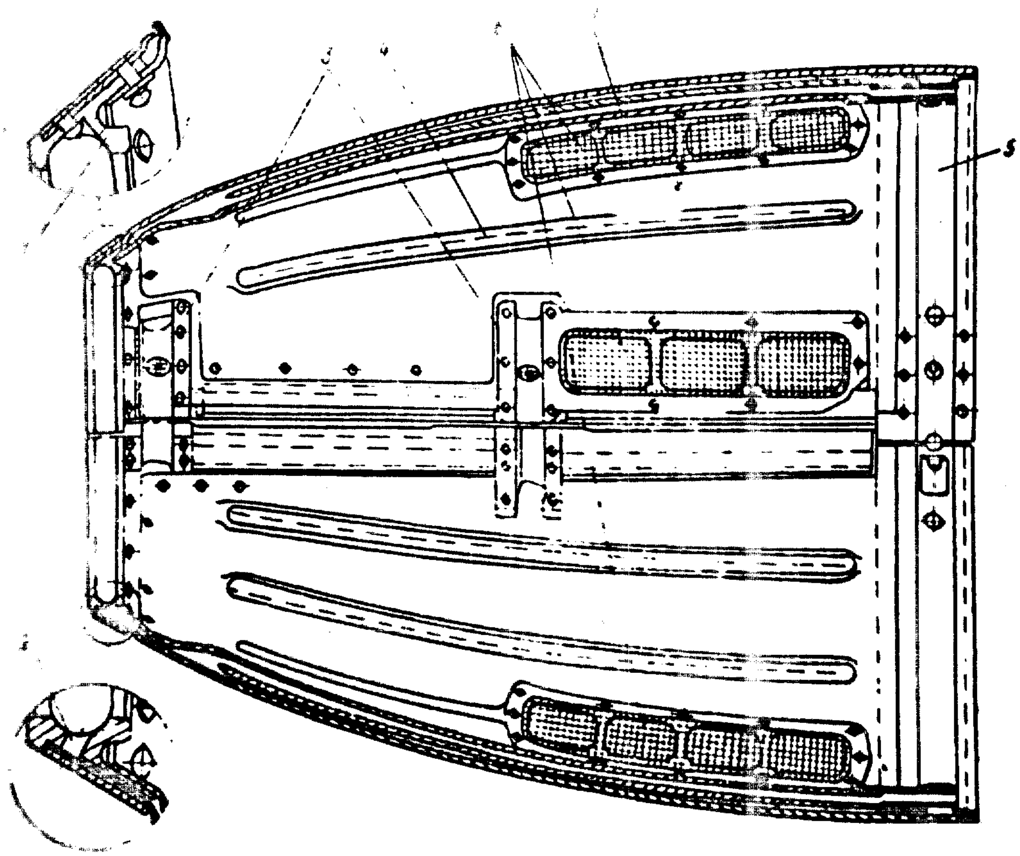

Figure 111. Aero-dynamic Cover

1. graduated ring; 2. opening for carrying hot air; 3. holders; 4. hollows; 5. collector; 6. gratings; 7. sheath for carrying hot air.

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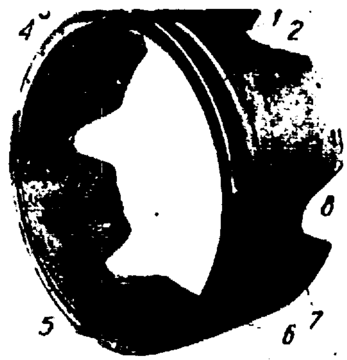

Figure 112. Strut of Cover

1. opening for feeding air; 2. round grooves for fastening the cover; 3. elipsed opening for carrying air to the cover; 4. opening for discharge of air from the cover; 5. cross-section for sheath of aero-dynamic cover; 6. openings for the fastening screws; 7. openings for feeding air to the reinforcement arms; 8. grooves for reinforcement arms

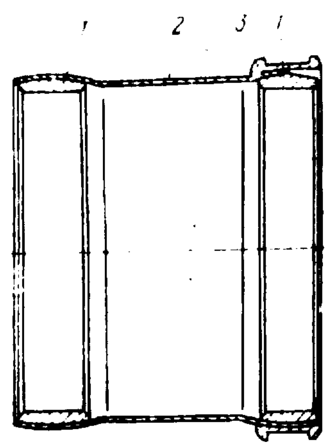

Figure 113. Spherical Connecting Piece

1. spherical ring; 2. body of connecting piece; 3. ring by which aero-dynamic cover is centered.

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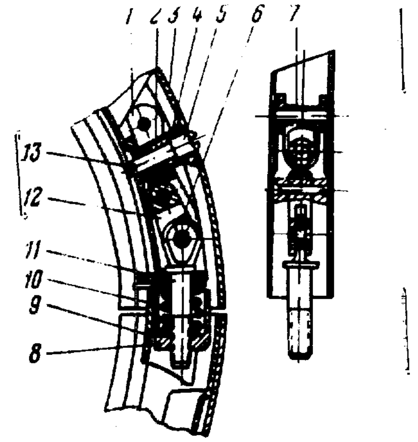

Figure 114. High-Speed Closing Device of Cover

1. lever; 2. spring; 3. lid; 4. cylindrical packing; 5. stop; 6. pin; 7. spring; 8. special bolt; 9. holder; 10. spring; 11. screw with eye; 12. loop; 13. support pin.

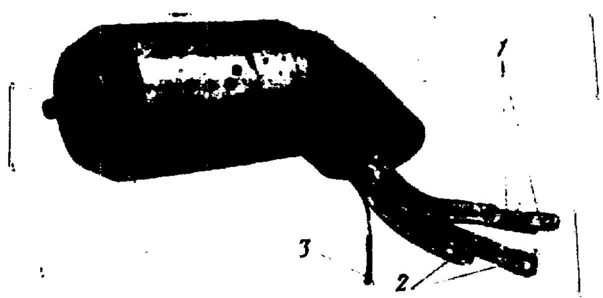

Figure 115. Dynamo GSR-18000D.

1. plus outlets; 2. minus outlets; 3. excitation outlet.

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No Foreign Dissem

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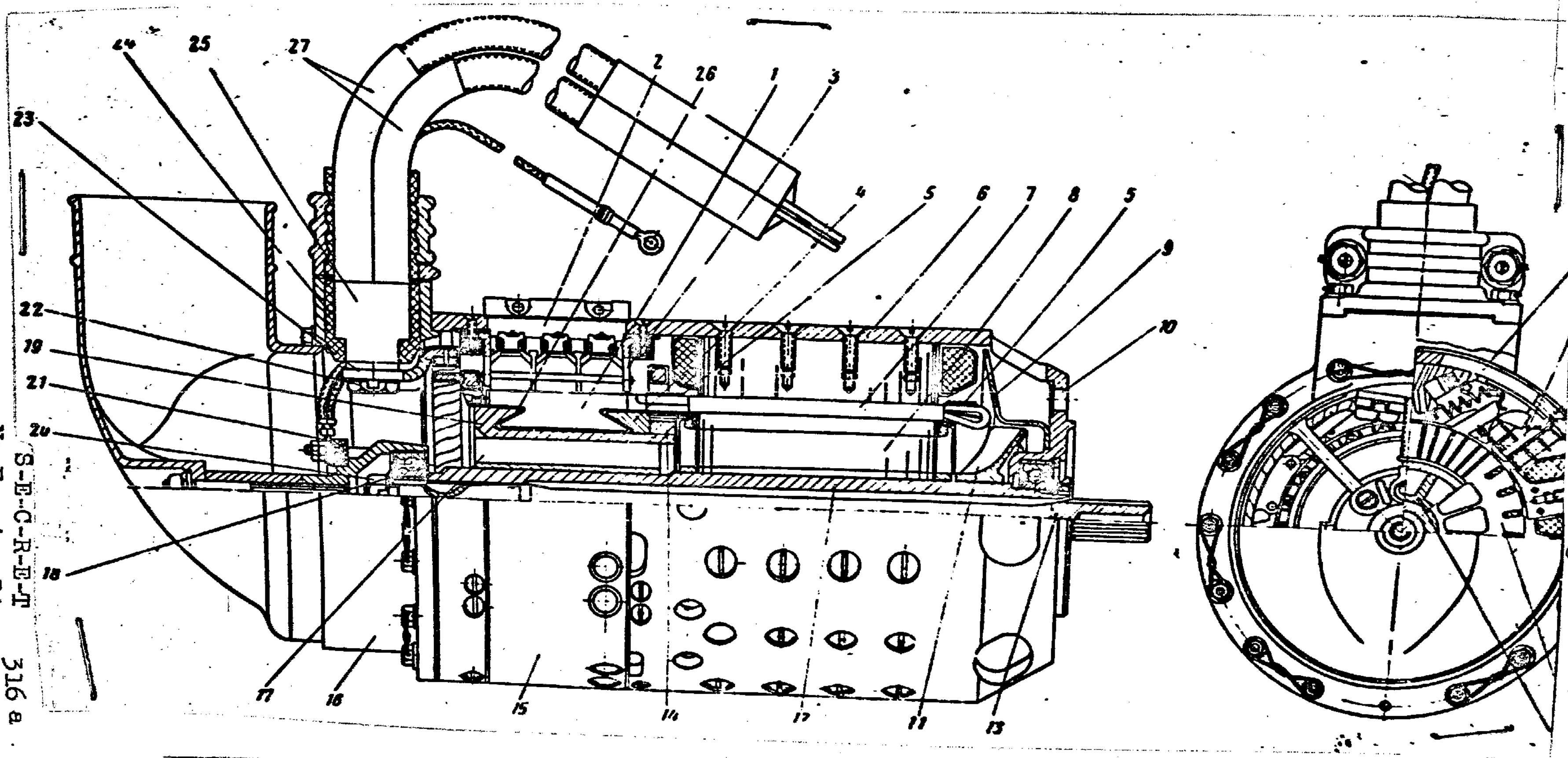

Fig. 116. D. C. Generator GSR-18000D

1 -- Commutator segments; 2 -- opening for access to cummutator and brushes; 3 -- brush holders; 4 -- pressure shim; 5 -- banding; 6 -- housing; 7 -- winding; 8 -- armature; 9 -- protective gratings; 10 -- hole for mounting generator; 11 -- fan; 12 -- hollow shaft; 13 -- drive shaft; 14 -- nut; 15 -- protective strap; 16 -- cover; 17 -- cruciform spider; 18 -- ball bearing; 19 -- commutator housing; 20 -- nut; 21 -- plastic post; 22 -- screw; 23 -- bus bar; 24 -- plastic post; 25 -- cable terminals; 26 -- insulating cones; 27 -- exit leads; 28 -- armature core; 29 -- main poles; 30 -- auxilliary poles.

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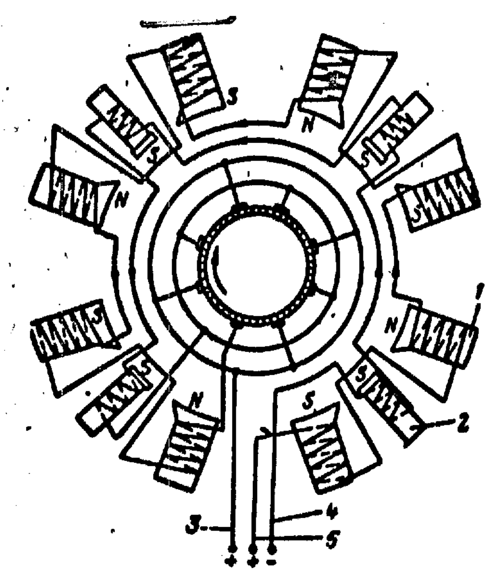

Obr. 117. Elektrické schema dynama GSR-18000D.
1-hlavní póly; 2-vedlejší póly; 3-plusový vývod; 4-společný minusový vývod; 5-vývod buzení.

Fig. 117. Electric Circuit of D. C. Generator GSR-18000D

1 -- Main poles; 2 -- auxiliary poles; 3 -- positive lead; 4 -- combined negative lead; 5 -- lead for excitor winding.

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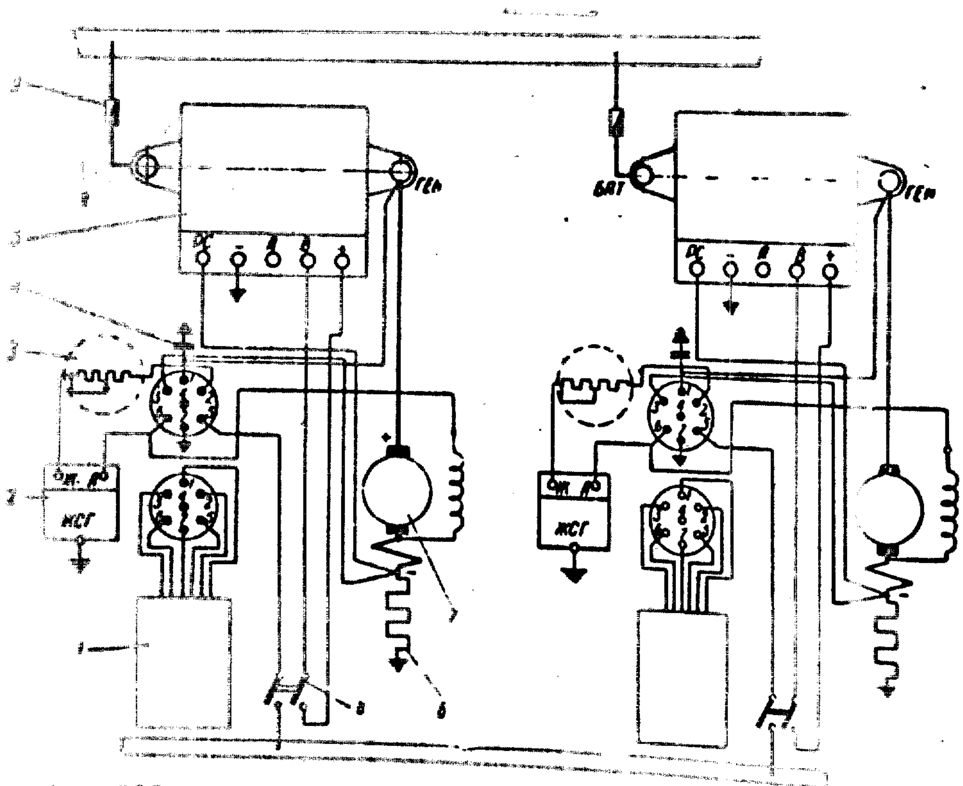

Obr. 118. Schema vnějšího zapojení dynam GSR-18000D. 1-regulátor napětí RUG-82; 2-stabilisační transformátor; 3-dálkově namontovaný reostat VS-20; 4-kondensátor KBM-31; 5-diferenční minimální relé; 6-odpor; 7-dynamo GSR-18000D; 8-hlavní vypinač; 9-pojistka.

Fig. 118. External Hook-up Circuit of D. C. Generator GSR-18000D

1 -- Voltage regulator RUG-82; 2 -- stablizing transformer; 3 -- remotely mounted rheostat VS-20; 4 -- capacitor KPM-31; 5 --differential minimum relay; 6 -- resistor; 7 -- D. C. generator GSR-18000D; 8 -- main switch; 9 -- fuse.

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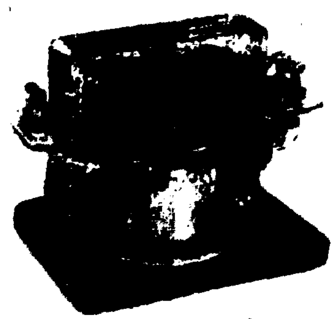

Obr. 119. Diferenční minimální relé DMR-600A.

Fig. 119. Differential Minimum Relay DMR-600A

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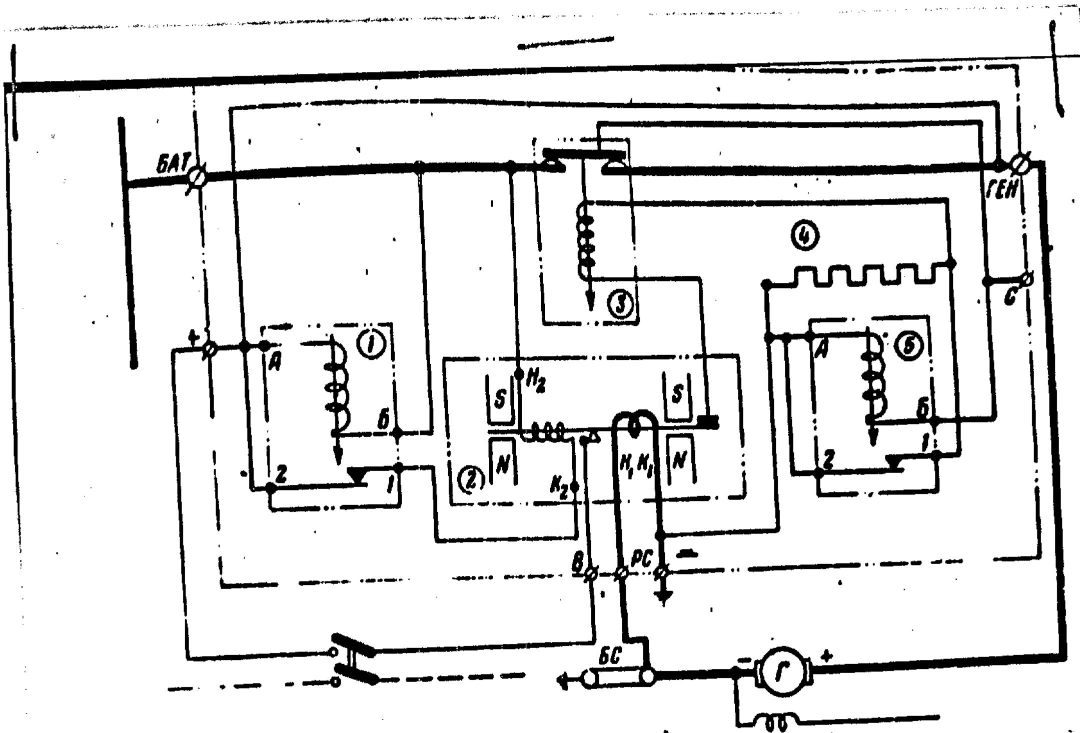

Obr. 120. Základní schema diferenčního minimálního relé DMR-600A. 1-komutační relé; 2-vysílací relé; 3-kontaktor; 4-odpor; 5-relé napětí.

Fig. 120. Basic Circuit of Differential Minimal Relay DMR-600A

1 -- Commutation relay; 2 -- transfer relay; 3 -- contact; 4 -- resistor; 5 -- voltage relay.

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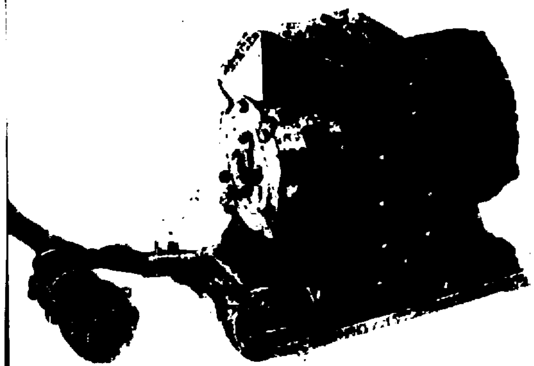

Obr. 121. Regulátor napětí RUG-82.

Fig. 121. Voltage Regulator RUG-82

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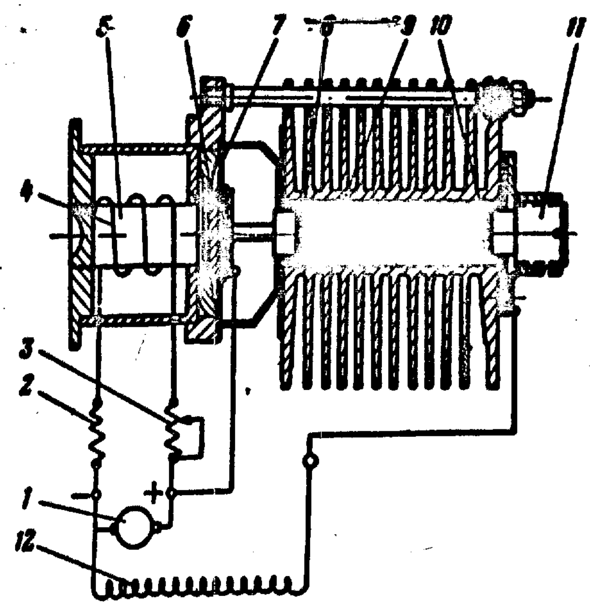

Obr. 122. Nejjednodušší uhlíkový regulátor. 1-dynamo; 2-odpor teplotní kompensace; 3-řiditelný odpor; 4-vinutí elektromagnetu; 5-jádro; 6-kotva; 7-pružina kotvy; 8-uhlíkový kontakt kotvy; 9-uhlíkový sloupec; 10-uhlíkový kontakt seřizovacího šroubu; 11-seřizovací šroub; 12-bočníkové vinutí generátoru.

Strana 57.

Fig. 122. Simple Carbon Regulator

1 -- Generator; 2 -- temperature compensation resistor; 3 -- variable resistor; 4 -- winding of electromagnet; 5 -- core; 6 -- armature; 7 -- armature spring; 8 -- carbon terminal of armature; 9 -- carbon column; 10 -- carbon terminal of set screw; 11 -- set screw; 12 -- generator compensating winding.

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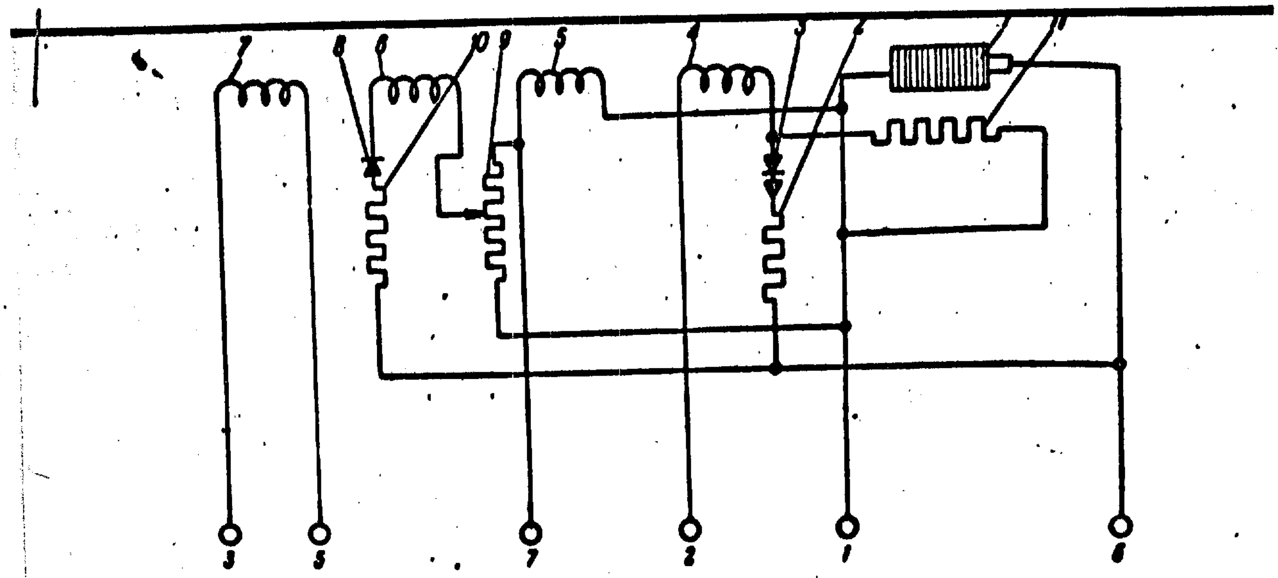

Obr. 123. Základní schema RUG-82.
1-uhlíkový sloupek; 2-odpor SN-1; 3-selenový usměrňovač (desky ∅ 18); 4-pracovní vinutí; 5-kompensační vinutí; 6-korekční vinutí; 7-vinutí pro vyrovnávání napětí; 8-selenový usměrňovač (jedna deska ∅ 18); 9-odpor RPO-9 200 Ω; 10-odpor PO-2,5-250 Ω; 11-odpor PO-20-25 Ω.

Fig. 123. Basic Circuit of RUG-82

1 -- Carbon column; 2 -- resistor SN-1; 3 -- selenium rectifier; (plates with a diameter of 18); 4 -- operating winding; 5 -- compensating winding; 6 -- correction winding; 7 -- winding to equalize voltage; 8 -- selenium rectifier (one plate diameter of 18); 9 -- resistor RPO-9; 200 ohms; 10 -- resistor PO-2 250 ohms; 11 -- resistor PO-20 25 ohms.

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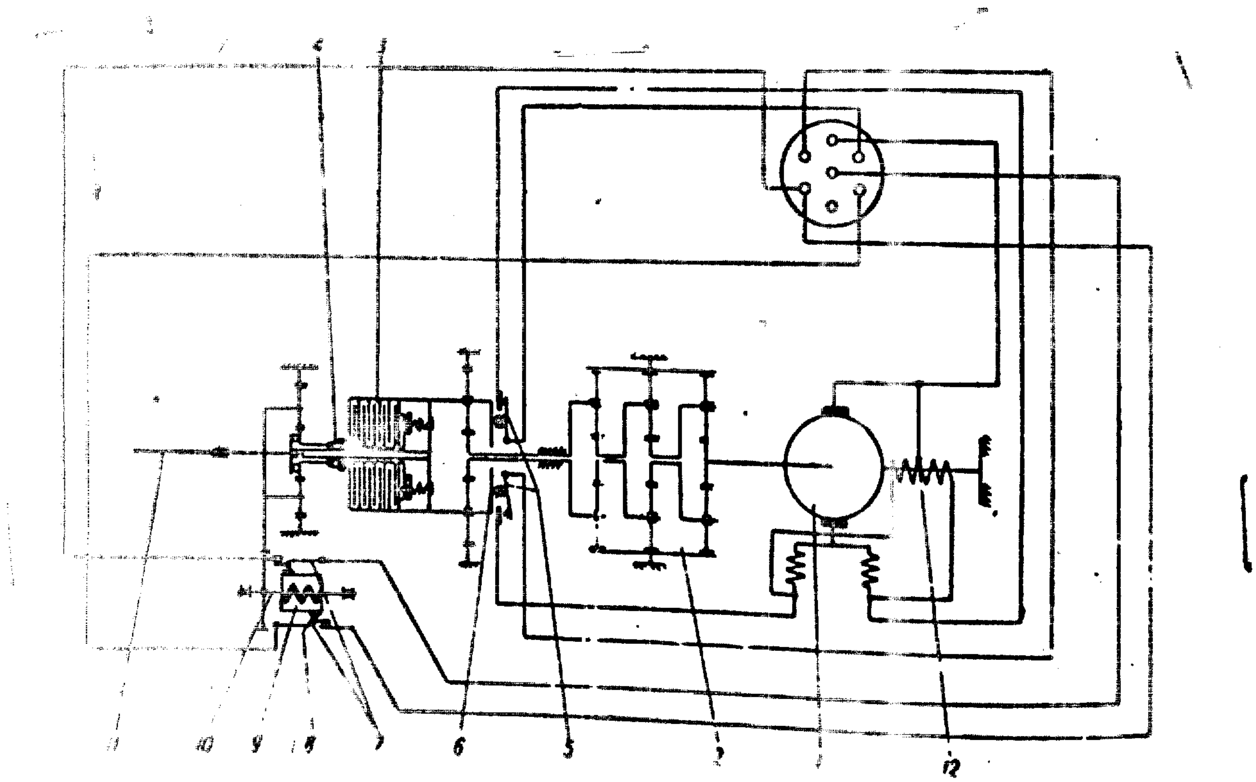

Obr. 125. Základní schema elektromechanismu MZK-2.
1-reversní motor D-12TU; 2-reduktor pětistupňový planetový; 3-třecí spojka; 4-kuličkový regulátor; 5-panely koncových vypinačů; 6-čelní vačka; 7-panely koncových vypinačů signálních lamp; 8-opěrný šroub, 9-matice; 10-šroub; 11-výstupní hřídel; 12-brzdicí spojka.

Fig. 125. Basic Circuit of Electromechanism MZK-

1 -- Reversing motor D-12TU; 2 -- five-stage planetary reductor; 3 -- friction clutch; 4 -- ball regulator; 5 -- panel for terminal switches; 6 -- face cam; 7 -- panels of terminal switches for signal light; 8 -- supporting screw; 9 -- nut; 10 -- bolt; 11 -- shaft; 12 -- braking clutch.

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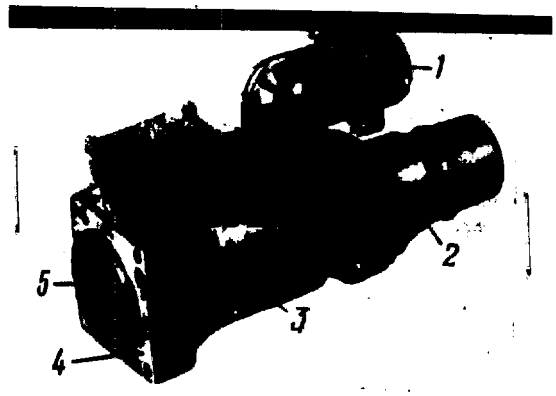

Fig. 124. Electromechanism MZK-2

1 -- Socket SR28P7NS7; 2 -- electric motor; 3 -- reductor with switching mechanism of terminal switches; 4 -- flange; 5 -- end of shaft.

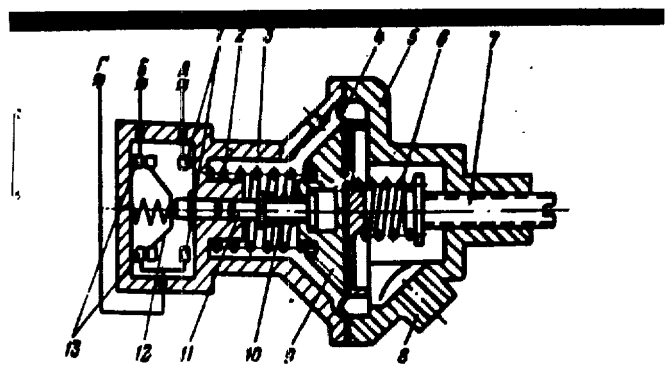

Fig. 126. Pneumatic Switch PK

1 and 13 -- Pairs of fixed contact points; 2 -- working spring; 3 -- housing; 4 -- diaphragm; 5 -- cover; 6 -- adjustment spring; 7 -- adjustment screw; 8 -- air inlet fitting; 9 -- diaphragm disc; 10 -- extension spring; 11 -- push rod; 12 -- movable contact plate.

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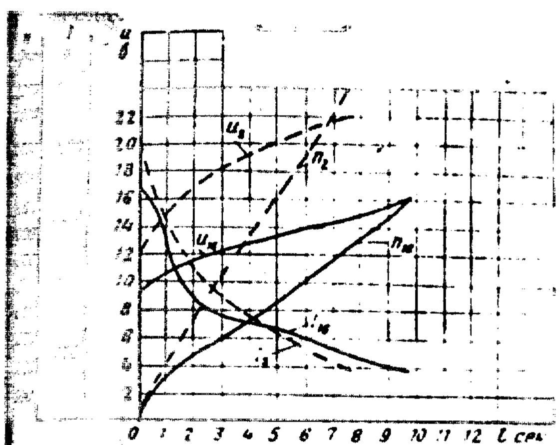

Křivky změny síly proudu, na-
...u otáček elektromotoru
...časové závislosti pro 2 a 16.
...startéru pomocí dvou akumulá-
...terií 12A-30.

Fig. 130. Curves showing change of current and voltage, as well as number of revolutions of the electric motor SA-189BM, expressed as a function of time for the second and sixteenth starting operation from 2 storage batteries 12A-30.

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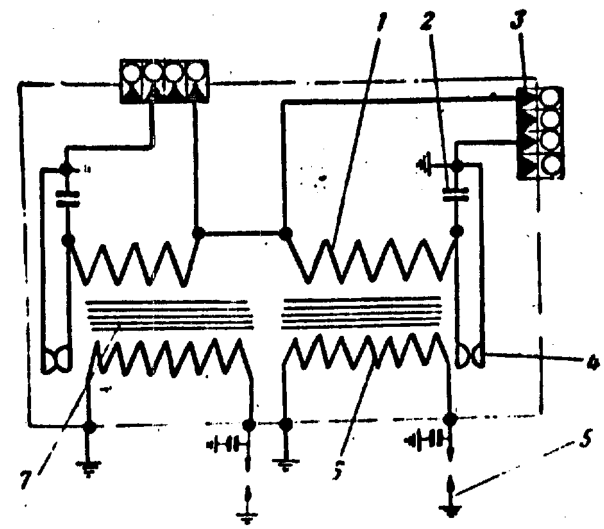

Obr. 131. Základní schema bloku spouštěcích cívek KPM1-2.
1-primární vinutí; 2-kondensátor; 3-zásuvkový spoj; 4-přerušovač; 5-vybíječ; 6-sekundární vinutí; 7-jádro.

Fig. 131. Basic Circuit of the Block of Starting Coils KPM1-2

1 -- Primary winding; 2 -- capacitor; 3 -- socket contact; 4 -- circuit breaker; 5 -- discharge gap; 6 -- secondary winding; 7 -- core.

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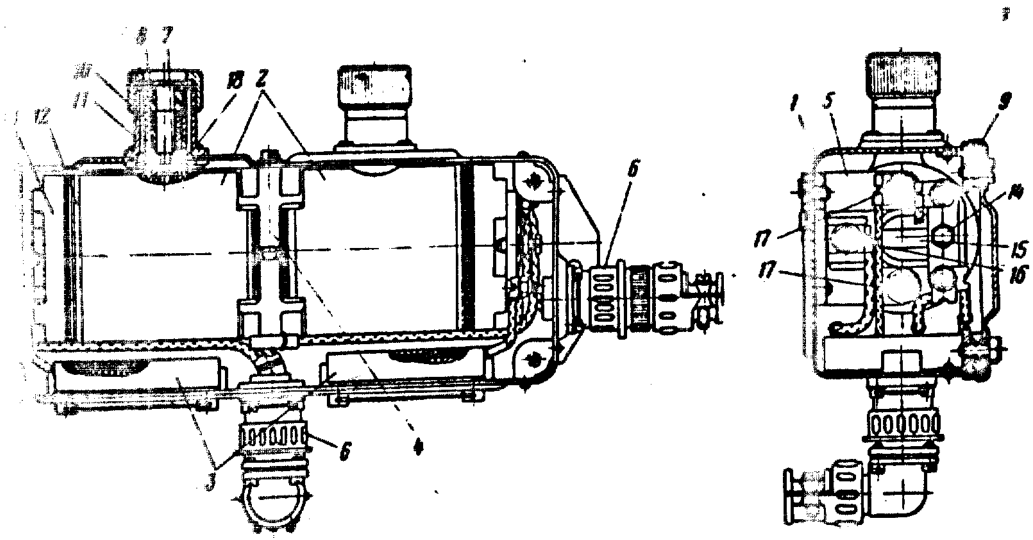

132. Blok spouštěcích cívek KPM1-2.
..; 2-indukční cívka; 3-kondensátor; 4-upevňovací vzpěra; 5-konsola;
..y s vidlicí; 7-kontaktové zařízení; 8-těsnicí trubka; 9-víko;
..ační trubka; 11-nátrubek; 12-kostra; 13-panel; 14-šroub; 15-kotva;
..šroub; 18-kontakt.

Fig. 132. Block of Starting Coils KPM 1-2

1 -- Housing; 2 -- induction coil; 3 -- capacitor; 4 -- mounting brace; 5 -- bracket; 6 -- connector; 7 -- contact assembly; 8 -- gasket sleeve; 9 -- cover; 10 -- insulating sleeve; 11 -- nipple; 12 -- form; 13 -- panel; 14 -- screw; 15 -- armature; 16, 17 -- screw; 18 -- contact point.

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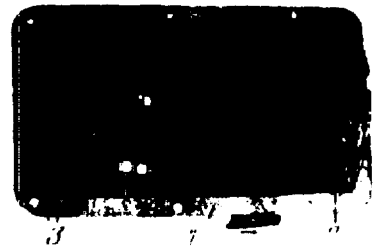
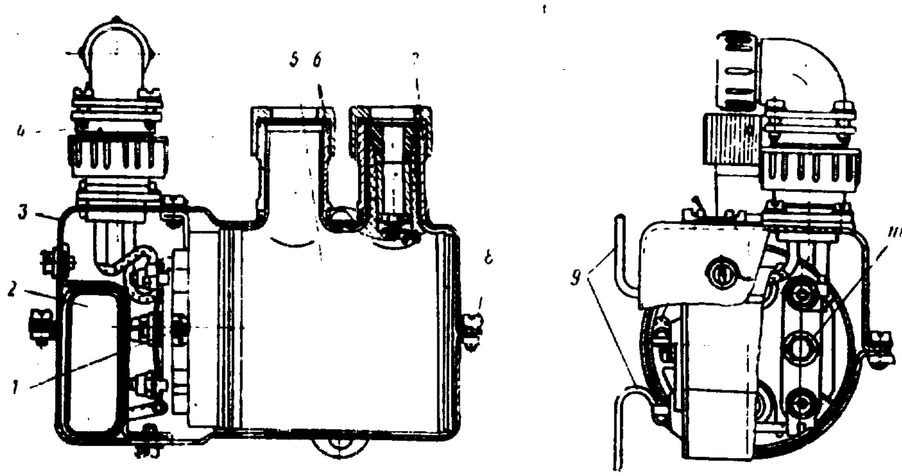


Obr. 133. Spouštěcí cívka KP-21 (pohled bez víka).
1-těleso; 2-cívka; 3-kondensátor.

Fig. 133. Starting Coil KP-21 (View with cover removed)

1 -- Housing; 2 -- coil; 3 -- capacitor.



Obr. 134. Spouštěcí cívka KP-21.
1-přerušovač; 2-kondensátor; 3-těleso; 4-zástrčkový spoj; 5-indukční cívka; 6,7-nátrubky; 8-šroub; 9-záchytka; 10-seřizovací šroub.

Fig. 134. [illegible] KP-21

[illegible] -- capacitor; [illegible] -- housing; [illegible]
-- [illegible] coil; 6, 7 -- nipples; [illegible] -- screw; [illegible]
-- [illegible]

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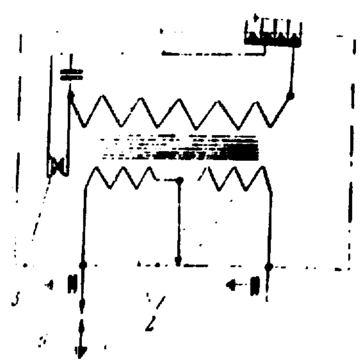

Obr. 135. Základní schema spouštěcí cívky KP-21.
1-primární vinutí; 2-sekundární vinutí; 3-kontakty vibrátoru; (přerušovače); 4-kondensátor; 5-jádro cívky; 6-svíčka; 7-zástrčka.

Fig. 135. Basic Circuit of Starting Coil KP-21

1 -- primary winding; 2 -- secondary winding; 3 -- vibrator contact points (breaker); 4 -- capacitor; 5 -- core of coil; 6 -- plug; 7 -- connector.

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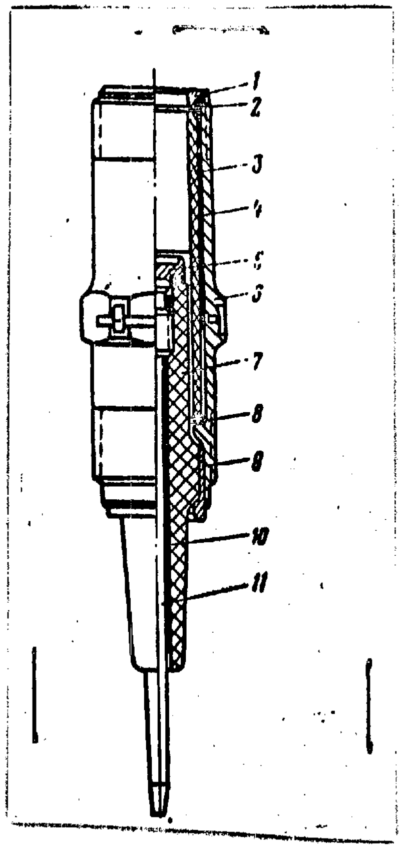

Fig. 136. Spark Igniter Plug SD96A

1 -- form ring; 2 -- paronite washer; 3 -- ceramic insulator sleeve; 4 -- washer; 5 -- steel contact head; 6 -- flange; 7 -- ceramic insulator; 8 -- paronite washer; 9 -- case; 10 -- heat resistant cement; 11 -- central electrode.

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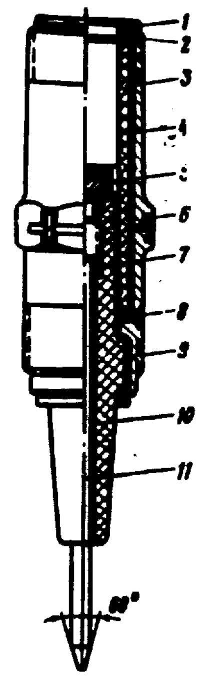

Fig. 137. Ionizer (legend the same as for Illustration 136)

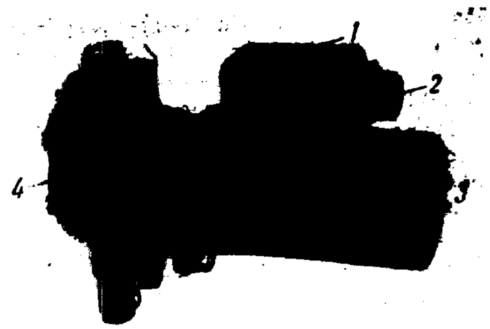

Fig. 138. Starter Pump PNR10-3M

1 -- terminal box; 2 -- plug VS-4; 3 -- electric motor MU-102A; 4 -- pump.

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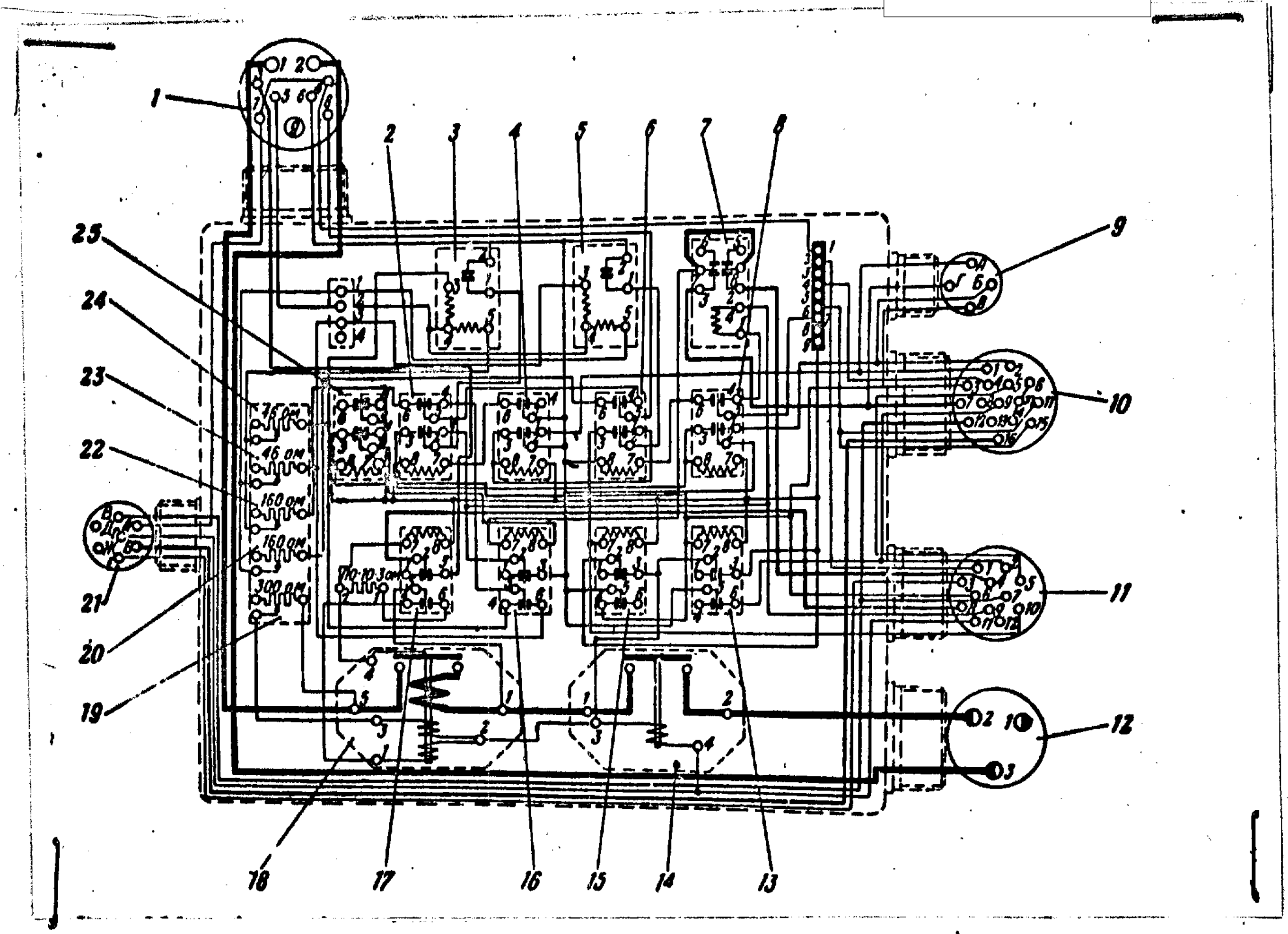

Fig. 139. Basic Circuit of Starting Control Box PT-4M

1 -- Socket SR48P9EG1 (for hook-up of starter mechanisms); 2 -- interposed relay RP-2B (for activating relay 3 and relay 5 in circuit TD-1); 3 -- signal relay PLN-4 (for on-off switching of the ignition); 4 -- interposed relay RP-2B; 5 -- signal relay RLN-4 (for switching-on automatic equipment); 6 -- interposed relay RP-2B (for activating relays 3 and 5 in circuit TD-1); 7 -- relay RL-20G (engine ignition); 8 -- ignition circuit; 9 -- socket VS-4 (for ignition indicator lamps); 10 -- socket SR40P16ES2 (electric circuit of the engine); 11 -- circuit socket SR32P12NG1; 12 -- network socket SR40P3NS9; 13 -- relay RP-2B (of the automatic starting sequence); 14 -- breaker K-100; 15 -- relay RP-2B (cutting out automatic equipment); 16 -- interposed relay RP-2B (for activating relays 3 and 5 in circuit TD-1); 17 -- relay RP-2B (opening the electromagnetic fuel valve of the starter); 18 -- maximum rpm relay RMO-4; 19 -- variable resistors RMO-4 for disconnecting the SA-189B; 20 -- variable tuning resistor RLN-4 for activating automatic equipment; 21 -- socket VS-7 (SU-7) of electromechanism MZK-2; 22 -- variable resistor RLN-4 for activating ignition; 23 -- variable resistor RLN-4; 24 -- variable resistor RLN-4; 25 -- relay RP-2B.

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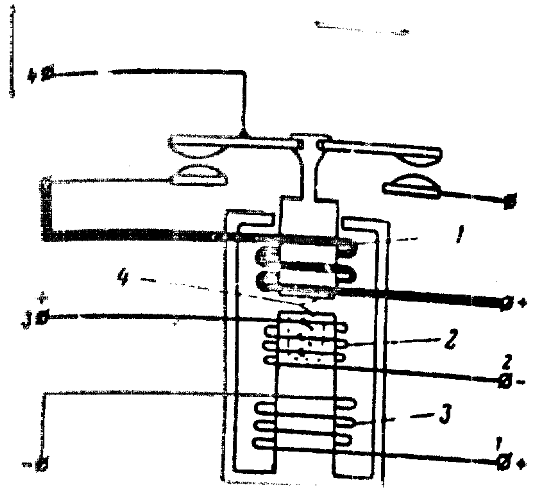
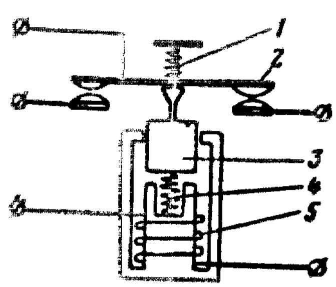


Obr. 140. Základní schema relé maximálních otáček RMO-4.
1-seriové vinutí; 2-kompensační vinutí; 3-bočníkové vinutí; 4-pružina.

Fig. 140. Basic Circuit of Maximum Rpm Relay RMO-4

1 -- series winding; 2 -- compensation winding; 3 -- shunt winding; 4 -- spring.



Obr. 141. Schema spínače K-100.
1-pružina; 2-pracovní kontakty; 3-kotva; 4-pružina; 5-vinutí.

Fig. 141. Circuit of Switch K-100

1 -- spring; 2 -- working contact points; 3 -- armature; 4 -- spring; 5 -- winding.

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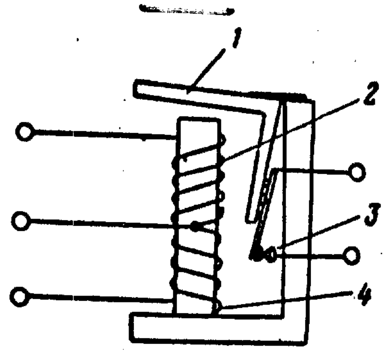
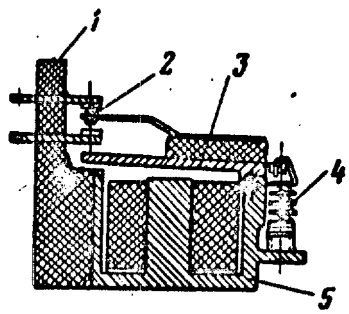


Obr. 142. Schema relé RLN-4.
1-kotva; 2-kompensační vinutí; 3-pracovní kontakty; 4-bočníkové vinutí.

Fig. 142. Circuit of Relay RLN-4

1 -- armature; 2 -- compensation winding; 3 -- working contact points; 4 -- shunt winding.



Obr. 143. Základní schema relé RL-20G a RP-2B.
1-kontaktní panel; 2-pohyblivé kontakty; 3-kotva; 4-vratná pružina; 5-kostra.

Fig. 143. General Diagram of Relay RL-20G and RP-2B

1 -- terminal panel; 2 -- movable contact points; 3 -- armature; 4 -- return spring; 5 -- housing.

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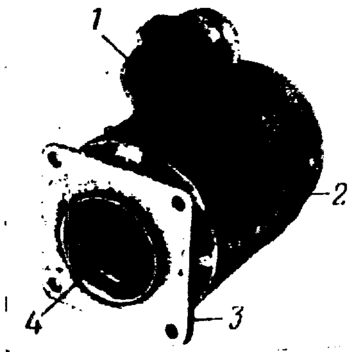
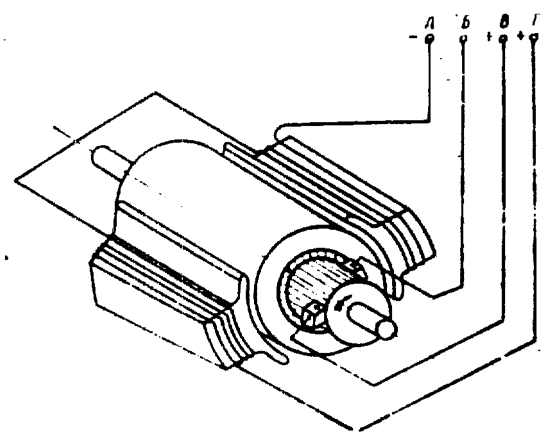


Obr. 144. Tachodynamo TD-1. 1-zásuvka; 2-těleso; 3-příruba; 4-koncovka hřídele.

Fig. 144. Tacho-Generator TD-1

1 -- socket; 2 -- body; 3 -- flange; 4 -- end of shaft.



Obr. 145. Schema spojů vinutí tachodynama TD-1.

Fig. 145. Circuit of Contacts of the Winding of Tacho-Generator TD-1

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S-E-C-R-E-T
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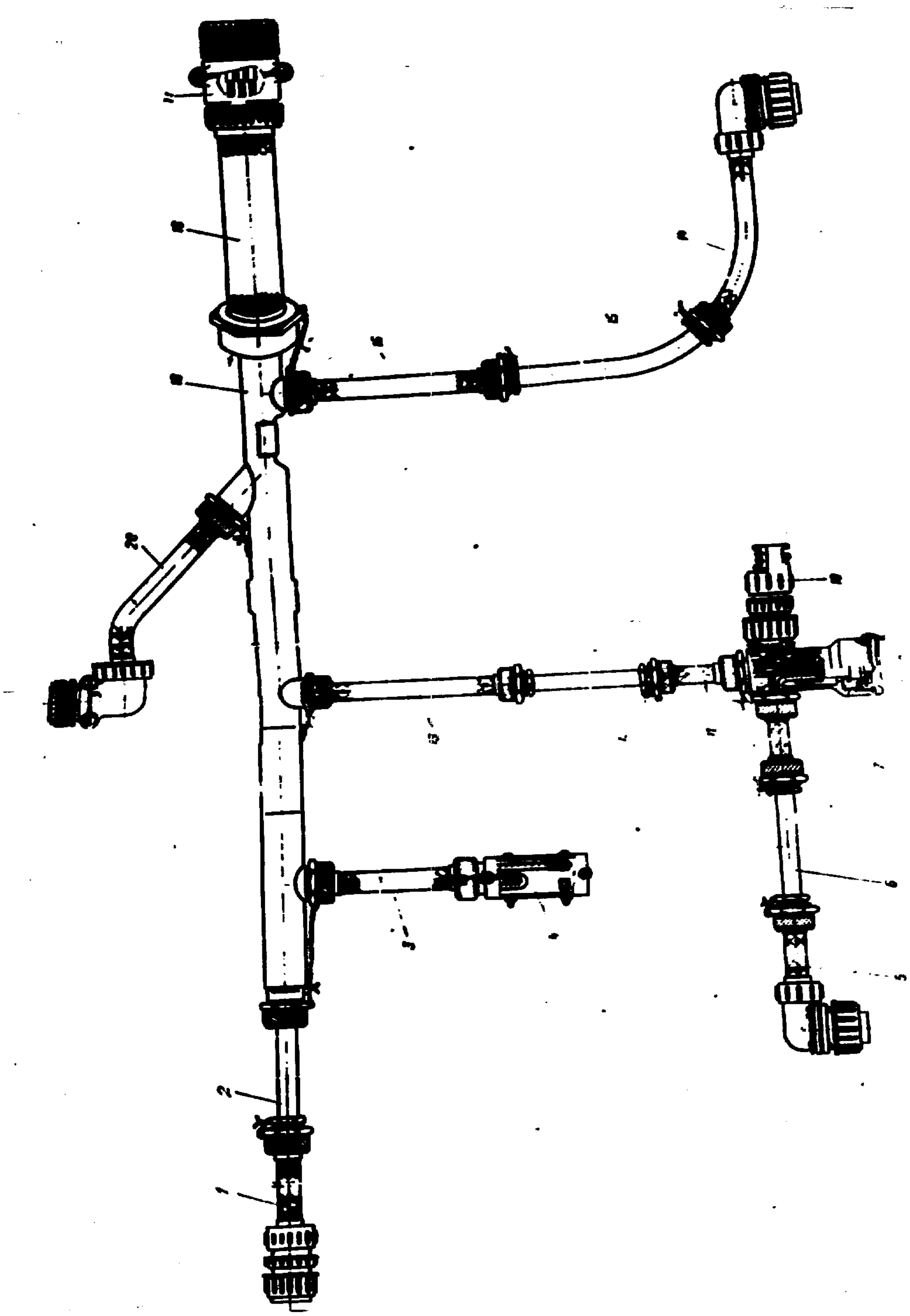
S-E-C-R-E-T
No Foreign Dissem



S-E-C-R-E-T
No Foreign Dissem

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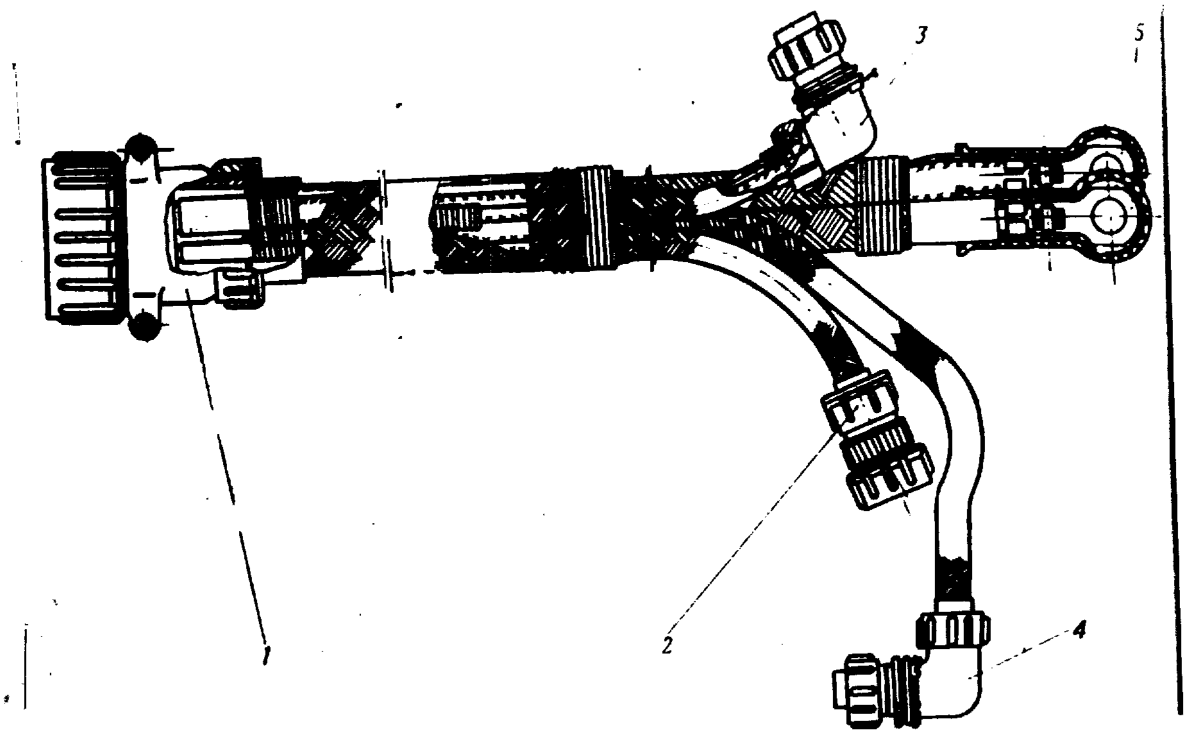

Fig. 147. Cables Starter S300-M

1 -- plug connector SR48P9EG1; 2 -- lead to tacho-generator with plug connector SP-4E; 3 -- lead to coil KP-21 with plug connector SU-4E; 4 -- lead to electromagnetic fuel valve with plug connector SU-4E; 5 -- leads for electric motor A-189BM.

S-E-C-R-E-T
No Foreign Dissem

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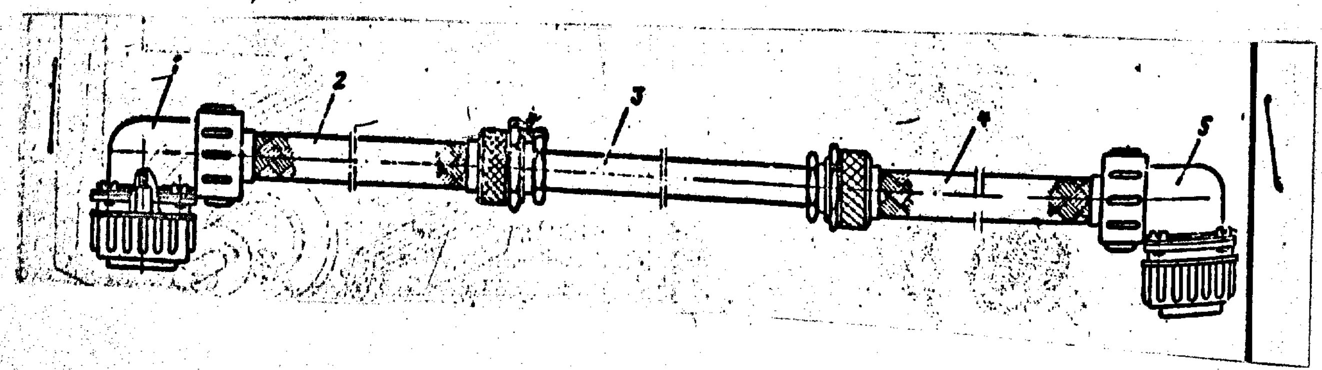

Fig. 148. Lead Between Blocks of Starting Coils KPM 1-2

1 -- plug connector SU-4E; 2 -- shield hose; 3 -- shield tubing; 4 -- shield hose; 5 -- plug connector SU-4E.

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Obr. 149. Vodič od spodního bloku KPM1-2 k čerpadlu PNR10-3M.
1-zástrčkový spoj ŠU-4E pro spojení s KPM1-2; 2-stínicí hadice; 3-stínicí trubka; 4-přechodový kus; 5-vodič k elektromagnetickému ventilu; 6-zástrčkový spoj ŠU-4E; 7-vedení k čerpadlu PNR10-3M; 8-zástrčkový spoj ŠU-2E.

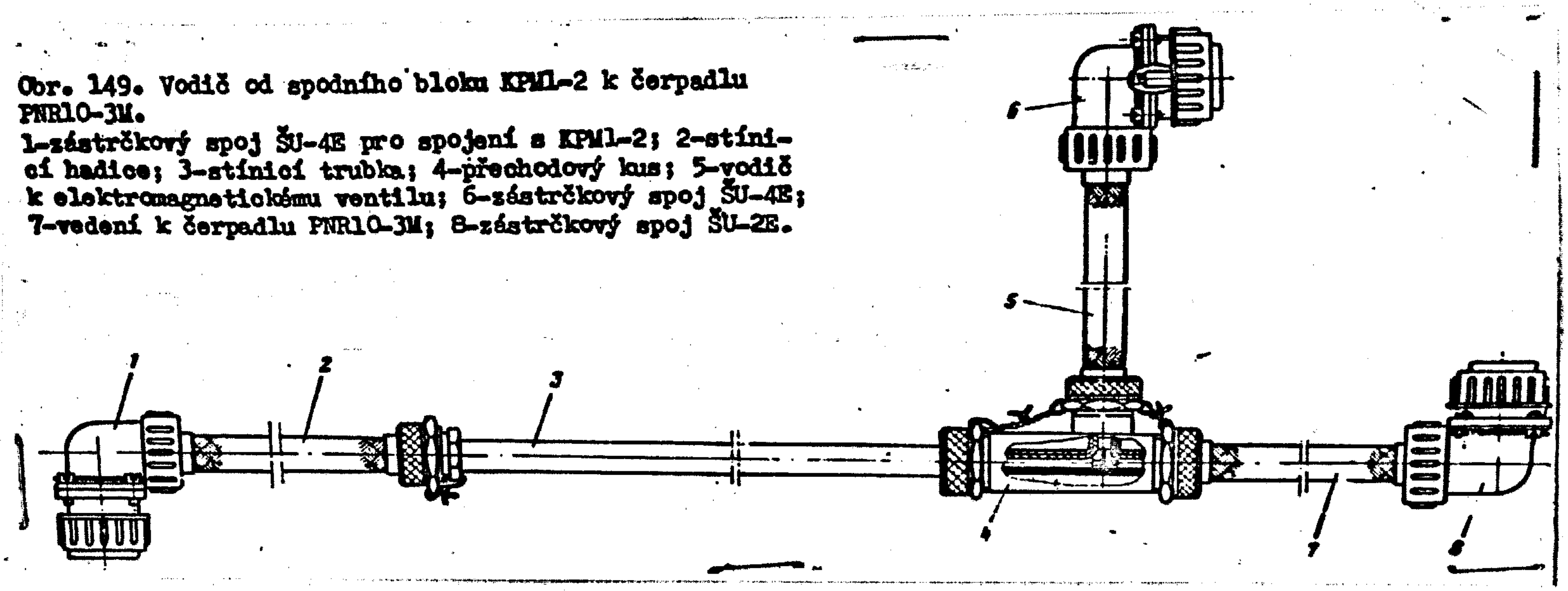

Fig. 149. Lead from Lower KPM 1-2 Block to Pump PNR 10-3M

1 -- plug connector SU-4E for connecting with the KPM 1-2; 2 -- shield hose; 3 -- shield tubing; 4 -- adapter; 5 -- lead to electromagnetic valve; 6 -- plug connector SU-4E; 7 -- lead to pump PNR 10-3M; 8 -- plug connector SU-2E.

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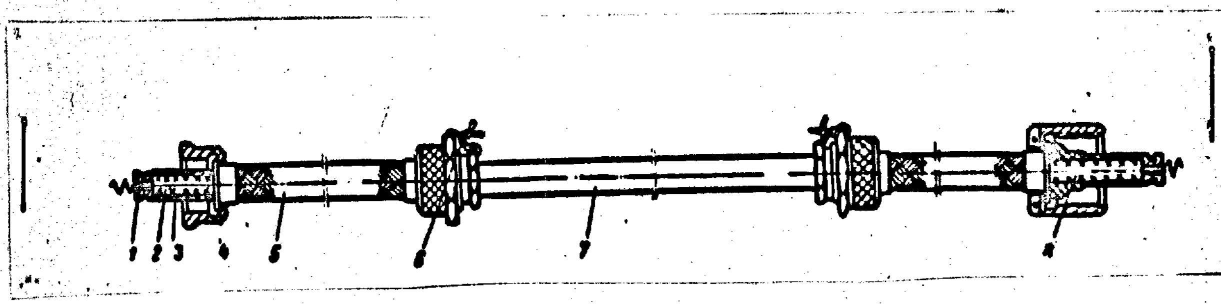

Fig. 150. High-Voltage Lead

1 -- contact arrangement KU-10; 2 -- lead; 3 -- insulating tube; 4 -- nut; 5 -- shield hose; 6 -- lock wire; 7 -- shield tubing; 8 -- gasket sleeve.

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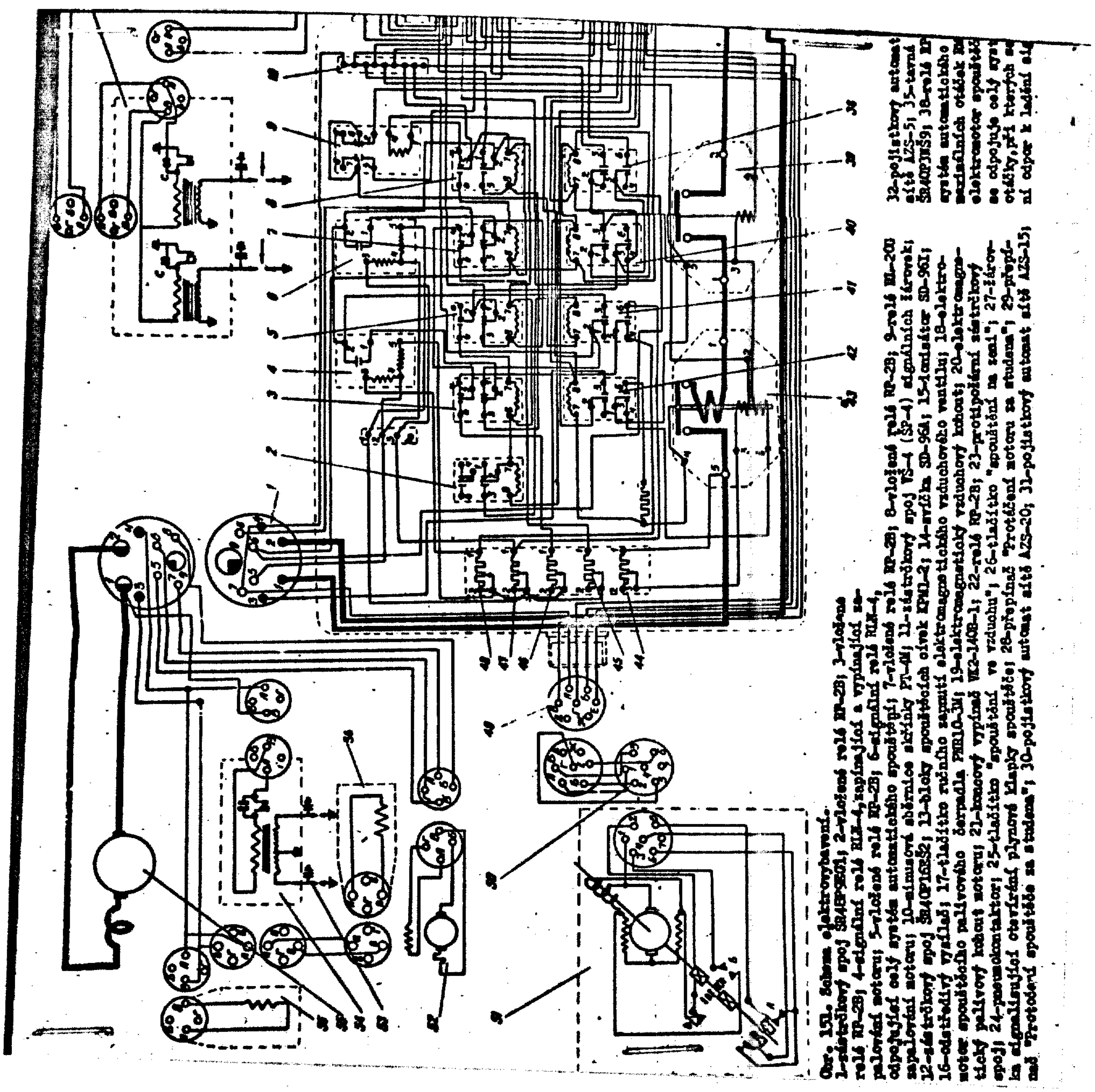

Obr. 151. Schema elektrovybavení.
1-zástrčkový spoj ŠR48P9EG1; 2-vložené relé RP-2B; 3-vložené relé RP-2B; 4-signální relé RLN-4, zapínající a vypínající zapalování motoru; 5-vložené relé RP-2B; 6-signální relé RLN-4, odpojující celý systém automatického spouštění; 7-vložené relé RP-2B; 8-vložené relé RP-2B; 9-relé RL-200 zapalování motoru; 10-minusová sběrnice skříňky PT-4M; 11-zástrčkový spoj VŠ-4 (ŠP-4) signálních žárovek; 12-zástrčkový spoj ŠR40P16ES2; 13-bloky spouštěcích cívek KPM1-2; 14-svíčka SD-96A; 15-ionisátor SD-96I; 16-odstředivý vysílač; 17-tlačítko ručního zapnutí elektromagnetického vzduchového ventilu; 18-elektromotor spouštěcího palivového čerpadla PNR10-3M; 19-elektromagnetický vzduchový kohout; 20-elektromagnetický palivový kohout motoru; 21-koncový vypínač VK2-140B-1; 22-relé RP-2B; 23-protipožární zástrčkový spoj; 24-pneumokontaktor; 25-tlačítko "spouštění ve vzduchu"; 26-tlačítko "spouštění na zemi"; 27-žárovka signalisující otevírání plynové klapky spouštěče; 28-přepínač "Protáčení motoru za studena"; 29-přepínač "Protočení spouštěče za studena"; 30-pojistkový automat sítě AZS-20; 31-pojistkový automat sítě AZS-15; 32-pojistkový automat sítě AZS-5; 35-tavná [illegible] ŠR40PJNŠ9; 38-relé RP[illegible] systém automatického [illegible] maximálních otáček [illegible] elektromotor spouště[illegible] se odpojuje celý syst[illegible] otáčky, při kterých se[illegible] ní odpor k ladění sí[illegible]

Fig. 151

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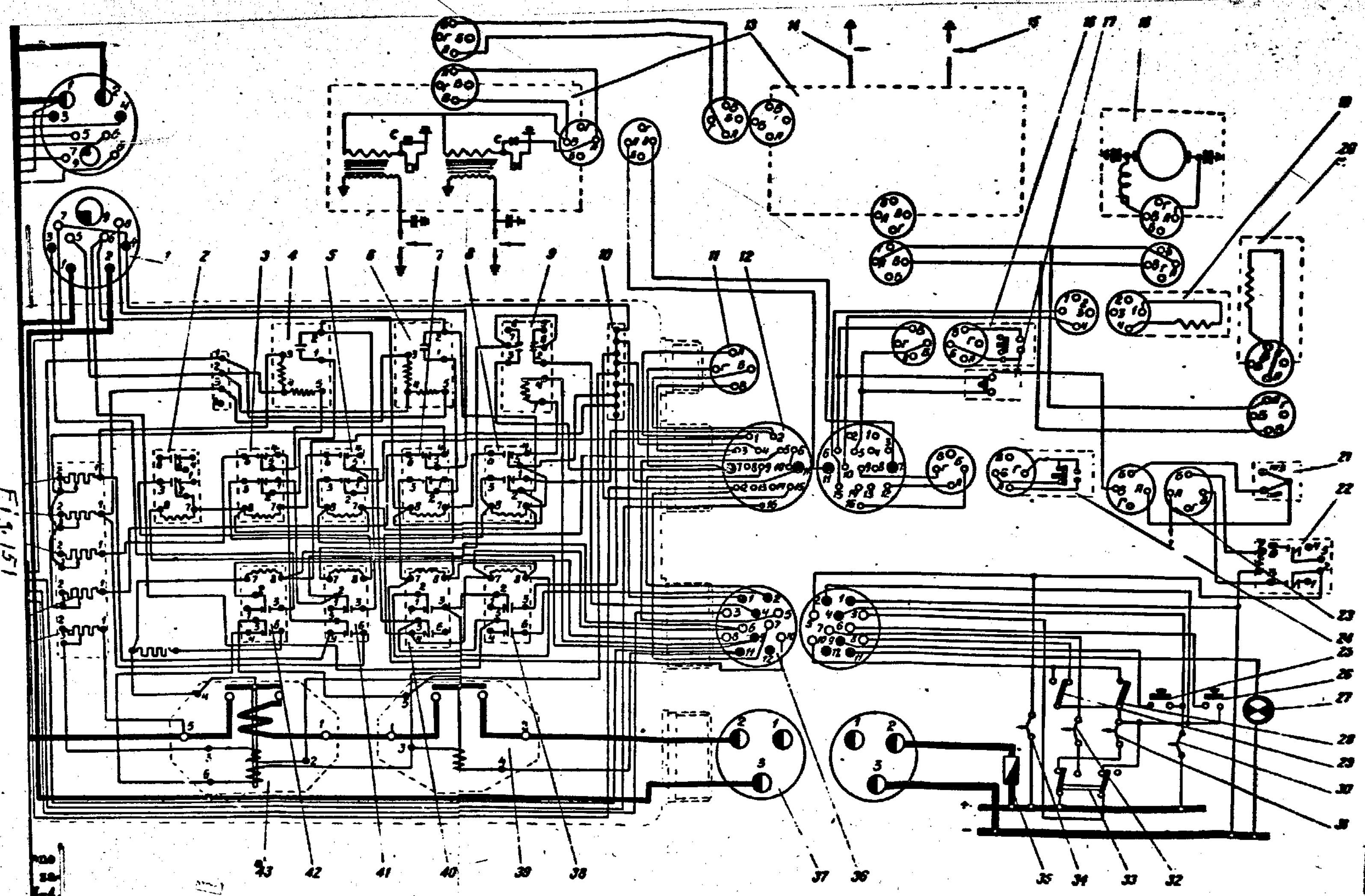

Fig. 151

relé RP-2B; 8-vložené relé RP-2B; 9-relé HL-20G
-zástrčkový spoj VŠ-4 (ŠP-4) signálních žárovek;
KPM1-2; 14-svíčka SD-96A; 15-ionisátor SD-96I;
magnetického vzduchového ventilu; 18-elektro-
omagnetický vzduchový kohout; 20-elektromagne-
l; 22-relé RP-2B; 23-protipožární zástrčkový
hu"; 26-tlačítko "spouštění na zemi"; 27-žárov-
epínač "Protáčení motoru za studena"; 29-přepí-
t sítě AZS-20; 31-pojistkový automat sítě AZS-15;

32-pojistkový automat sítě AZS-5; 33-hlavní přepínač (na schematu je zapojen); 34-pojistkový automat sítě AZS-5; 35-tavná pojistka na 200A; 36-síťový zástrčkový spoj ŠR32P12NG1; 37-síťový zástrčkový spoj ŠR40P3NŠ9; 38-relé RP-2B, blokující automatické spouštění; 39-spínač K-100; 40-relé RP-2B, odpojující systém automatického spouštění; 41-vložené relé RP-2B; 42-relé RP-2B pro zapalování spouštěče; 43-relé maximálních otáček RMO-4; 44-proměnný odpor k ladění relé RMO-4 na otáčky, při kterých se odpojuje elektromotor spouštěče SA-189BM; 45-regulační odpor k ladění signálního relé 6 na otáčky, při kterých se odpojuje celý systém automatického spouštění; 46-regulační odpor k ladění signálního relé 4 na otáčky, při kterých se odpojuje zapalování motoru a spouštěcí palivové čerpadlo PNR10-3M; 47-regulační odpor k ladění signálního relé 6; 48-regulační odpor k ladění signálního relé 4 na otáčky, při

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Fig. 151. Circuitry of Electrical Equipment

1 -- plug connector SR48P9EG1; 2 -- interposed relay RP-2B; 3 -- interposed relay RP-2B; 4 -- signal relay RLN-4 which opens and closes the engine ignition; 5 -- interposed relay RP-2B; 6 -- signal relay RLN-4 which cuts out the entire system of automatic starting devices; 7 -- interposed relay RP-2B; 8 -- interposed relay RP-2B; 9 -- relay RL-20G for engine ignition; 10 -- negative bus bar of control box PT-4M; 11 -- plug connector VS-4 (SP-4) for indicator lamps; 12 -- plug connector SR-40P16ES2; 13 -- block of starting coils KPM 1-2; 14 -- spark igniter plug SD-96A; 15 -- ionizer SD-961; 16 -- centrifugal governor; 17 -- control button for manual switching of electromagnetic air valve; 18 -- electric motor of starter fuel pump PNR 10-3M; 19 -- electromagnetic air valve; 20 -- electromagnetic fuel valve of engine; 21 -- terminal switch VK2-140B-1; 22 -- relay RP-2B; 23 -- fire-prevention plug connector; 24 -- pneumatic breaker; 25 -- button marked "Air Start"; 26 -- button marked "Ground Start"' 27 -- bulb which signals the opening of the starter gas valve; 28 -- switch marked "Crank Engine Cold"; 29 -- switch marked "Crank Starter, Cold"; 30 -- fuses for AZS-20 circuit; 31 -- fuse array for AZS-15 circuit; 32 -- fuse array for AZS-5 circuit; 33 -- master switch (closed on drawing); 34 -- fuse array for AZS-5 circuit; 35 -- melting fuse for 200 amps; 36 -- circuit plug connector SR32P12MG1; 37 -- circuit plug connector SR40P3NS9; 38 -- relay RP-2B for blocking automatic starting; 39 -- switch K-100; 40 -- relay RP-2B for cutting out the automatic starting sequence; 41 -- interposed relay RP-2B; 42 -- relay RP-2B for energizing the starter; 43 -- maxim rpm relay RMO-4; 44 -- variable resistor for adjusting relay RMO-4 to revolutions at which the electric motor of starter SA-189BM is cut out; 45 -- regulation resistor for adjusting signal relay 6 to the number of revolutions at which the entire automatic starting sequence is cut out; 46 -- variable resistor for adjusting signal relay 4 to the number of revolutions at which engine ignition and starter fuel pump PNR 10-3M are cut out; 47 -- variable resistor for tuning signal relay 6; 48 -- variable resistor for adjusting signal relay 4 to the number of revolutions required to cut in engine ignition and starter fuel pump PNR 10-3M; 49 -- plug connector PS-7 (SU-7) for electromechanism MZK-2; 50 -- plug connector SR28P7NG7; 51 -- electromechanism MZK-2 which opens the gas valve of starter; 52 -- tachogenerator TD-1; 53 -- sparkigniter plug SD-55S; 54 -- starter ignition coil KP-21' 55 -- electric motor of starter SA-189BM; 56 -- electromagnetic starter fuel valve.

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Figure 152 -- View of the turbostarter (from the right)

1. Electromagnetic valve
2. SA-189BM electric motor
3. TD-1 tacho-generator
4. Dynamo-transmitter of the TE-45 tachometer
5. Fuel pump - TNR-3R regulator
6. Electromagnetic valve

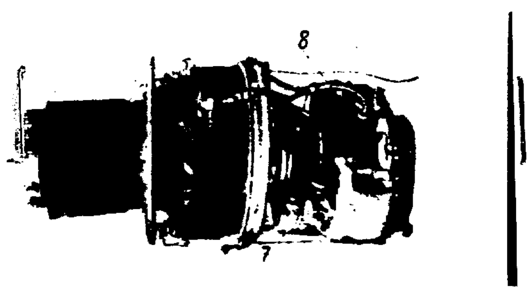

Figure 153 -- View of the turbostarter (from the left)

7. Oil pump
8. KP-21 starter coil

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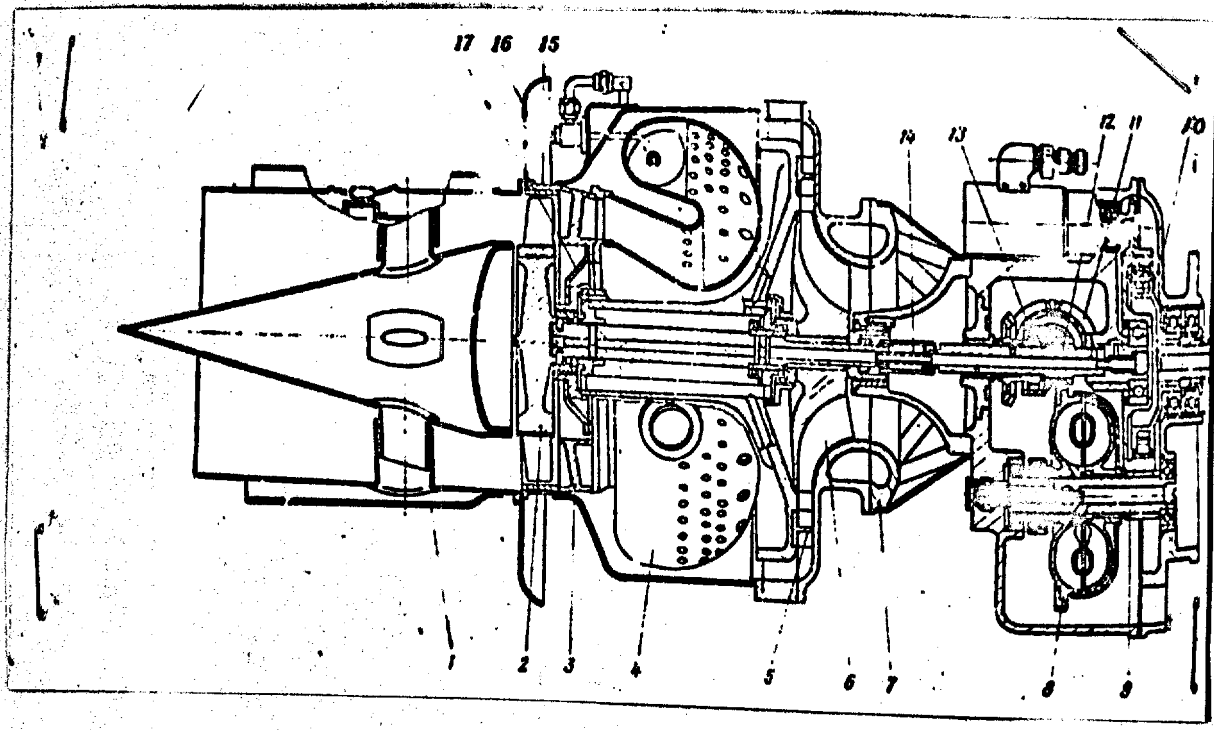

Figure 154 -- Schematic diagram of the turbostarter

1. Exhaust nozzle
2. Turbine
3. Guide vanes
4. Starter combustion chamber
5. Blade diffuser
6. Compressor rotor
7. Intake
8. Hydraulic coupling
9. Drive shaft
10. Centrifugal clutch
11. Drive gear for SA-189BM electric motor
12. Reduction gearing drive shaft
13. Disengaging clutch
14. Oil release line
15. Housing of turbine
16. Shield
17. Flange

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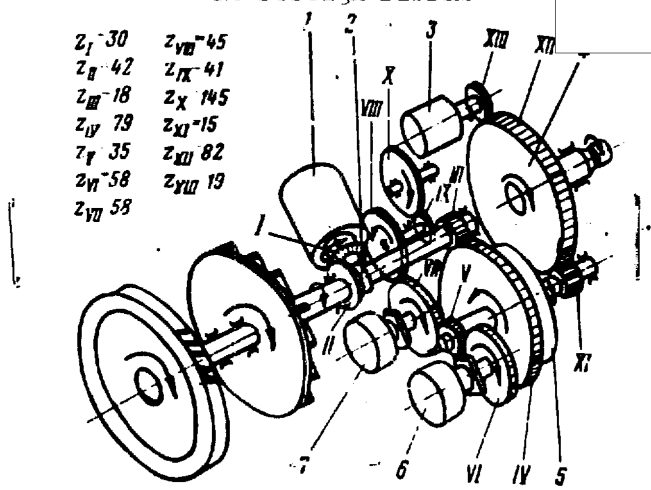

Figure 155 -- Transmission diagram of starter

1. Electric motor
2. Disengaging clutch
3. Tachogenerator
4. Centrifugal clutch
5. Hydraulic coupling
6. Oil pump
7. Fuel pump - regulator

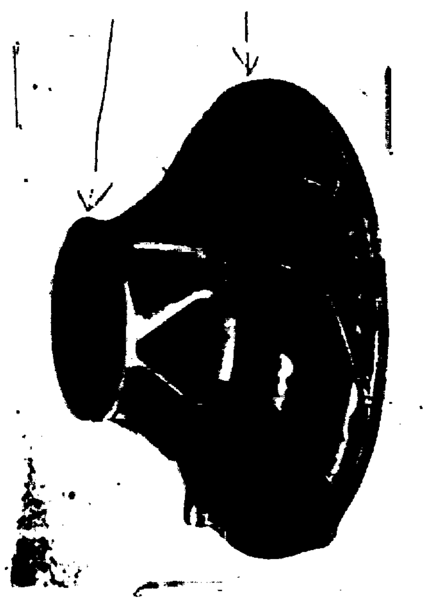

Figure 156. Cover and intake part of the compressor

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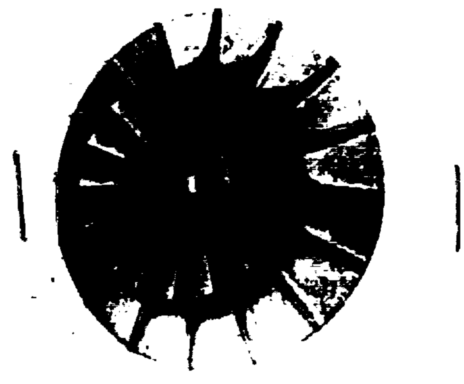

Figure 157 -- Disk (rotor) of compressor

Figure 158 -- Housing of compressor

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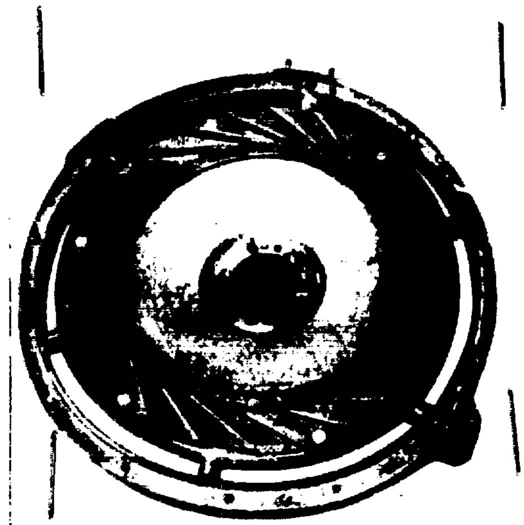

Figure 159 -- Housing of compressor (view from diffuser)

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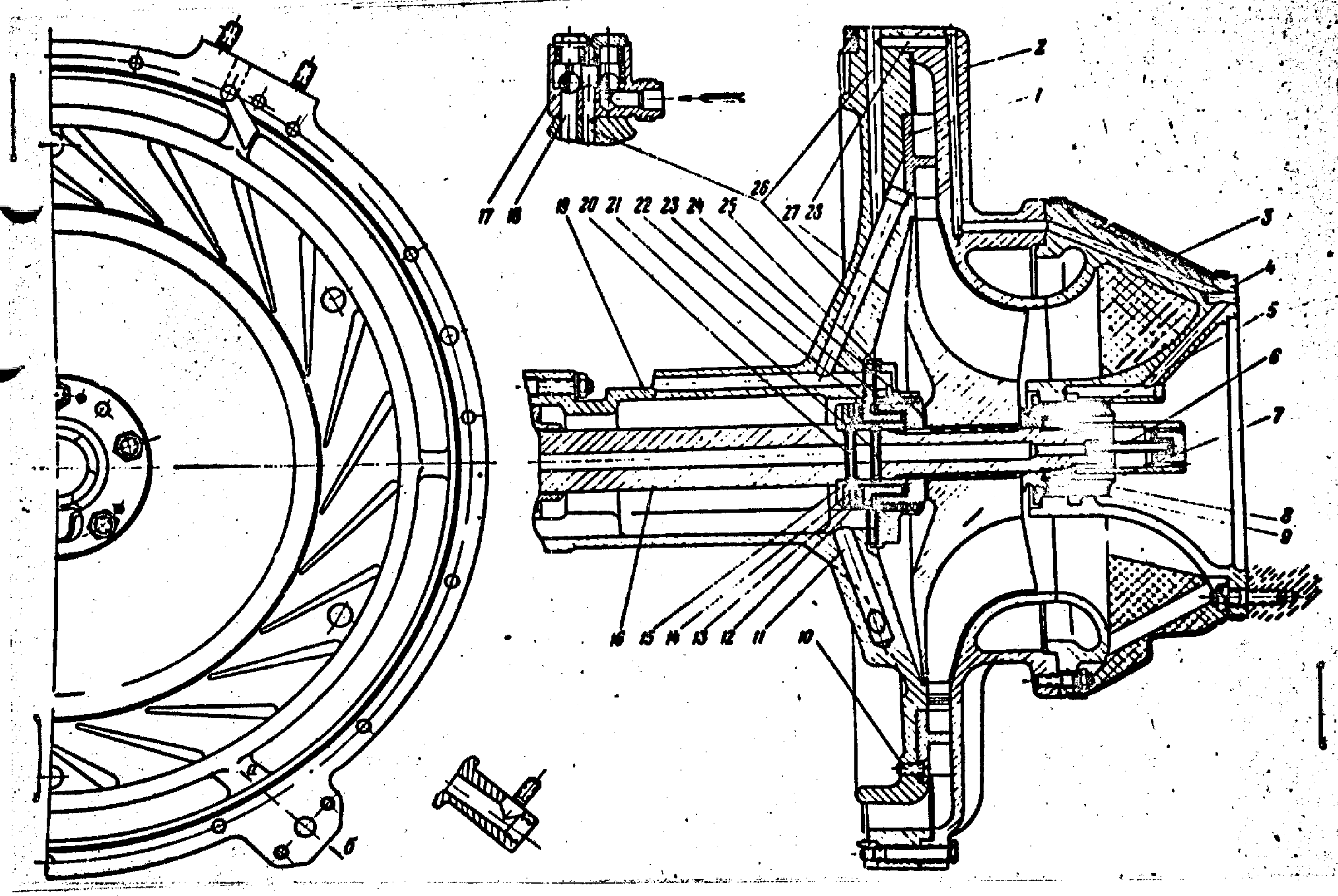

Figure 160 -- Compressor (cross-section)

1. Diffuser
2. Compressor cover
3. Screen
4. Intake section
5. Securing lock
6. Oil release line
7. Seal
8. Nut
9. Bushing
10. Screw
11. Oil output channel
12. Ring
13. Calibrated ring
14. Shoe ring
15. Shoe
16. Rotor shaft
17. Air distribution valve
18. Channel for supply of air to starter
19. Compressor housing
20.-21. Jets
22. Rear bearing
23. Rear seal
24. Stamped washer
25. Seal cover
26. Channels for supply of air to seals
27. Rotor
28. Channel for supply of air to seal

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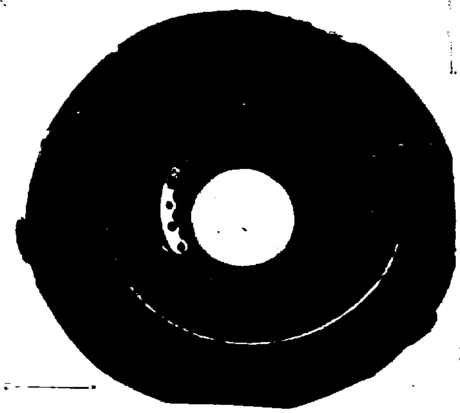

Figure 161 -- Combustion chamber

(over-all view)

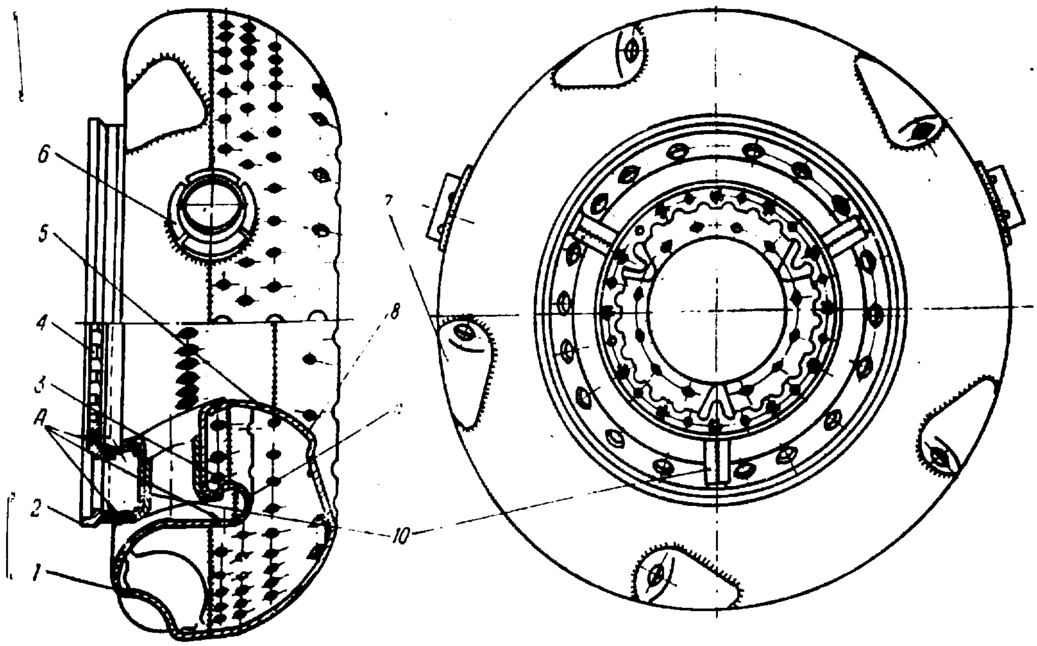

Figure 162 -- Combustion chamber (section)

1. Rear wall
2. Ring
3. Outer Wall
4. Flange
5. Inner wall
6. Sleeve
7. Recess
8. Forward wall
9. Connecting ring
10. Reinforcement

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Figure 163 -- Turbine housing with ring (over-all view)

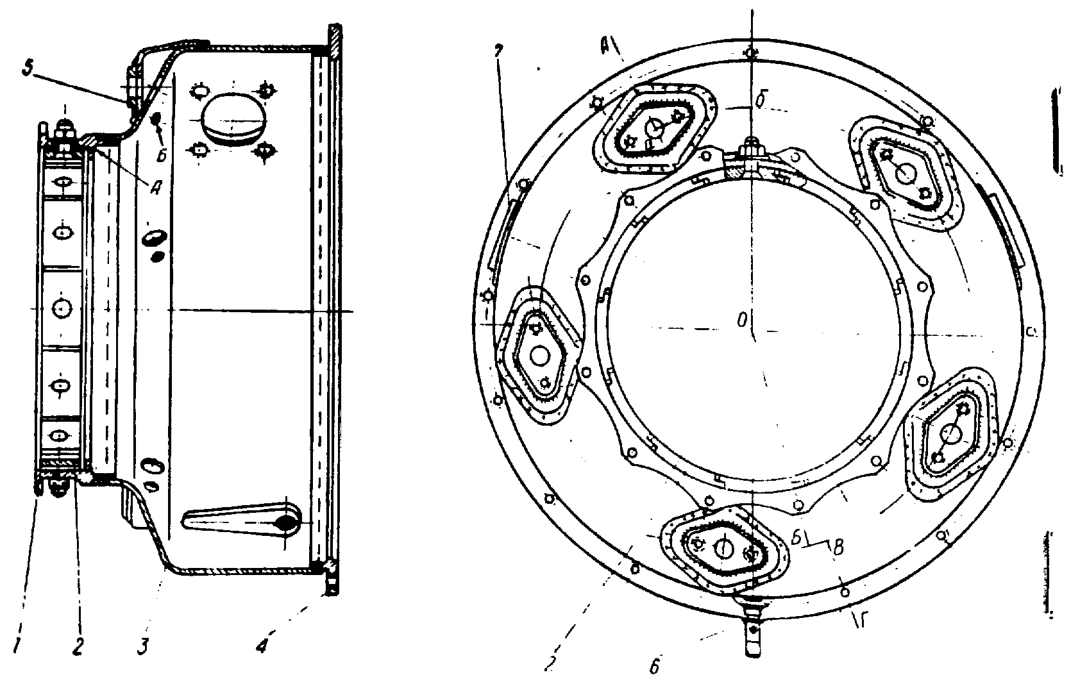

Figure 164 -- Turbine housing with ring (cross-section)

1. Turbine housing
2. Segment of ring
3. Combustion chamber liner
4. Flange
5. Cover plate
6. Nipple
7. Flange

A. and B. Openings

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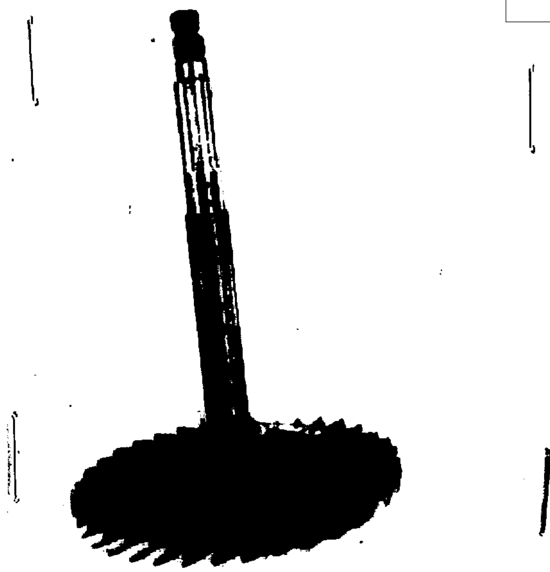

Figure 165 -- Turbine wheel with rotor shaft (general view)

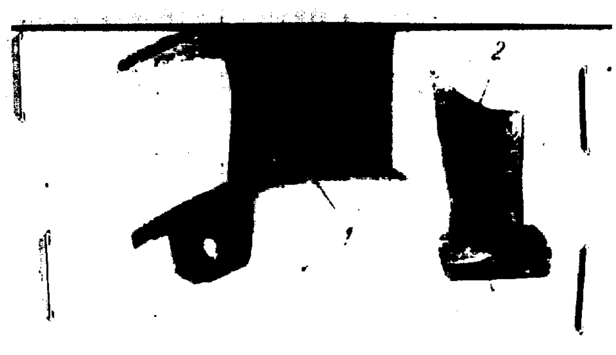

Figure 166 -- Blades

1. Vane of guide system

2. Turbine bucket

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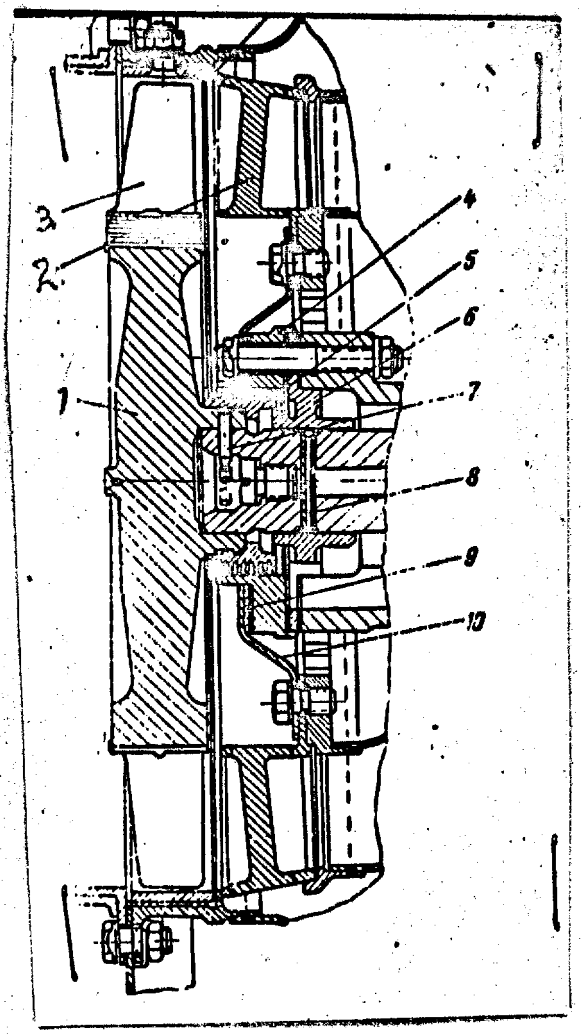

Figure 167 -- Turbine (cross-section)

1. Turbine wheel
2. Guide system
3. Turbine bucket
4. Seal cover
5. Forward seal
6. Forward bearing
7. Pin
8. Jet
9. Alignment
10. Flange

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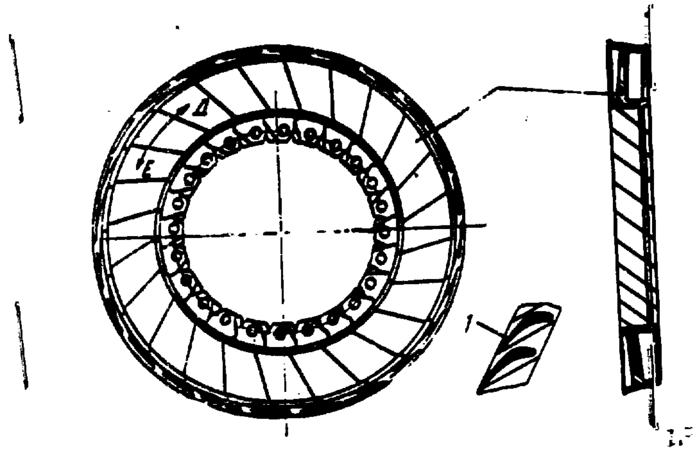

Figure 168 -- Guide system

1. Vanes

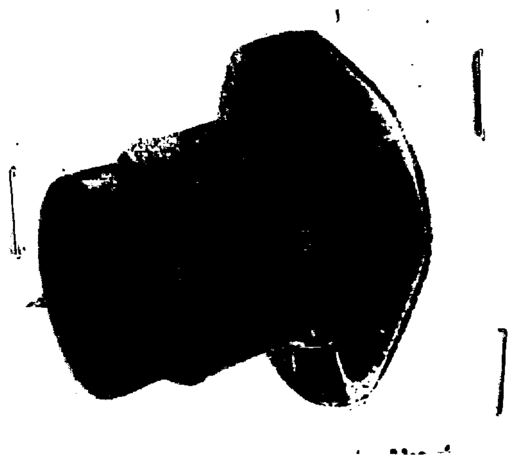

Figure 169 -- Exhaust tube (over-all view)

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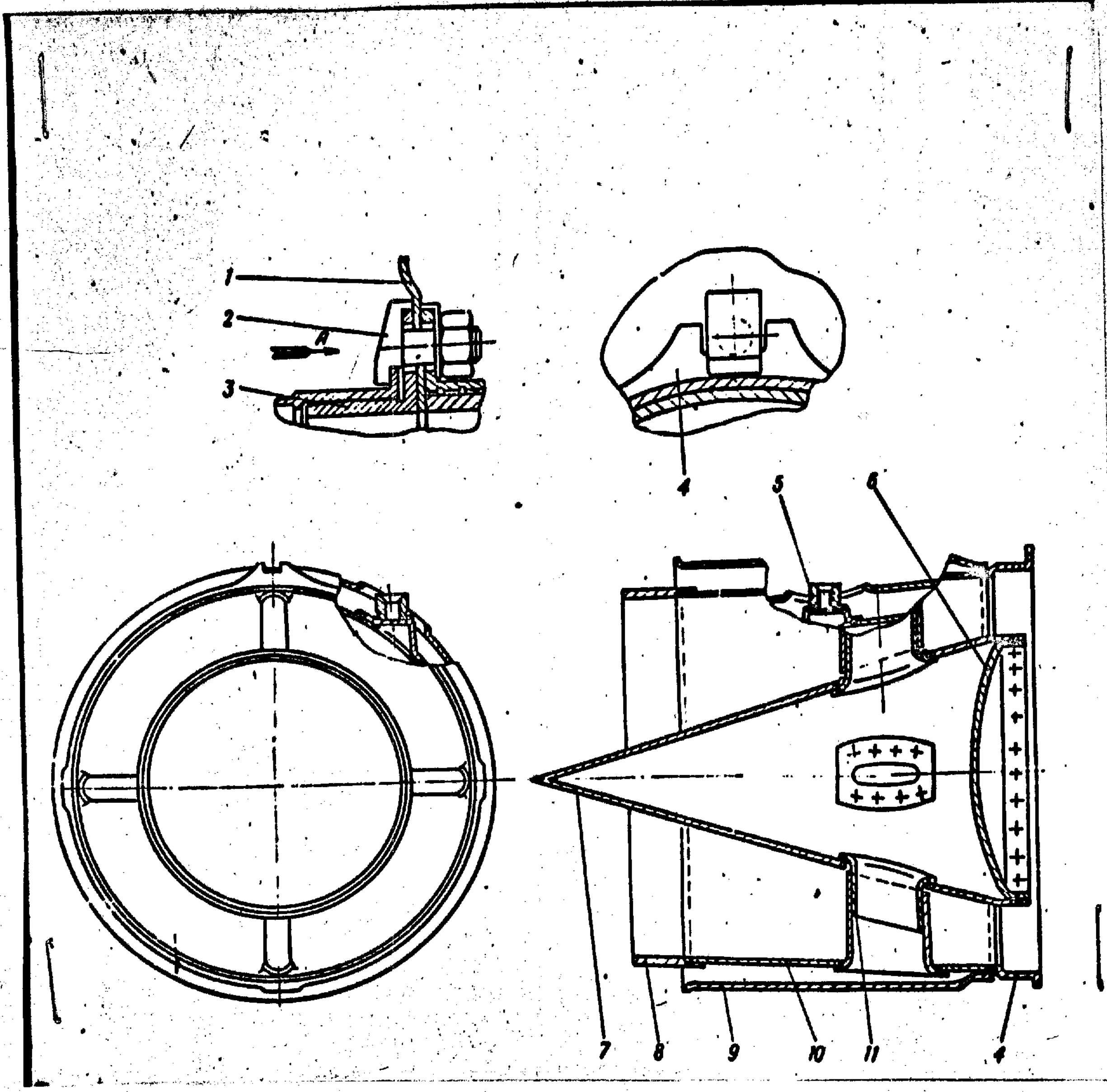

Figure 170 -- Exhaust tube

1. Plate
2. Bolt
3. Coupling flange
4. Flange
5. Thermocouple socket
6. Head
7. Cone
8. Ring
9. Sleeve
10. Outer wall
11. Telescoping strut

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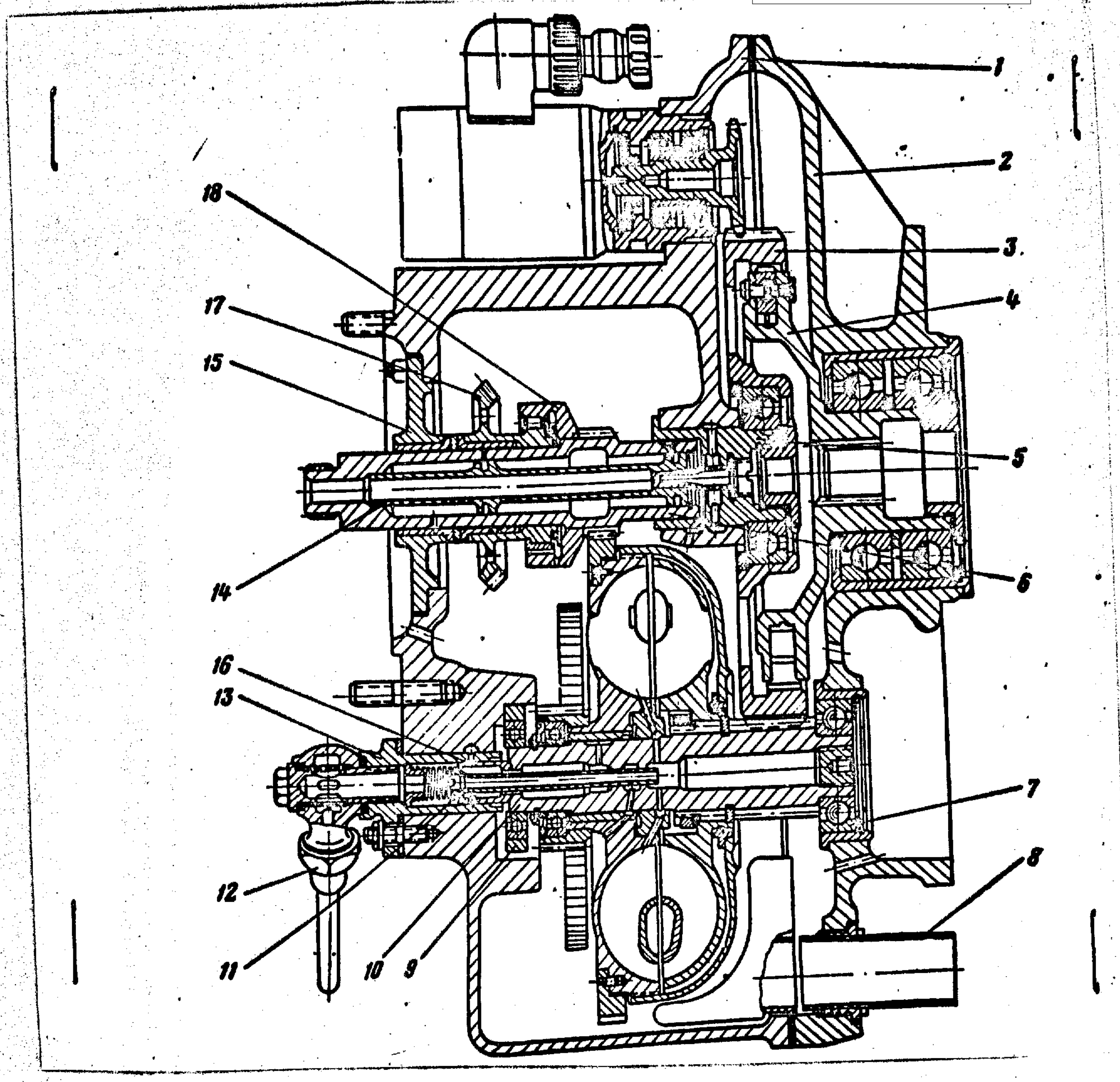

Figure 171 -- Reduction gearing (cross-section)

1. Front housing
2. Rear housing
3. Rachet gear
4. Body of the centrifugal coupling
5. Rear bearing
6. Drive shaft of reduction gearing
7. Ball bearing
8. Tube
9. Ball bearing case
10. Driven shaft of reduction gearing
11. Release line
12. Nozzle for supply of oil
13. Input sleeve
14. Release line
15. Forward bearing of reduction gearing drive shaft
16. Bearing [illegible] sleeve
17. Driven gear of electric motor
18. Disengaging clutch

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Figure 172 -- Front Housing of Reduction Gearing

19. Flange for attaching tachogenerator TD-1
20. Flange for attaching front bearing of drive shaft
21. Flange for attaching intake
22. Threaded nipple for oil supply
23. Compartment with triangular flange
24. Flange for attaching oil pump
25. Triangular flange for attaching housing for providing oil to hydraulic coupling
26. Flange for attaching fuel pump - regulator TNR-3R
27. Lug with outlet
28. Flange for attaching tachometer transmitter
29. Flange for attaching electric motor SA-189BM

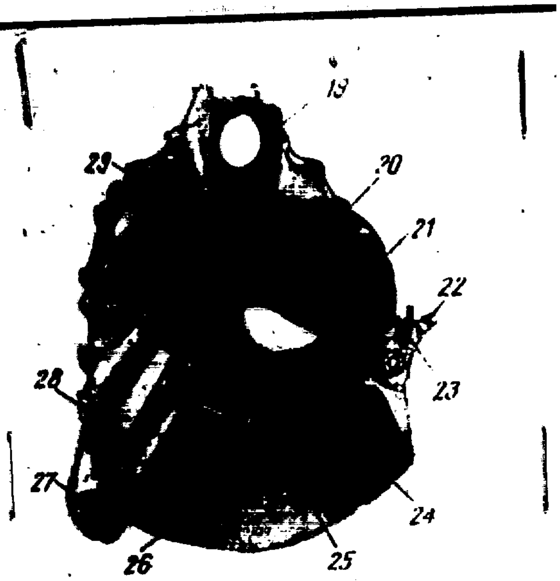

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Figure 173 -- Front Housing of Reduction Gearing (rear view)

30. Projections

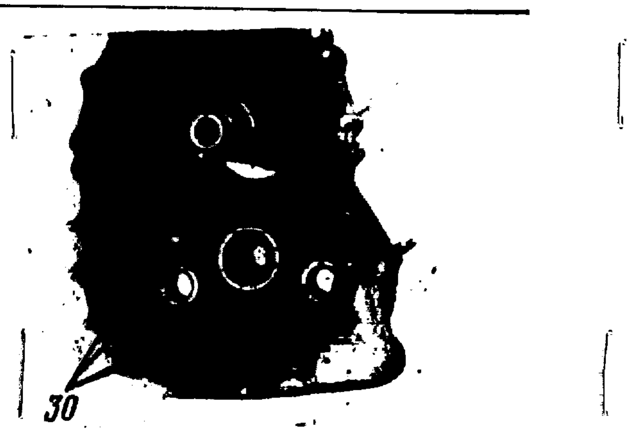

Figure 174 -- Disengaging Clutch (over-all view)

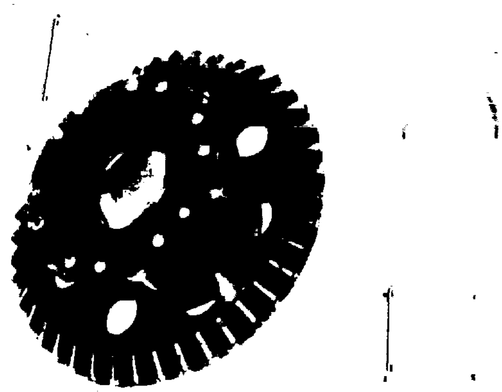

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Figure 175 -- Disengaging Clutch

1. Drive plate
2. Rollers
3. Washer
4. Cage
5. Projections of drive plate

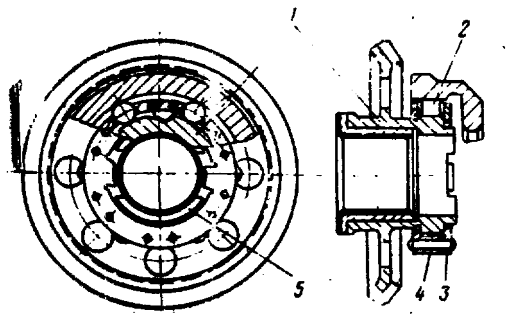

Figure 176 -- Left Half of Hydraulic Coupling

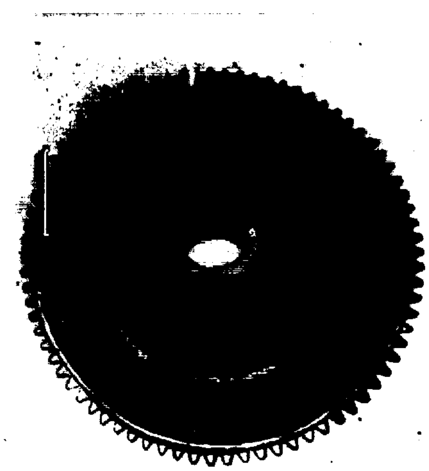

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Figure 178 -- Hydraulic Coupling

1. Slide bearing
2. Small gear
3. Large gear
4. Left (drive) half of hydraulic coupling
5. Cover
6. Right (driven) half of hydraulic coupling
7. Bronze ring
8. Transmission sleeve
9. Stop
10. Inside ring
11. Bolt
12. Ball bearing
13. Support ring
14. Wire catch
15. Plate valve

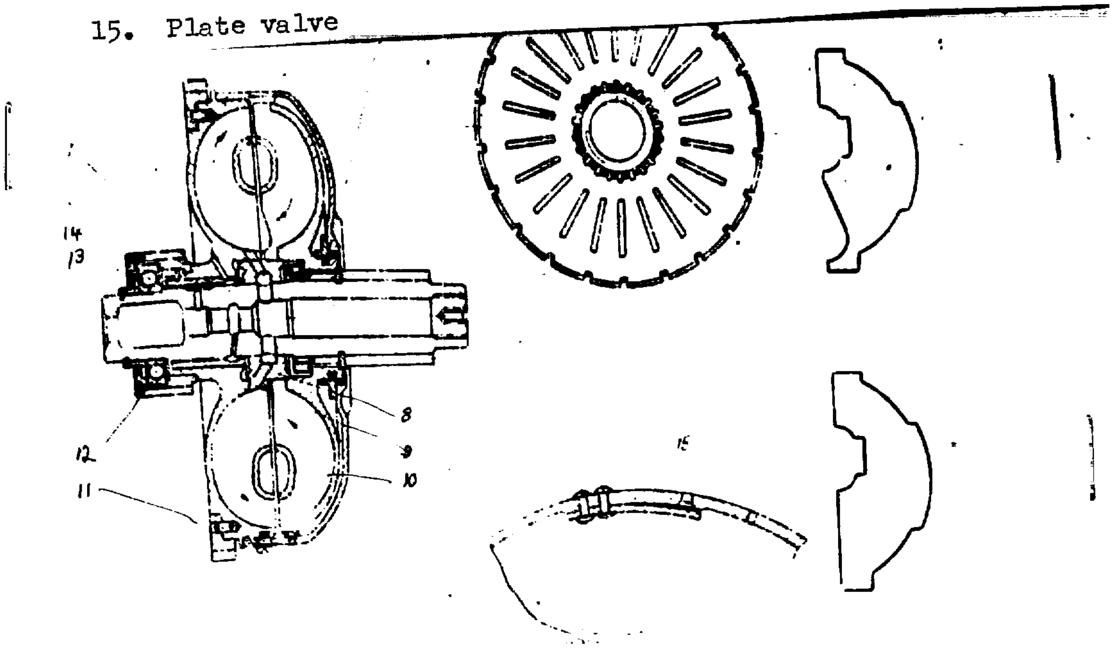

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Figure 177 -- Right Half of Hydraulic Coupling

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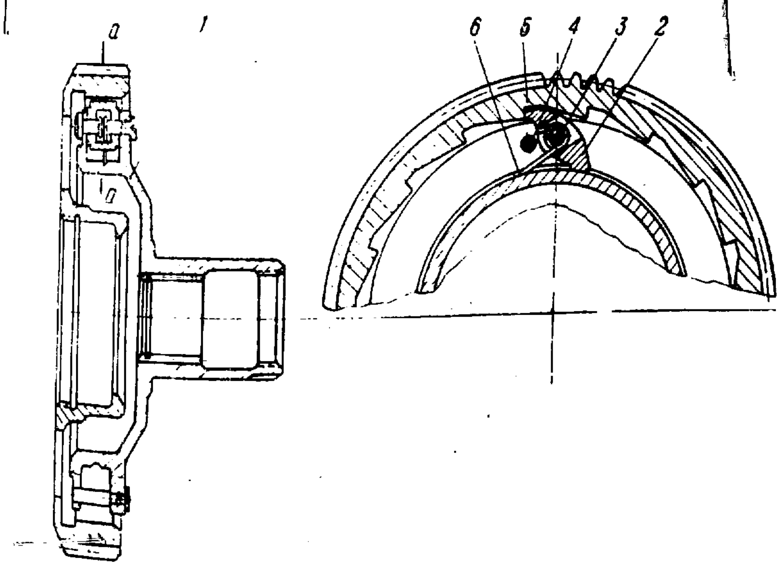
Figure 179 -- Centrifugal Clutch

1. Housing of centrifugal clutch
2. Ratchet
3. Pin
4. Stop
5. Gear
6. Spring



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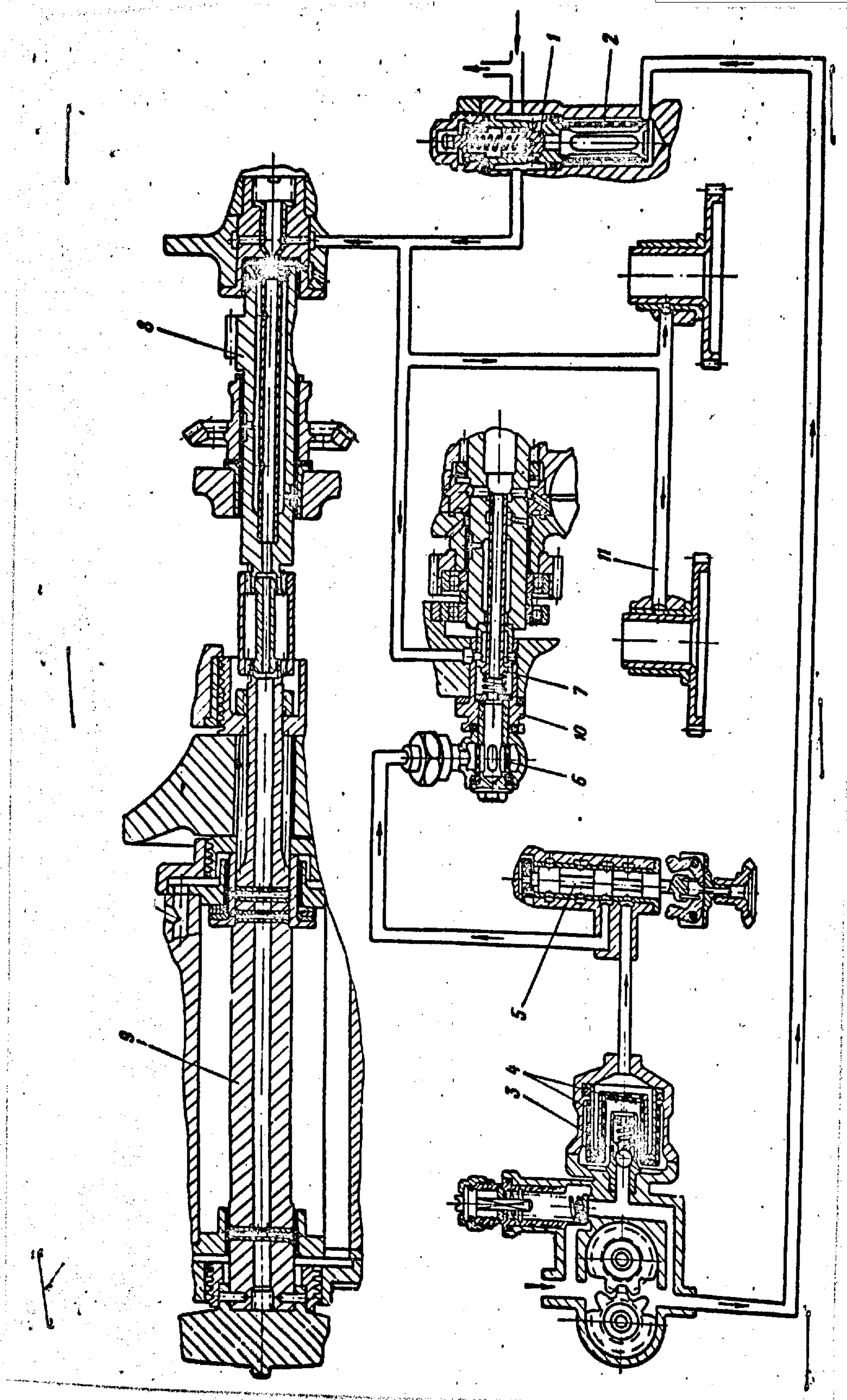

Fig. 180

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Figure 180 -- Diagram of Oil System of Starter

1. Check valve
2. Screen filter
3. Check valve of oil pump
4. Filters
5. Piston of fuel pump - regulator
6. Filter
7. Overflow tube
8. Drive shaft of reduction gearing
9. Shaft of rotor
10. Input sleeve
11. Oil channel

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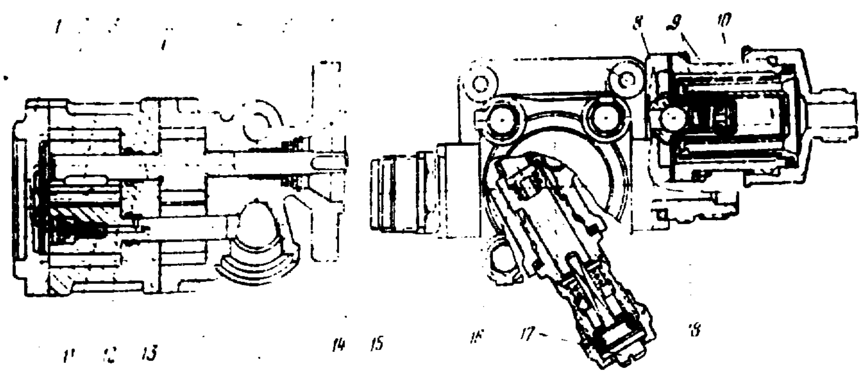
Figure 181 -- Oil Pump (general view)

Figure 182 -- Oil Pump of Starter

1. Cover
2. Gear of suction stage
3. Wedge
4. Rubber rings
5. Drive shaft
6. Packing
7. Housing
8. Ball check valve
9. Filters
10. Outlet
11. Ball valve
12. Oil channel
13. Middle housing
14. Fitting for oil output
15. Fitting for oil input
16. Relief valve
17. Adjusting screw
18. Fitting for oil drain



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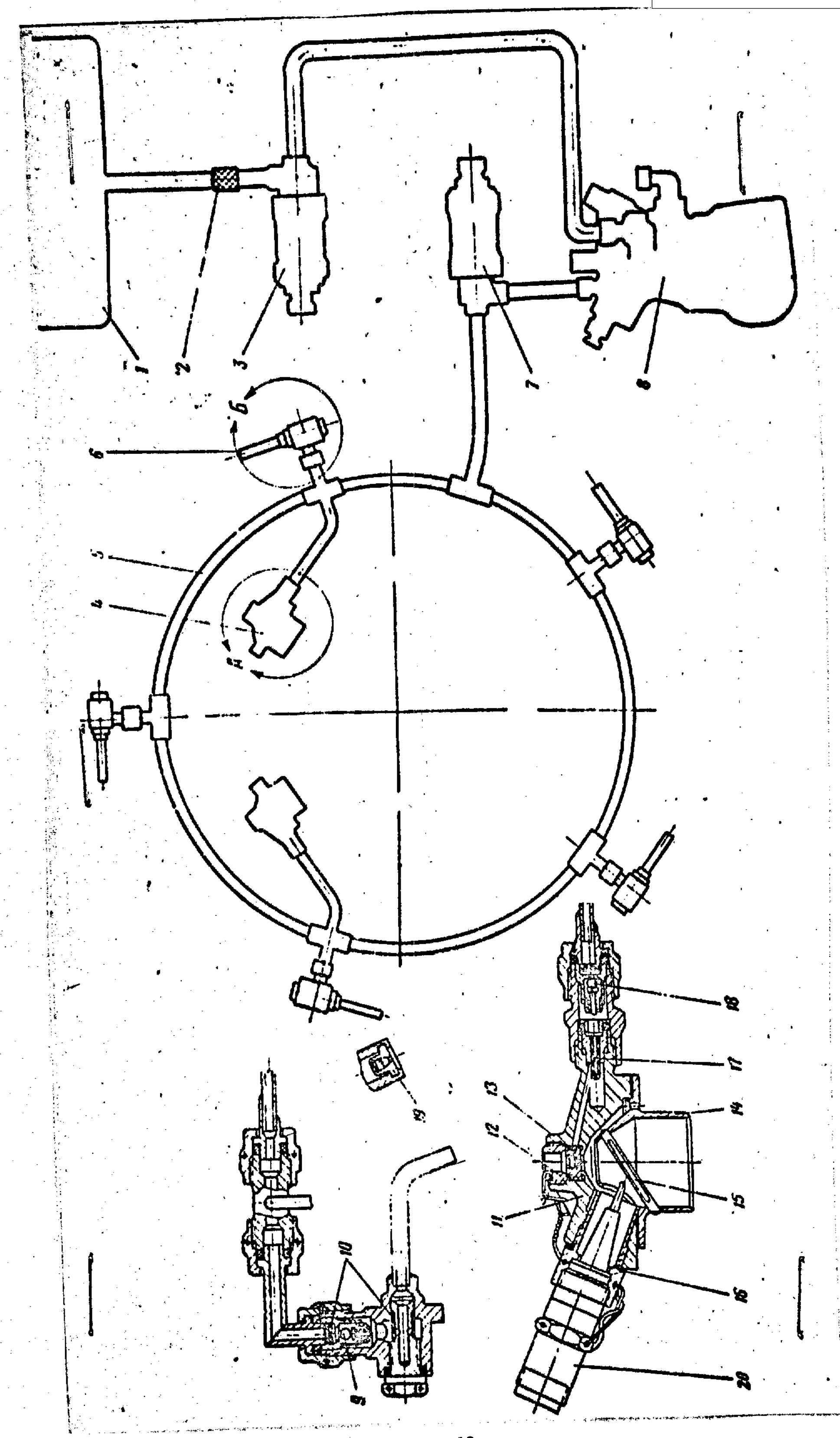

Fig. 183

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Figure 183. Diagram of Fuel System of Starter

1. Fuel tank of aircraft
2. Filter
3. Electromagnetic valve
4. Ignition
5. Fuel collector
6. Operating jet
7. Electromagnetic valve
8. Fuel pump
9. Check valve
10. Filter
11. Ignition system housing
12. Nut
13. Atomizer
14. Jet of ignition system
15. Discharger
16. Washer
17. Filter
18. Check valve
19. Atomizer
20. SD-55ANM spark plug

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Figure 184. Fuel Manifold (general view)

4. Ignition
5. Tubing
6. Jet

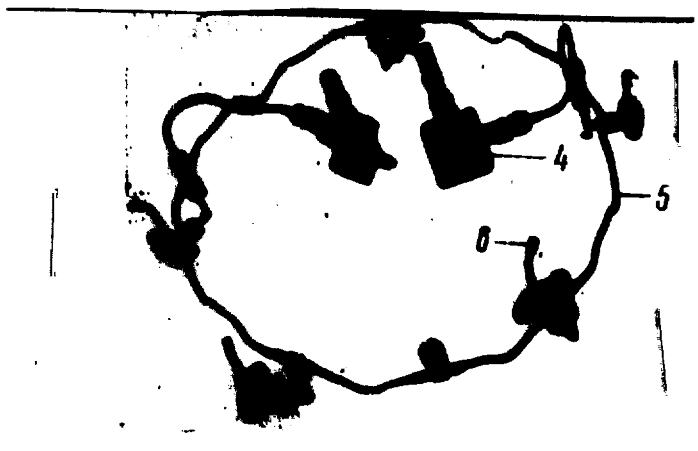

Figure 185. View of TNR-3R Fuel Pump

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Figure 186. Basic Diagram of the TNR-3R Fuel Pump

1. Adjustment screw of relief valve
2. Screw for adjusting consumption of fuel during starting
3. Centrifugal regulator screw
4. Pipe fitting
5. Fuel pump
6. Filter
7. Pipe fitting for output to collector
8. Throttle valve
9. Relief valve
10. Jet
11. Spring
12. Channel to engine oil tank
13. Piston
14. Oil channel to hydraulic coupling
15. Regulator oil intake
16. Centrifugal weight of regulator
34. Driving gear

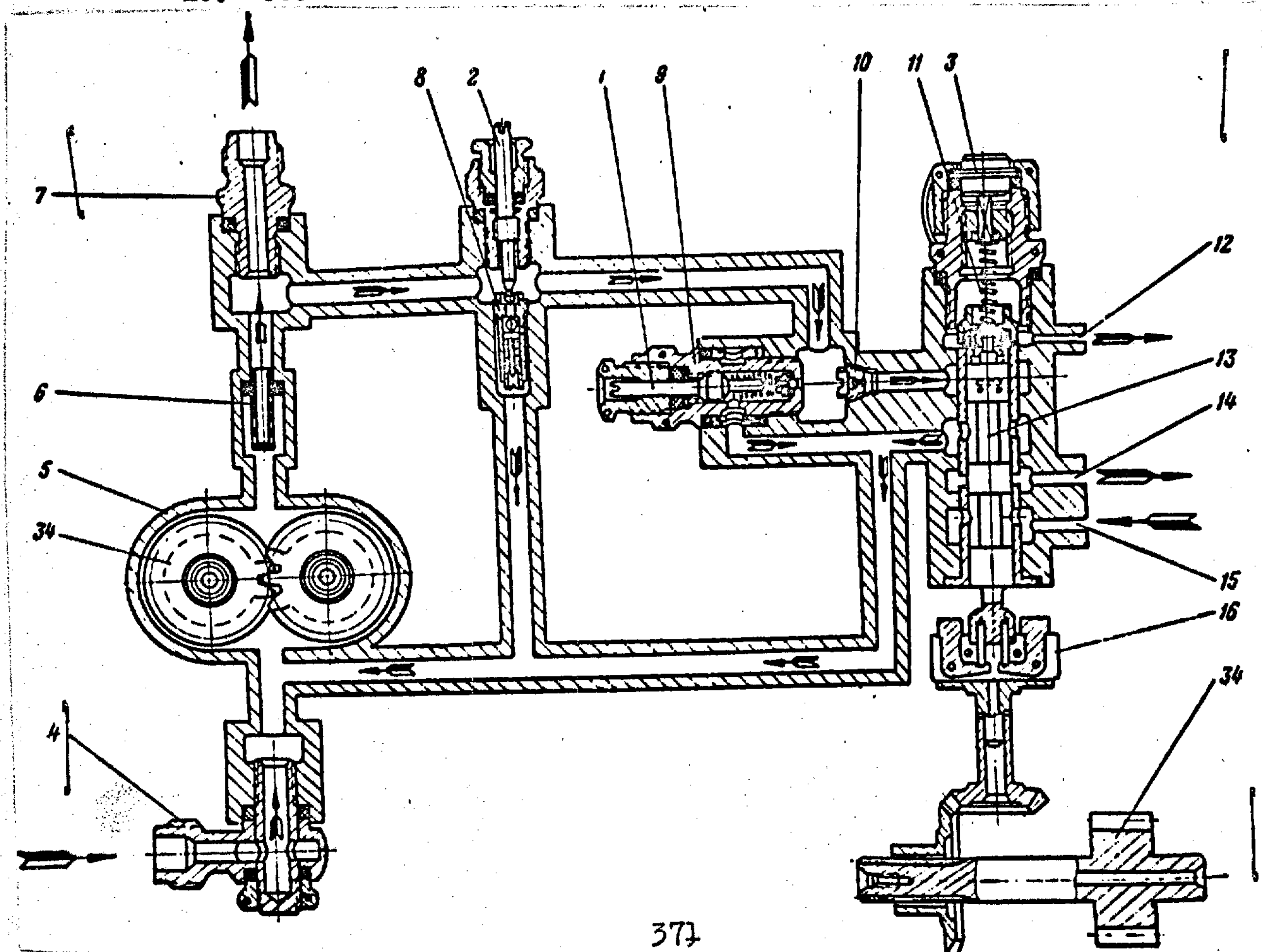

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Figure 187. Kinematic Diagram of Fuel Pump

13. Piston
16. Centrifugal Weights
17. Drive shaft of reduction gearing
18. Large gear of hydraulic coupling
19. Small gear of hydraulic coupling
20. Drive gear of pump
21. Drive bevel gear
22. Driven bevel gear

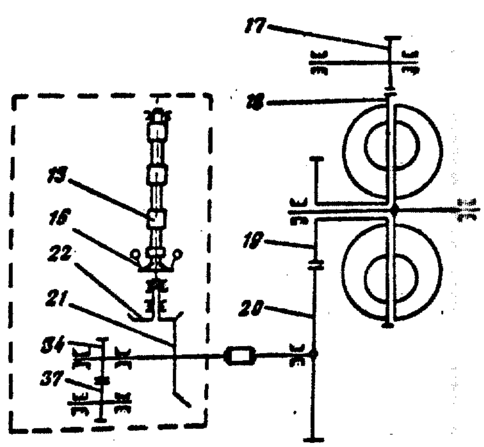

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Figure 188

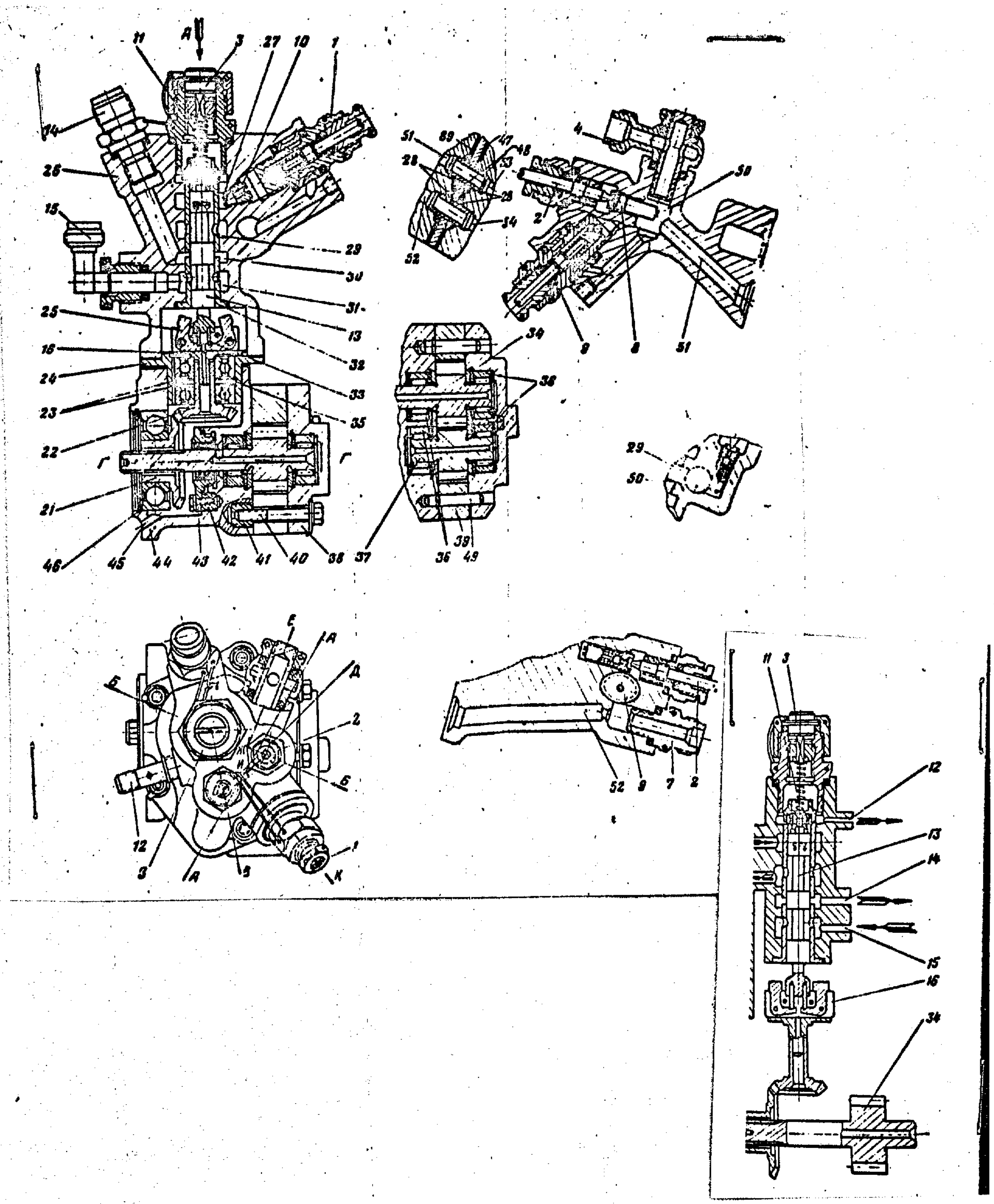

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Figure 188. The TNR-3R Fuel Pump

1. Relief valve adjustment screw
2. Screw for adjustment of fuel consumption at starting
3. Centrifugal regulator screw
4. Rotating screw-in fitting for supply of fuel to pump
7. Fitting for fuel output to collector
8. Throttle valve
9. Relief valve
10. Jet
11. Spring
12. Drain fitting
13. Piston
14. Fitting for oil output to hydraulic coupling
15. Filler for supply of oil to pump
16. Fork with centrifugal weights
21. Gear bevel
22. Bevel gear
23. Setting washer
24. Adapter unit
25. Weights
26. Regulator housing

27, 29, 30, 31. Ring recesses

28. Ring seal
32. Sleeve

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Figure 188. (cont'd)

33. Pins
34. Gear
35. Retainer ring
36. Bushing
37. Gear
38. Pump cover
39. Cross brace
40. Screw
41, 42. Sleeves
43. Flange
44. Fuel pump housing
45. Opening for outflow of oil
46. Setting washer
47. Packing
48. Sleeve
49. Pin
50. Space for supply and removal of oil
51. Channel for supply of oil to pump
52. Oil supply channel
53. Channel for intake of oil to pump
54. Channel for removal of oil from pump
89. Packing

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Figure 189. Fuel Pump Housing

36. Bushing
41, 42. Sleeves
44. Fuel pump housing
53. Pump oil intake channel
54. Pump oil output channel
55. Packing ring
56. Filter component
57, 58. Screens
59. Spring
60. Flange
61. Channel for Fuel input to filter
62, 63. Washers

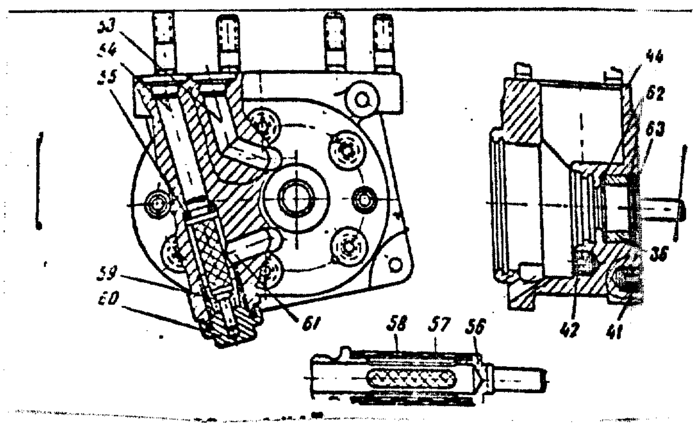

Figure 190. Spreader

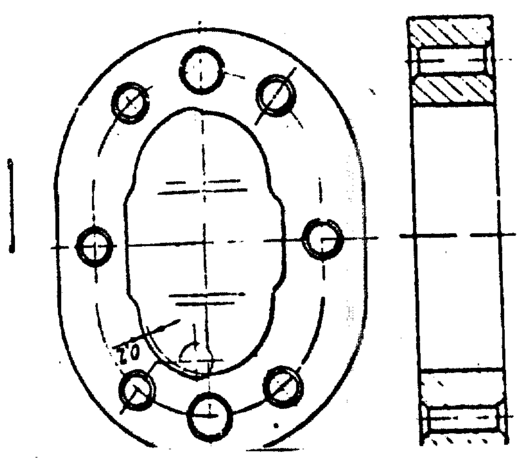

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Figure 191. Flange

43. Flange

64. Cup

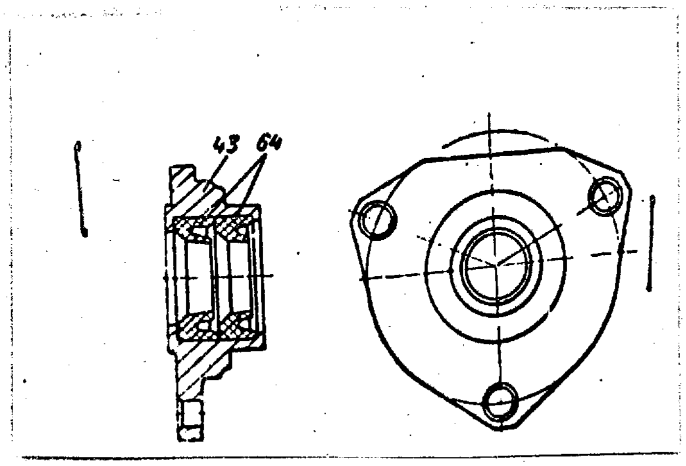

Figure 192. Adapter Unit

24. Adapter unit

48. Sleeve

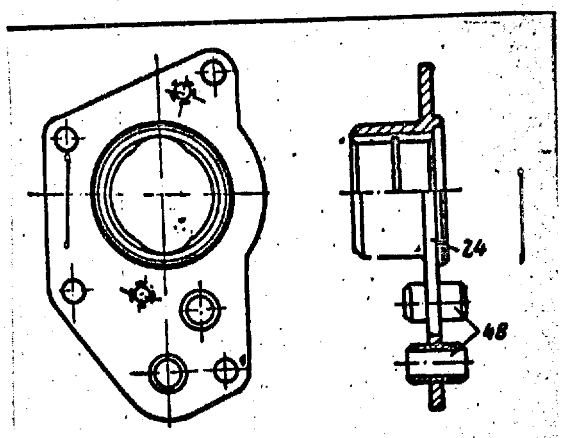

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Figure 193. Fork with Centrifugal Weights

16. Fork with centrifugal weights

25. Weight

65. Pin

66. Weight

68. Washer

69. Bushing

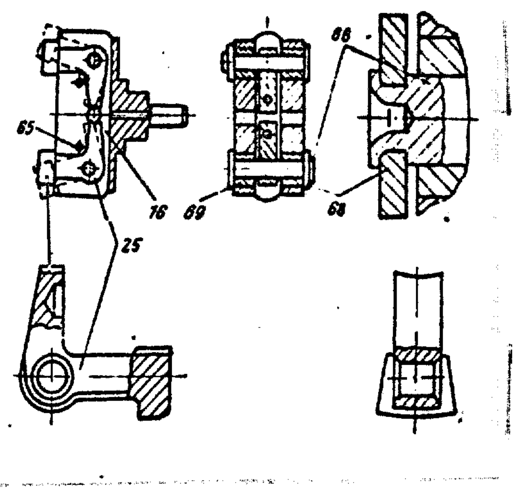

Figure 194. Bushing

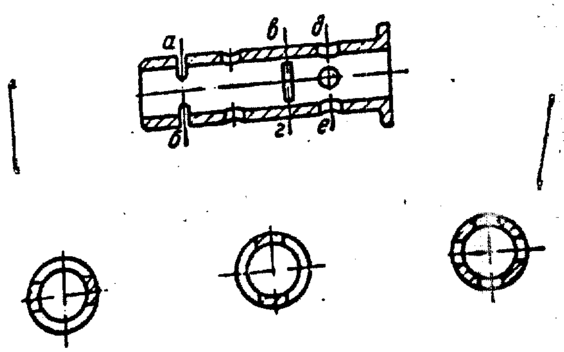

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Figure 195. Piston

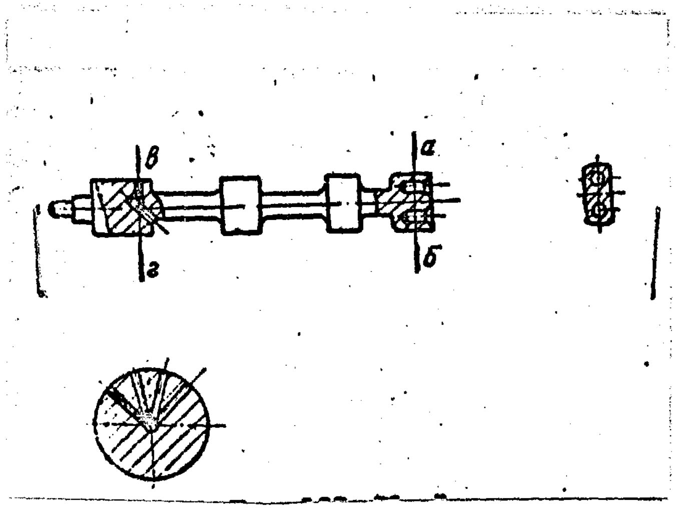

Figure 197. Throttle Valve with Adjustment Screw

2. Adjustment screw of throttle valve

77. Valve seat
78. Ball
79. Valve plate
80. Spring
81. Guide sleeve
82. Nut
83. Adjustment screw housing

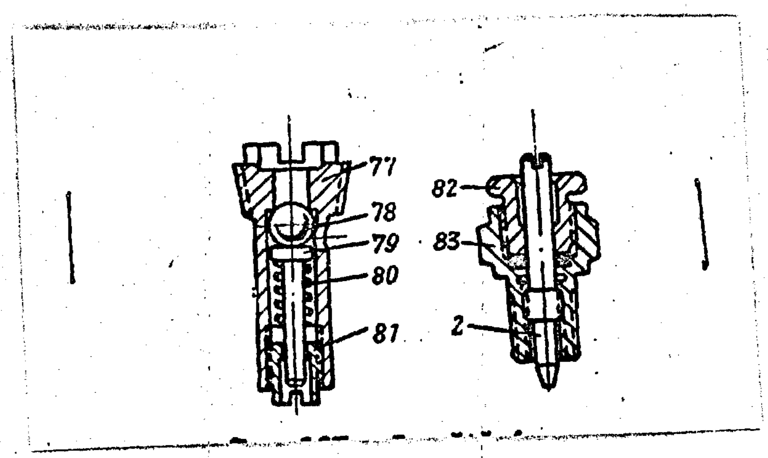

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Figure 199. Thermocouple

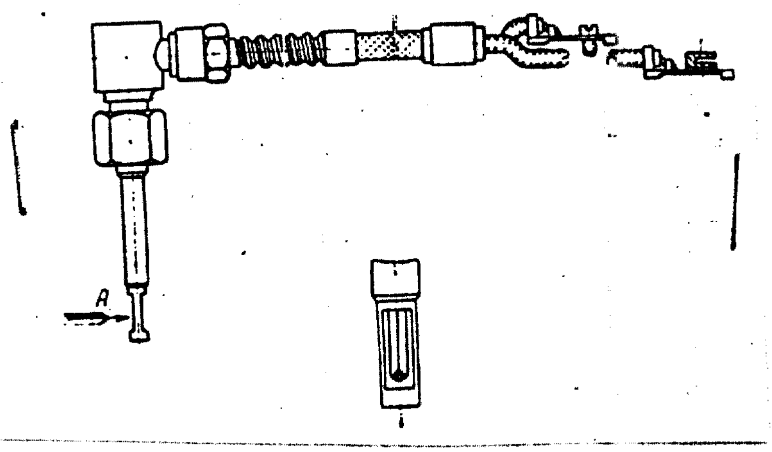

Figure 196. Centrifugal regulator assembly

3. Centrifugal regulator screw
11. Spring
13. Piston
32. Sleeve
70. Locking nut
71. Ball bearing
72. Sleeve
73. Screw socket
74. Stop
75. Ball bearing ring
76. Spring

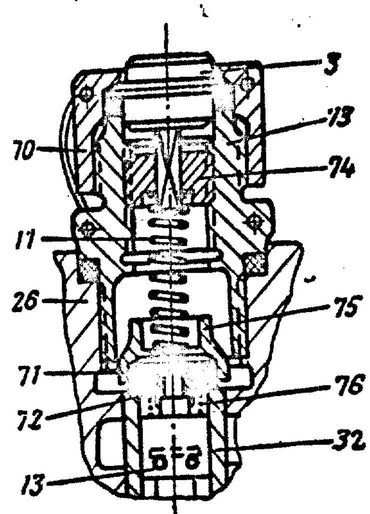

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Figure 198. Relief Valve

1. Adjustment screw of relief valve
84. Nut
85. Relief valve housing
86. Spring
87. Valve disc
88. Ball

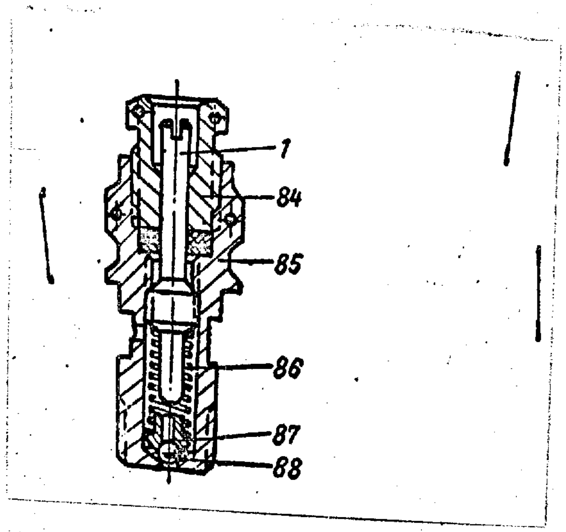

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Figure 200. Dynamotransmitter of TE-45 Tachometer

1. Housing
2. Plug connector
3. Cover
4. Space with heavy lubrication
5. Ball bearing
6. Rotor axle
7. Stator
8. Permanent magnet
9. Packing
10. Friction gears
11. Ball bearing

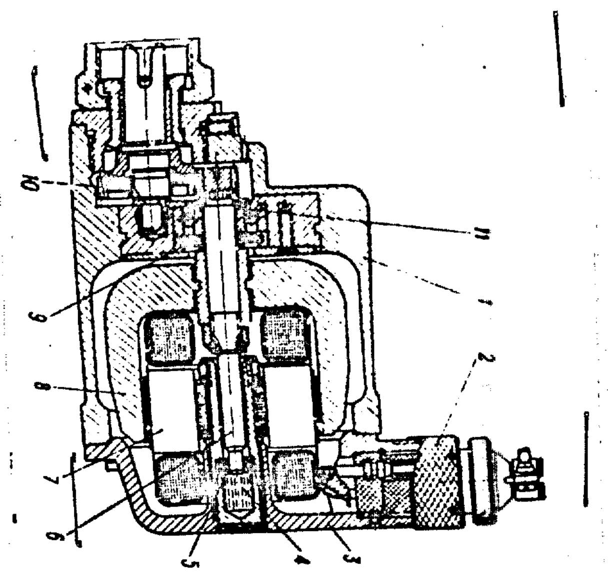

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Figure 201. TE-45 Tachometer

1. Plug connector
2. Stator winding
3. Rotor
4. Sensing element
5. Hair spring
6. Gear drive
7. Large pointer
8. Small pointer
9. Magnetic shielding
10. Magnet
11. Housing
12. Ball bearing
13. Heat compensator
14. Cover
15. Rotor shaft
16. Ball bearing

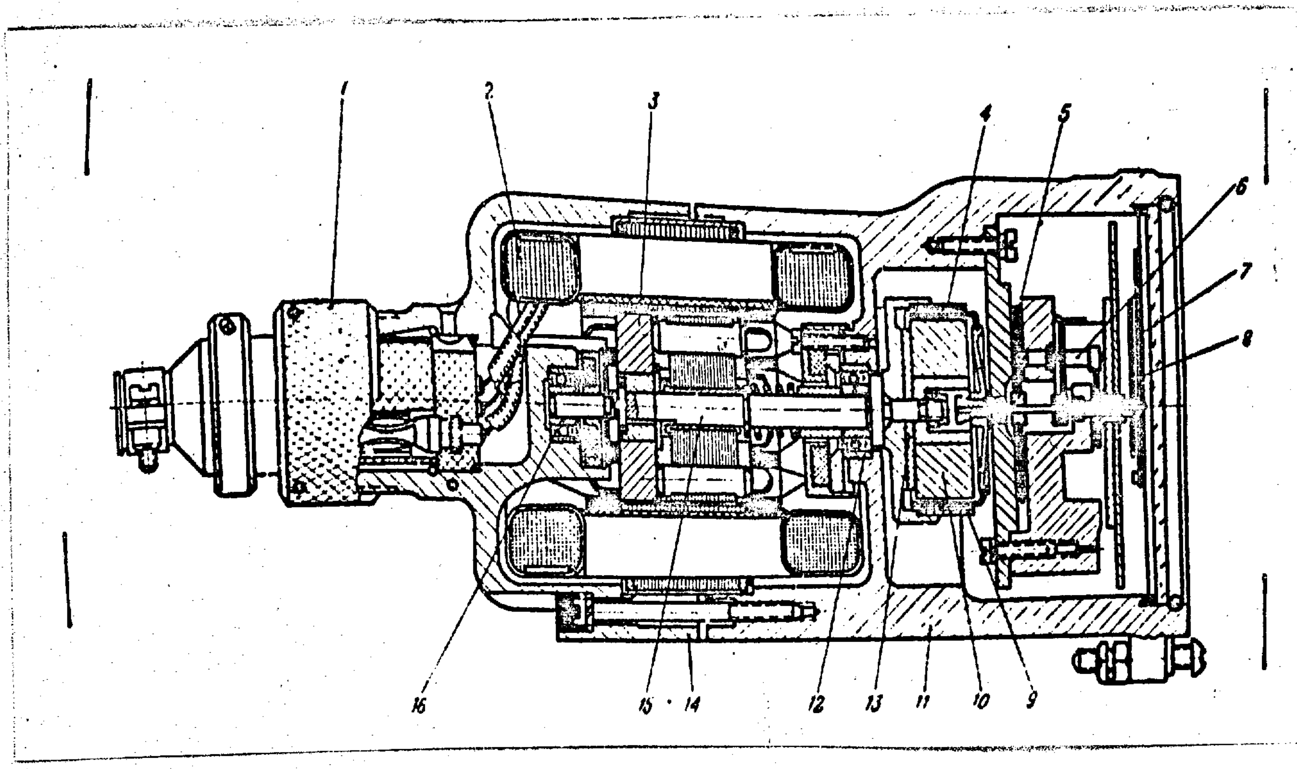

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Figure 202. The SD-24A Pressure Indicator

1. Plug connector
2. Screw
3. Rubber washer
4. Cover
5. Screw
6. Rubber washer
7. Washers
8. Pressure chamber cover
9. Housing
10. Ring
11. Diaphragm
12. Core
13. Terminal
14. Washer
15. Screw
16. Stop
17. Lower flat spring
18. Contact
19. Contact point
20. Upper flat spring
21. Graduated washers
22. Screw
23. Rubber washer
24. Set Screw
25. Socket
26, 27. Conductors from plug connector
28. Nut
29. Bar
30. Screw

A. Dynamic pressure chamber

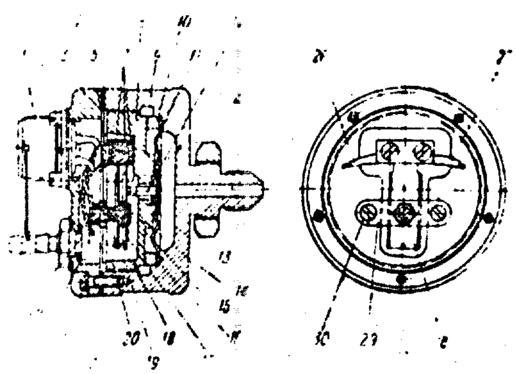

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Figure 203

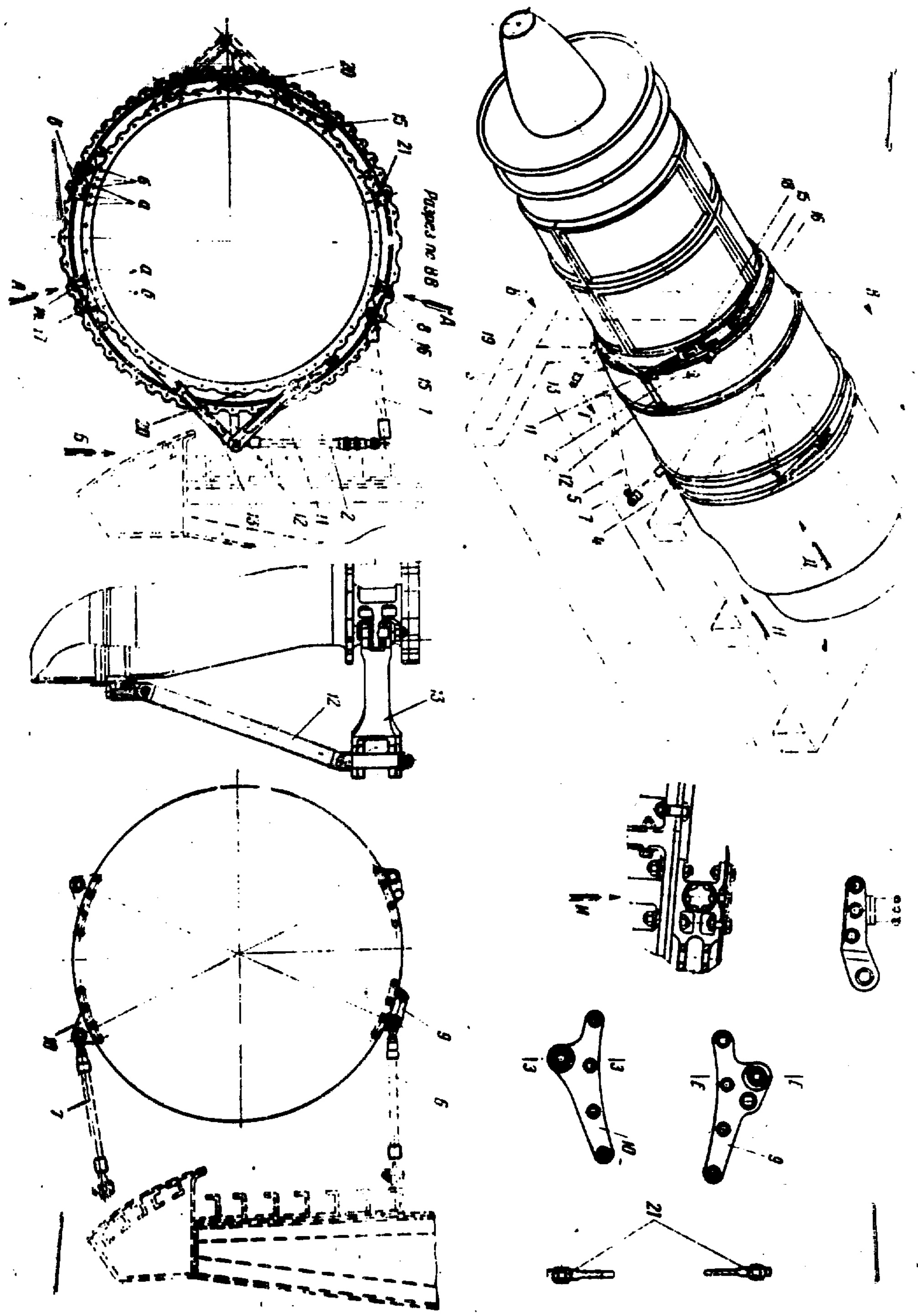

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Figure 203. Securing the Engine to Aircraft

1. Aircraft strut

2. Aircraft strut transferring weight of engine

3. Aircraft strut

4, 5. Aircraft struts transferring thrust of the engine

6. Aircraft strut

7. Auxillary aircraft strut

8. Point for securing strut No 4

9. Point for securing strut 6

10. Point for securing strut 7

11, 12, 13. Engine tie rods

14. Point for securing strut 5

15. Eye

16. Point for securing strut 1

17. Point for securing strut 3

18. Point for securing strut 11

19. Point for securing strut 13

20. Suspension mount

21. Swivel ring

a. Suspension mount base (lower) for 1st alternative

b. Suspension mount base (lower) for 2nd alternative

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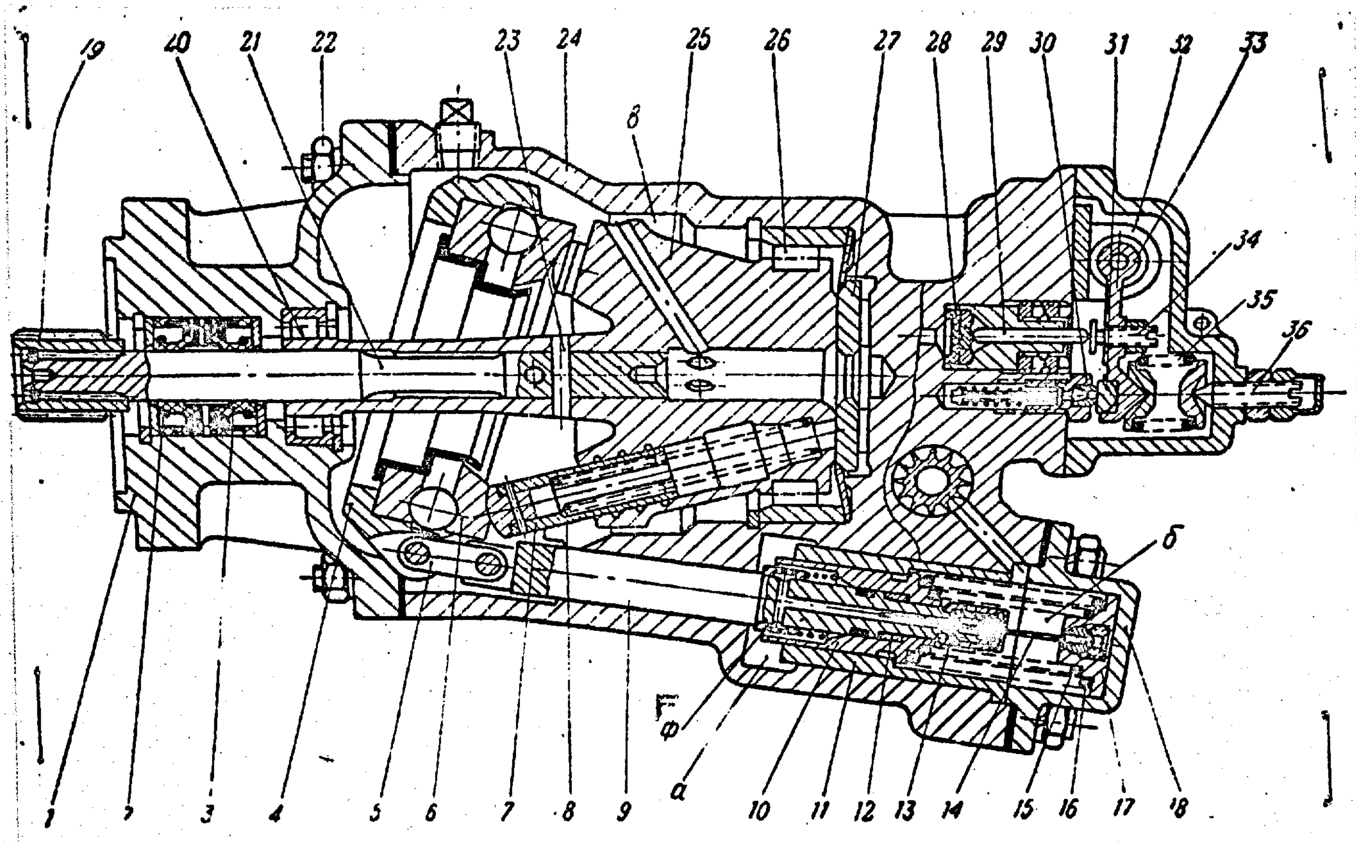

Fig. 204. Construction of the 435VF Assembly

1 -- flange; 2 -- spring; 3 -- sleeve; 4 -- bearing housing; 5 -- link; 6 -- tapered insert; 7 -- plunger; 8 -- spring; 9 -- push rod; 10 -- servo piston; 11 -- cylinder of servo piston; 12 -- variable insert; 13 -- nut; 14 -- jet; 15 -- spring; 16 -- spring; 17 -- base bearing; 18 -- cap; 19 -- connector; 2o -- roller bearing of rotor; 21 -- shaft; 22 -- nut; 23-- pin; 24 -- housing; 25 -- rotor; 26 -- roller bearing of rotor; 27 -- bronze bushing; 28 -- diaphragm; 29 -- rod; 30 -- seat; 31 -- flat valve; 32 -- boss; 33 -- lever; 34 -- support screw; 35 -- valve spring; 36 -- adjustment screw; F -- cleaner.

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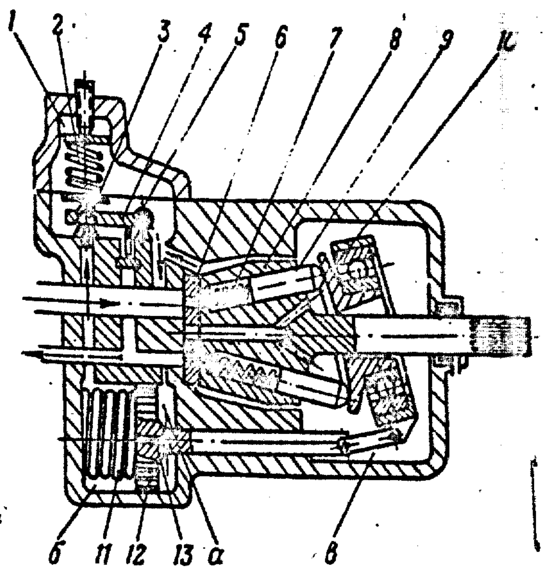

Fig. 205. Operating Diagram of the 435VF Assembly

1 -- regulating valve; 2 -- valve spring; 3 -- valve; 4 -- lever; 5 -- rod; 6 -- closing washer (busher); 7 -- spring; 8 -- rotor; 9 -- plunger; 10 -- tapered insert; 11 -- servo piston spring; 12 -- servo piston; 13 -- jet.

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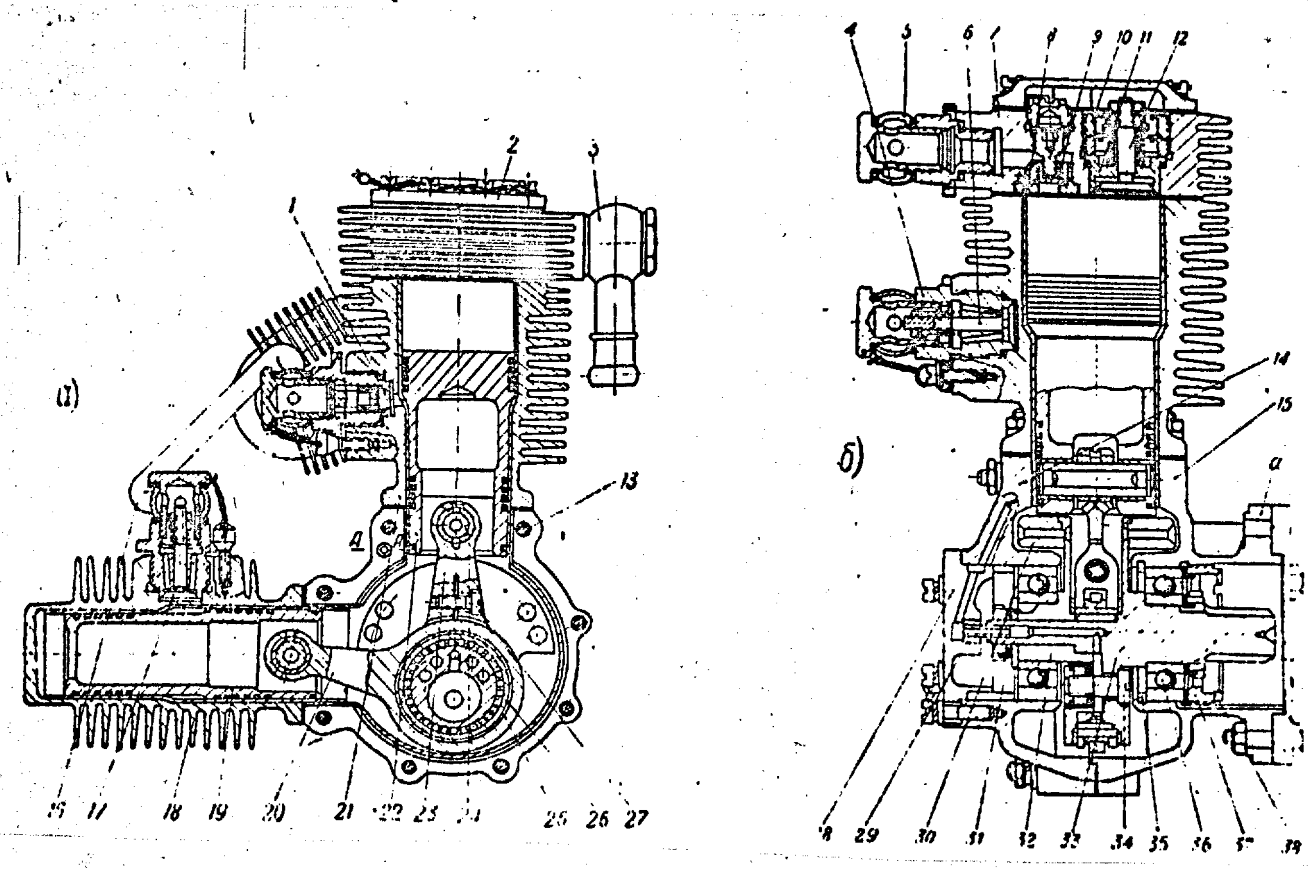

Fig. 206. Design of the AK-150N Assembly

1 -- exhaust valve of second stage; 2 -- cover; 3 -- air feed terminal union; 4 -- flange; 5 -- rotating union; 6 -- intake valve of second stage; 7 -- cylinder head; 8 -- seat; 9 -- exhaust valve; 10 -- nut; 11 -- seat; 12 -- intake valve; 13 -- bolt; 14 -- compressor housing, forward half; 15 -- compressor housing, rear half; 16 -- tubing; 17 -- sear; 18 -- cylinder; 19 -- piston; 20 -- main connecting rod; 21 -- cylinder; 22 -- piston; 23 -- connecting rod; 24 -- pin; 25 -- insert; 26 -- bushing; 27 -- bolt; 28 -- rear cover; 29 -- floating case; 30 -- counterbalance; 31 -- nut; 32 -- crankshaft, rear portion; 33 -- crankshaft, forward portion (drive); 34 -- bolt; 35 -- ring; 36 -- crankshaft bearing; 37, 38 -- nuts.

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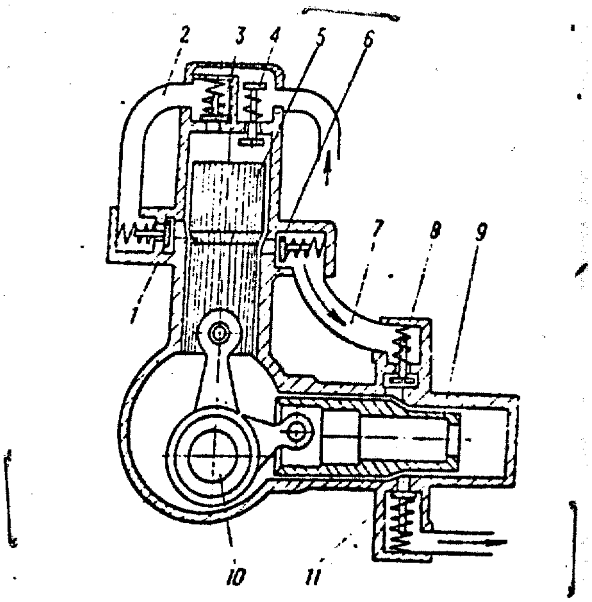

Fig. 207 -- Operating Diagram of the AK-150N Assembly

1 -- intake valve of second phase; 2 -- tubing; 3 -- exhaust valve of third phase; 4 -- intake valve of first phase; 5 -- piston; 6 -- exhaust valve of second phase; 7 -- tubing; 8 -- intake valve of third phase; 9 -- piston; 10 -- crankshaft; 11 -- exhaust valve of third phase.

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