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CENTRAL INTELLIGENCE AGENCY

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1. A 283-page English translation of a Czechoslovakian-language manual entitled IL-18 - Dl - 123/7, AI-20 Turboprop Engine (IL 18 - Dl - 123/7, Turbovrtulovy Motor AI-20) [redacted] The manual was issued in September 1961 by the Technical Documentation Department of the Czechoslovak Airlines.

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2. The manual gives basic engine specifications, characteristics, and design features; includes descriptions of the oil system, fuel system, and electrical and automatic starting equipment of the engine; and describes the installation of the engine on the IL-18 aircraft.

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IL 18 – D1 – 123/7

AI–20 TURBOPROP ENGINE

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CONTENTS

Page

31. Propeller shaft
32. IKM components 50X1
33. Reduction gear lubrication system
34. Schematic of the negative torque automatic control transmitter
35. Lateral section of reduction gear
36. Electromagnetic valve for feathering the propeller for pitch control
37. Transmitter when permissible revolutions are exceeded
38. Schematic of the propeller feathering transmitter
39. Front housing (view from right front)
40. Front housing (rear view)
41. Lateral section of front housing
42. Starter-generator drive
43. Drives, located in the lower portion of the front housing
44. Kinematic diagram of the front housing and associated drives
45. Front housing (right front view)
46. Front housing (right rear view)
47. Central drive
48. Drive housing
49. Drive housing (inside view)
50. Drive housing (outer view)
51. Drive housing cover (outer view)
52. Drive housing cover (inside view)
53. Propeller brake
54. Compressor
55. Compressor rotor
56. Compressor rotor

57. Front compressor roller bearing
58. Coupling between compressor rotor and reduction gear
59. Disc
60. Rotor blade
61. Mounting the blade in the compressor rotor disc
62. Rear compressor bearing
63. Compressor shaft coupling with the turbine shaft
64. Baffle seal [assembly]
65. Baffle seal
66. Inlet guide vane assembly
67. Compressor housing
68. Compressor housing (upper half)
69. Compressor housing (lower half)
70. Rear engine mounts
71. Compressor stator ring
72. Stator ring, stage V, compressor
73. Rotor ring
74. Air bleed valve
75. Air bleed valve
76. Hot air bleed valve for heating inlet guide vanes
77. Hot air bleed valve for heating inlet guide vanes
78. Combustion chamber
79. Combustion chamber
80. Inlet section of combustion chamber
81. Burners
82. Burner

83. Fuel system

84. Fuel nozzle

85. Igniter

86. Auxiliary starting fuel nozzle

87. Turbine

88. Change in static heat T, pressure p, and absolute speed c in the individual stages on the central radius of the turbine.

89. Turbine rotor (cross section)

90. Mounting turbine buckets on disc

91. Disc, turbine stage II (front view)

92. Disc lock nuts

93. Turbine nozzle assembly, stage I

94. Turbine nozzle assembly, stage II

95. Interstage packing

96. Exhaust nozzle

97. Turbine housing

98. Turbine cooling diagram

99. Diagram of engine oil system

100. Diagram of engine air vent system

101. GMN-20 main oil pump.

102. GMN-20 main oil pump

103. Gear of pressure stage, main oil pump

104. MNP-20 auxiliary oil pump

105. VO-20 air separator

106. MNO-20 oil scavenge pump

107. Scavenge pump, power drive box

108. Centrifugal de-aerator
109. MF-20 oil filter
110. MIKM oil pump
111. Oil filter
112. 348-I fuel pump
113. 707-I fuel pump
114. STG-12TM starter-generator
115. KPN-4 Coil
116. SPN-4 spark igniter plug
117. Electromagnetic starter fuel valve
118. VE-2S Switch
119. MP-5 Electromagnetic device
120. Sketch of pneumatic icing indicator SO-4A
121. SO-4A Icing indicator
122. MZK-2 Electromechanism
123. MZK-2 electromechanism
124. DTE-2 Sensor
125. ITE-2 Tachometer
126. UPRT-2 Transmitter
127. UPRT-2 Indicator
128. SGO-8 Generator
129. APD-75 Automatic starting device (without cover)
130. PSG-2A Starter case
131. Engine cowlings
132. Engine mounting

133. Exhaust pipe

134. Drains, inboard engines

135. Drains, outboard engines

136. Cooling system, outboard nacelle

137. Cooling system, inboard nacelle

138. Fuel system

139. Pressure fueling system (from below)

140. Oil system

141. Fire Extinguishing System

142. Fuel system diagram

143. Engine starting diagram

B. Change in Pp oil control pressure with oil pump rpm

C. Changes of fuel consumption with respect to compressor inlet air pressure

D. Change of fuel consumption according to engine mode

E. Change of fuel consumption according to compressor inlet air temperature

F. Change of the "bust" coefficient of loss of total pressure at compressor intake per "M" flight.

G. Change of the "B" coefficient according to "M" flight.

H. Fuel consumption in relation to KTA-5 F drive rpm.

OPERATIONAL MANUAL

Czechoslovak Airlines

AI-20 Engine
IL-18 Airplane

Chapter I.

April 1961 50X1

BASIC ENGINE SPECIFICATIONS

Designation AI-20

Type .... Turboprop

Rotation direction (viewed from exhaust.. Counterclockwise

Compressor .... Axial, ten-stage, compression factor at nominal mode (H [altitude] = 8000m, v[speed] = 175 meters/second), 8.5

Combustion chamber .... Annular, with 10 "heads" and a common burner [apparently a canannular, with 10 burners.]

Turbine.................................... Axial, three-stage

Jet exhaust .... Fixed exhaust diameter, 0.225 M^2

Reduction gears .... Planetary; transmission ratio - 0.08732

Propeller shaft torque meter .... Hydraulic

Amount of air, behind tenth compression stage:

a.- For air conditioning on all flight regimes to altitudes of ten kilometers 0.22 kg/second max

b.- For de-icing on normal and lower modes .... 0.13 kg/second, max

Engine RPM

Idling speed .... 10400 ± 200

In all operational modes .... 12300 ± 90

Maximum horsepower output 4015

50X1

Max. permissible gas temperature for starting in °C 750

Max. gas temperature behind the turbine during engine operation

Operation condition	Mode	Gas temperature behind turbine in °C, maximum
Any ground start	starting	470 if t_H greater than 15°C 520 if t_H less than 15°C
In flight to H [altitude] = 10km	maximum	470^x
	Nominal	440^x
	0.85 nominal or lower	420^x

Note: ^x Temperature of the gas behind the turbine is kept close to the temperature of the outside air according to standard atmosphere conditions. At temperature deviations of surrounding air from standard atmosphere conditions the gas temperature behind the turbine changes appropriately to 1°C for each 1° deviation.

Transition time [ground] from idling speed to moving speed in seconds .... 15, max

Type of fuel .... T-1, TS-1, T-2, LRX-55 or their equivalent

a. Booster pump - Designation.......... 707.1

Type .... Centrifugal

Transmission ratio .. 0.1854

Rotation direction .. Clockwise

b. Main fuel pump - Designation .... 661 A (or 348.1.)

Type .... Piston

Transmission ratio .. 0.3937

Rotation direction .. Clockwise

c. Main fuel nozzles - Designation .... FR 20

Type .... Centrifugal, two50X1nel

Number 10

Fuel pressure at moving speed before nozzles (in kg/cm^2) 78, max

Grade of lubricating oil .... Mix 75% by volume transformer oil and 25% MK-22 MS-20, LB-18, or LB-22 oils, or, if need be, other similar equivalents

Oil consumption in liters/hour .... 1.2 max.

Flow of oil to the engine on nominal mode and when temperature of input oil is 80°C in liters/minute .... 135, max.

Heat transfer by oil on nominal regime and temperature of input oil at 80°C ... 850, max.

Temperature of input oil in °C:

Min. permissible 40

Max. permissible after 15 minutes ... 90

Recommended 70-80

Oil system:

a. Main oil pump - Designation GMN-20

Type .... Gear, two-stage

Transmission ratio 0.4821

Rotation direction ...... Counterclockwise

Pump performance at engine rotor rpm of 12,300 and oil temperature 70 - 80 °C, in liters per minute, minimum

50X1

1/ Pressure side with intake pressure of 0.6 - 0.8 kg/cm^2 and 4 0.5 kg/cm^2 .. 240, min.

2/ Scavenge side with back pressure of 2 kg/cm^2 ...... 275, min

b. Pressure oil pump - Designation MNP-20

Type .... Piston

Transmission ratio........ 0.5509

Rotation direction .... Clockwise

Performance at engine rotor rpm of 12,300, back pressure of 0.6-0.8 kg/cm^2 and oil temperature 70 - 80°C, in 1 liters per minute, minimum . 90

c. Air separator - Designation VO-20

Type .... Centrifugal

Rotation direction .... Counterclockwise

d. Scavenge pump - Designation MNO-20

Type .... Gear, two-stage

Transmission ratio 0.5509

Rotation direction .... Counterclockwise

Performance at engine rotor rpm of 12,300, back pressure of 0.5 kg/cm^2 and oil temperature 90-100°C, in liters per minute, minimum 80

e. Oil pump IKM [torque meter] - Designation MIKM-20

Type .... Piston

Rotation direction .... Clockwise

Transmission ratio 0.3097

50X1

Performance at engine rotor rpm of 12,300, back pressure of 80 kg/cm^2, in liters per minute, minimum 15

f. Centrifugal de-aerator - Type .... Driven

Transmission ratio 0.92

Rotation direction .... Clockwise

g. Oil filter - Designation MF-20

Type .... Gauze strainer

Number 2

Oil pressure in main assembly for all ground operation modes in kg/cm^2 .... 5-5.5
at idling speed .... 4 min

Control systems:

a. Fuel control Component - Designation KTA-5F

Type .... Hydraulic

Transmission ratio for driving pump and centrifugal regulators 0.4265

Rotation direction of drive .. Counterclockwise

RPM range of automatic regulator .... 1,000 - 13,100

b. Propeller governor - Designation .... H-60 D

Type .... Hydraulic-centrifugal

Transmission ratio 0.4602

Rotation direction .... Counterclockwise

Propellers - Designation .... AV-58 I

Type .... Puller type, four-bladed, variable pitch, full feathering

Transmitter for automatic pitch control [feathering?] Electrohydraulic

50X1

Starting system

a.	Starter generator	- Designation	STG-12TM
		Number	2
		Transmission ratio	0.5396
		Rotation direction	Counterclockwise
		Necessary output for propulsion, max. horsepower	15
b.	Starter coil	- Designation	KPN-4
		Number	2
c.	Igniter - 1/ Starter nozzle	- Type	Centrifugal
		Fuel pressure at nozzles, in kg/cm^2	2 - 3
	2/ Spark plug	- Designation	SPN-4
		Number	2
d.	Delivery valve for starting fuel	- Type	Electromagnetic
e.	Starter generator switch at starting	-Designation	VE-2S
		Type	Electrohydraulic
		Engine rotor RPM at instant of starter cut-off	4500 - 6500

De-icing system:

a.	Icing indicator	-Designation	SO-4A
		Type	Pneumoelectric

b. Electromechanism controlling air supply for heating compressor inlet guide vanes

- Designation MP-5

Engine and airframe accessories

50X1

a.	Generator	- Designation	SGO-8U
		Type	Alternating current
		Transmission ratio	0.3305
		Rotation direction	Counterclockwise
		Necessary output for drive (in horsepower) max	15
b.	Tachometer transmitter indicator, engine RPM	- Designation	DTE-2
		Type	Electrical
		Transmission ratio	0.194
		Rotation direction	Clockwise
c.	Throttle position indicator transmitter -	- Designation	UPRT-2
		Type	Electromechanical
d.	Propeller brakes with control mechanism -	- Designation	MZX-2
		Type	Friction - disk
		Transmission ratio	0.4602
e.	Hydraulic pump	- Designation	MP-25
		Type	Piston
		Transmission ratio	0.1673
		Rotation direction	Clockwise
		Necessary output for driving pump	Max., 15 horsepower

Other engine specifications:

Length .... 3076 ± 5 mm

Width .... 842 ± 5 mm

50X1

Engine mode (at H[altitude] =), V[speed] = 0, barometric pressure = 760 mm Hg, t[temperature] = 15°C)

Mode	Angle of setting on dial UPRT-2	Rotor rev. rpm	Rotor rev. %	Average fuel pressure in front of nozzles in kg/cm^2	Hourly fuel consumption, Max. kg/cm^2	Oil pressure in engine in kg/cm^2	Oil temp. on entry to engine in °C: Min. at entry	Oil temp.: recommended	Oil temp.: Max for 15 min.	Torque meter pressure in kg/cm^2
Start	98-105			78	1040					80
Nominal	84 2			62	950					67
0.85 nom	72 2		95-	53	870	5		70		56
0.7	61 2	1230	96-	46	790	to	40	to	90	
0.6	50 2	90	42	42	745	5.5		80		
0.4	35 2			-	-					
0.4	Min.19			-	-				Max 100	8
Idle	0	10400 200	76- -79		380	Min 4				0

Height .... 1180 5 mm

Weight of dry engine .... 1075 kg 2%

Chapter II

ENGINE CHARACTERISTICS

The characteristics of a turbo prop engine are the main parameters of the engine which depend on the operating mode and altitude and speed of flight.

The main parameters of a turboprop engine concern the propeller and equivalent performance, the value of its reactive thrust, specific fuel consumption, gas temperature at the turbine, and the like, which depend on the type of construction, engine operating limits (altitude and flight of speed), and the manner of its control.

Performance and specific fuel consumption are influenced by the following factors:

a. Degree of air pressure increase in the compressor;
b. Gas temperature in the combustion chamber (at the turbine);
c. Functioning of main engine components (compressor, combustion chamber, turbine, and exhaust);'
d. Propellers and flight conditions; i.e., speed and altitude flight.

Altitude and speed characteristics of the AI-20 engine were constructed on the basis of completed experimental findings, gained from tests of several engines on the ground and in altitude tests.

Figures 3 - 14 show experimental and calculated altitude and speed characteristics for basic modes of the AI-20 engine operating with the exhaust pipe [attached] without regard to losses at the plane's air intake.

In connection with flight requirements levied on the aircraft (such as climbing and landing) and the design capabilities of the main components of the engine, a regulating system for all operational modes, by automatic correction of fuel consumption the following conditions of altitude and speed characteristics are satisfied.

a. Maintenance of nearly constant efficient engine performance at the specified flight altitude, at which maximum allowable turbine inlet gas temperature is reached. The altitude range where performance is constant, is called the performance limit range and the altitude where the maximum allowable turbine inlet temperature is reached [is called the] performance limit altitude;

b. Maintainance of constant inlet gas temperature at altitudes above ~~then~~ the performance limit altitude. The altitude range, where inlet gas temperature is kept constant, is called the temperature limit range.

At performance limit altitudes the inlet gas temperature reaches T_4 [illegible], maximum allowable quantity, appropriate to the mode. In

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50X1

raising the flight altitude (above altitude limits), the regulating system maintains gas temperature T [?] almost constant. On each engine mode (0.4 nominal, 0.6 nominal, etc.) at altitudes higher than the limit performance altitude a constant inlet gas temperature is maintained for all flight speeds.

Equivalent engine performance Nekv, is maintained constant to the altitude limit by raising inlet gas temperature; this is limited from the standpoint of engine stability and aircraft requirements.

With increase of flight altitude at constant speed (higher than the altitude limits) the over-all level of air pressure increases as a result of air temperature drop, and therefore at constant inlet gas temperature (T [?] equals a constant) the temperature drop in the turbine grows (degree of expansion in the turbine). Therefore, with increase of flight altitude the specific output of the turbine will increase (produced from 1 kilogram of air, passing through the engine) and be transmitted to the propeller. Since by raising the flight altitude the air flow through the engine drops faster than the specific output of the turbine increases the absolute turbine output which will be transmitted to the propeller N_{vrt} and thus also the N_{ekv} will drop. At the same time lowering of the engine output by increasing the flight altitude to H = 11,000 meters takes places more freely than does decreasing atmospheric air, [?] which is accomplished by increased turbine output and by slower decrease of air flow than the decrease of air density.

At altitudes when H = 11,000 meters the over-all level of pressure increase [in relation to] the flight altitude increase will remain constant and thus the specific turbine output and the absolute turbine output will also remain constant. Therefore, the propeller performance and equivalent engine output will diminish in proportion to the atmospheric pressure.

The level of the performance limit depends on the speed of the flight and does not depend on the engine regime. The greater the speed of flight the greater will be the level of the performance limit, because increasing speed increases resistance and this leads to an increase in air flow through the engine and therefore the maximum inlet gas temperature for a given mode is reached at a higher flight altitude. For all engine modes at same flight speed the limit level has the same designation.

Specific reactive thrust ($R_{spec} = R_c / G_v$) obtained from 1 kilogram of air is increased as the flight altitude increases, which is demonstrated by the increase in speed of the exhaust gases accompanied by an increase in temperature drop (to the detriment of decreasing gas density at exhaust from the turbine) at higher flight altitude. The absolute quantity of reactive thrust R_c decreases as the flight altitude increases with greater intensity than the increase in specific thrust, by lowering the air flow through the engine. The performance limit level depends on the speed of flight: the greater the speed of flight, the greater the altitude of performance limit level.

By increasing the speed of flight, the temperature drop in the turbine is also increased because of the over-all level of pressure increase. At constant rpm rotations this results in certain lowering of the turbine efficiency which, however, is negligible. Thereby at constant inlet gas temperature (at altitudes above the limit) the specific turbine output transmitted to the propeller is increased with the increase in flight speed. Since with the acceleration of flight speed the engine air flow increases, the absolute turbine output transmitted to the propeller and simultaneously the equivalent output during acceleration of flight speed also increases. In the realm of performance limitation, the increase in inlet temperature drop and the air flow through the engine during acceleration of flight speed results in decreased inlet gas temperature.

The reactive thrust, expressed by the equation $R_c = \frac{Gv}{g} (W_s - V_p)$, decreases with increase of speed of flight. This is explained by the fact that regardless of a certain increase of speed of the gases W_s emerging from the exhaust, together with the slight increase of gas temperature behind the turbine, the specific thrust $R_{sp} = \frac{1}{g} (W_s - V_p)$, decreases faster as a result of increasing flight speed. Therefore without regard to the air flow G_v through the engine, the absolute thrust R_c originating in the exhaust changes with increased flight speed.

The specific fuel comsumption, in relation to the equivalent output C_{Nekv} increases at limit performance altitudes by increasing flight speed as a result of constant (even a tendency toward diminishing) extent of equivalent output (as a result of lowering the inlet gas temperature) and at altitudes above altitudes limit with constant inlet gas temperature, gas consumption decreases in proportion to the increase in equivalent engine output (as a result of an increase in the over-all level of pressure increase during acceleration of flight speed).

On the AI-20 engine, a constant fuel supply is ensured, which is not dependent on the over-all temperature of the air flow at intake into the engine up to + 25 °C; the change of fuel delivery at the same time depends merely on air pressure at intake into the engine. By lowering air temperature at intake the air flow in the engine increases (as a result of increase in air density and the level of pressure increase in the compressor) and by unchanged fuel consumption, the inlet gas temperature becomes less. The result of this is that the equivalent engine output during tests remains approximately constant.

At an air temperature of + 25 °C at intake into the engine, the turbine inlet gas temperature reaches the maximum allowable level because of reduced passage of air through the engine and the decreased air density and the level of increase pressure in the compressor. During further increase in air temperature at intake the KTA regulating device decreases the supply of fuel, in order to prevent overheating of the turbine and the other engine parts. The fuel is restricted in such a manner that the turbine inlet fuel temperature is more or less constant. For a constant inlet gas temperature and a drop in the air flow in the engine, the engine output decreases.

Figure 15 shows, in graph form, the characteristics of the engine, which the manufacturer determined from laboratory tests.

 50X1

Chapter III

ENGINE DESIGN

1. REDUCTION GEAR

1.1. General description

The engine has a differential planetary reduction gear (Fig. 16, 17), which transmits power from the engine rotor drive shaft to the propeller shaft, with i = 11.4527.

The engine rotor drive shaft(11) (Fig. 17), to the reduction gear is powered by the engine rotor in a counter-clockwise direction.

Sun gear (10) of the reduction gear is mounted on the splines of shaft (11). The sun gear engages six planet gears (9) in planet gear carrier (8). Planet gears (9) rotate on their shafts in a clockwise direction and engage with inner ring gear (7), rolling within it in a clockwise direction.

In rolling within inner ring gear (7), planet gears (9) rotate planet gear carrier (8) and propeller shaft (17), connected to the carrier by splines, in a counter-clockwise direction. As planet gears (9) roll along inner ring gear (7), the peripheral force of planet gears (9) bears upon the gearing, which forces inner ring gear (7), to turn in a clockwise direction.

Inner ring gear hub (12) of the planet mechanism and sun gear (13) connected by splines, turn the same direction simultaneous with inner ring gear (7). Sun gear(13) engages six intermediate [planet] gears (1), which turn counter-clockwise on journals pressed into transmission housing (14).

The plant gears rotate inner ring gear(15), countershaft hub (16) and propeller shaft (17), joined together by splines.

Countershaft housing (14) is connected to the reduction gear housing by means of IKM torque meter mechanism (ring gear (2), cylinder (4), piston (6), cams (3) and (5) and the retaining parts).

The torque is transmitted from the engine shaft to the propeller shaft in parallel fashion in two ways:

50X1

-- about 30 percent through the planet [gear] and
-- remains through the countershaft housing.

Transmission from the drive shaft (11) to the propeller shaft (17) is as follows according to the kinematic diagram in (Fig. 17):

$$i = 1 + \frac{z_3}{z_1} \frac{z_3}{z_1} \frac{z_6}{z_4} = 1 + \frac{97}{35} + \frac{97}{35} \frac{97}{35} = \underline{11.4527}$$

whereby $\frac{1}{i} \quad \frac{1}{11.4527} = \underline{0.08732}$

The torque meter (Fig. 18) is connected into the reduction gear system and consists of the "rim" torque meter plate] (4), six cylinders (3) with pistons (2), cylinder and piston journals, oil line (5) and high-pressure pump (1).

The torque meter operates on the principle of balanced axial force, bearing upon cylinders (3) and the oil pressure under the pistons (2) in spaces "A".

Torque transmitted through the countershaft housing has the tendency to turn the rim (4), connected to the reduction gear housing by the cylinders and pistons. As a result of the effect of this torque, there develops a force exerting its effect on the axes of the cylinders, tending to shift the cylinders up against the pistons. The value of this force is expressed as:

$$F = \frac{M_p}{R}$$

where: M_p = torgue transmitted through the countershaft housing;

R = radius of the cylinder axis;
F = force pertinent to each cylinder.

Under the effect of the torque, the cylinders move against the pistons, in the course of which the piston ring overlaps groove "B." The flow of oil from space "A" is reduced and the oil pressure is increased, as long as the force of the oil pressure p_{IKM} does not equal axial force F. If the oil pressure p_{IKM} is known, the output may be computed according to the equation:

$$N = k \cdot p_{IKM} \cdot n$$

where: n = engine rpm;

p_{IKM} = oil pressure in the cylinder in kg/cm^2;

50X1

k = constant, dependent upon the dimensions of the components of the reduction gear and the torque meter, and for a given reduction gear is

$$k = \frac{1}{267.166513}$$

Upon conversion, $N = p_{IKM} \cdot 46$

Pressure in space "A" is developed by means of a special high-pressure oil pump (1).

Lubrication and cooling of the reduction gear components as well as the supply of torque meter oil pump is accomplished by oil delivered by the main oil pump, mounted in the front engine housing.

1.2. Reduction gear design

The reduction gear (Fig. 19) has the following parts:

(a). The reduction gear housing (43), enclosing the components of the reduction gear;

(b). Reduction gear housing cover (22);

(c). Drive shaft (26);

(d). Planetary mechanism (1st stage) containing the reduction gear sun gear (28), six planet gears (39), inner ring gear (40), ring gear hub (41), and planetary gear carrier (37);

(e). Countershaft containing countershaft sun gear (46), six planet gears (47), inner ring gear (48), countershaft ring gear hub (49), and countershaft housing (50).

(f). Propeller shaft (52);

(g). IKM torque meter mechanism consisting of rim (8) (Fig. 20), cylinder (7), piston (6), and torque meter oil pump drive gears (1) and (2).

1.2.1. Reduction gear housing

The reduction gear housing (Fig. 21 and 22) is cast of ML 5 magnesium alloy and is shaped like a truncated cone.

A flange with two rows of bolts is located on the forward part of the housing. The inside row (12 bolts) is for fastening the cover of the front part of the reduction gear. The outer row (10 bolts) is for mounting the aircraft shield. The three upper bolts (of the 12), which are larger than the others, are for mounting the housing of the electrical propeller de-icing brushes. Hole (3) (Fig. 21) in the lower portion of the flange is for draining oil from the cover of the front portion of the reduction gear into the reduction gear housing.

The flange has lug (1) for centering the cover. A steel sleeve for mounting the propeller roller bearing is pressed into the inner space of the front portion of the housing.

On the rear flange of the reduction gear housing (Fig. 22) there are:

-- Thirty evenly spaced holes (5) for mounting bolts;
-- Three channels (8) in the upper portion, for supply of oil from the governor to the propeller;
-- Two holes (1) in the lower portion to drain oil from the reduction gear to the front housing and one channel (11) to supply oil from the main oil pump for lubrication and cooling of the reduction gear parts and also for supplying the torque meter oil pump;
-- Six openings (14), even spaced along the periphery under the torque meter piston journals;
-- One oil feed hole (4) from the left side for feeding oil from the operational cylinder to the pressure meter and to the automatic propeller pitch control transmitter;
-- One hole (13) from the right side for electrical cable for propeller blade de-icing;
-- Six tap holes (6) for mounting reduction gear housing cover.

The inner space of the reduction gear housing is divided by a partiion, In the front part there is pressed roller bearing sleeve (3) (Fig. 22' and [sleeve] (2) (Fig. 21) for the roller and ball bearing of the propeller shaft and sleeve housing (4) (Fig. 23), made of ML5 alloy, with a nitrited steel, oil-passage sleeve (3), in which operate rings (2) of the oil distribution sleeve (1). In the front half of the housing is placed the propeller shaft and the oil-distribution components, and in the rear part there are the geared elements of the reduction gear and the torque meter. The front partition has channels which are extensions of oil channels (8) (Fig. 22) of the reduction gear rear flange.

The oil passage sleeve housing (4) (Fig. 23) and sleeve (3) have openings matching openings in the partition for passage of oil from the reduction gear housing channels to propeller shaft sleeve (1) and for propeller control and lubrication of the reduction gear.

Flange (10) (Fig. 22) with 18 bolts for mounting the propeller shaft ball bearing cover flange is on the partition inside the housing. The front end of the sleeve has a lubrication nozzle for the ball bearing.

50X1

The lower part of the housing has flange (9) with bolts and a passage opening for mounting the bearing sleeve of the oil pump and torque meter drive. The passage opening leads to the outer flange, to which is fastened to torque meter pump. This flange has two openings:

-- the first (right), is connected to the channel supplying oil to the torque meter pump.

-- the second (left), is connected to the openings of the torque meter journals for supply of oil to the meter.

The flange has four bolts and centering indents for mounting the pump. The torque meter pump oil supply and the feeding of this oil to the meter is accomplished by means of holes in the reducing gear lugs. The lugs have openings and recesses in which are mounted the torque pistons, with the aid of journals. The lug openings are closed except for one which is connected by means of channels to the pressure stage of the torque meter pump. For drainage of oil seeping through at the point of the journal's setting, the lugs have channels connected, by opening under the journals, to the inner reduction gear cavity.

The rear flange of the reduction gear housing has inner and outer cylindrical surfaces (7) and (12) (Fig. 22):

-- the outer serves for centering the engine cowling.
-- the inner, for centering the partition.

In the front outer portion of the reduction gear housing are two bolts for mounting the propeller de-icer electrical cable. Partition (2) (Fig. 24), which is made of cast ML5 magnesium alloy, is fastened to the rear flange of the housing.

The partition flange has the same openings as the reduction gear housing flange. Steel sleeve (1) for the planet gear carrier is pressed in the center opening of the partition. The wall [partition] has two openings for de-aeration and for oil drainage from the reduction gear into the front housing.

1.2.2. Partition

The partition has three cylindrical surfaces:

-- the outer for centering the shield,
-- two on the sides for centering the front housing and the reduction gear housing.

The front of the reduction gear housing has a cover (Fig. 25), cast of magnesium. The cover is mounted on the housing with twelve bolts. The center portion of the cover has rubber cup (1) through which the propeller shaft passes and which prevents loss of oil from the inner cavity.

The cover has a recess in which there is a ring (56) (Fig. 19) of roller bearing (2). The ring is secured by pins (57) to the cover, in the lower part of which is a cavity for drainage of oil from the packing space of the forward portion of the reduction gear.

The cover has a drainage hole for oil [see page] from under the rubber cup.

1.2.3. Drive shaft

The drive shaft transmits torque from the engine rotor to the reduction gear.

The shaft is made of 40CHNMA [40 KhMA] steel; it is heat treated and on the ends has external nitrited "involute grooves" [helical splinds?] The shaft is connected by its forward grooved end to sun gear (1) of the reduction gear, and by its rear grooved end to the compressor rotor. Also the bevel drive gear of the housing is mounted on the rear end.

On the forward end of the shaft are two splines:

-- one inside the shaft,
-- another on the grooving.

These splines are interconnected by holes for the flow of oil supplied by nozzle (25) (Fig. 19) for cooling and lubricating the spline coupling. The splines on the rear end of the shaft are copper coated. In the center of the opening on the rear end of the shaft is a bushing which prevents axial shifting of the shaft. The inner surface of the bushing is copper coated and isssecured to the shaft by a flat flexible ring.

1.2.4. Planet gear system

The planet gear system (1st stage) of the reduction gear consists of the following main components: sun gear (1) (Fig. 26), mounted on the drive shaft splines; planet gear carrier (7) (Fig. 27); six planet gears (3); journals (2); inner ring gear (8); ring gear hub (9) and details [components] of the planet gear bearings.

The gear coupling of the planet stage and the counter shaft have corrected [modified?] gears to reduce the contact strain and to equalize the specific slippage.

The sun gear of the reduction gear is cylinderical, made of 12CH2H4A [12Kh2N4A] steel, and has external front gearing. It has 35 carburized involute teeth and a central opening with copper-coated splines.

The sun gear is freely set on the splines of the drive shaft. The gear splines have three recesses:

-- one in the center for lubrication of the splines and
-- two on the edge for mounting the adjustment ring securing the gear in an axial position on the shaft.

The free setting of the sun gear on the splines makes possible the actual engagement of the sun gear with the planet gears during operation. The planet and sun gear teeth are cooled with oil supplied under pressure by nozzles (2) (Fig. 28) which are pressed into the planet gear (1).

For each pair (sun gear - planet gear) there is a special nozzles. The nozzles have three holes; the center hole supplies oil to the sun gear teeth at the point of initial engagement, while the two on the edge [supply oil] at the point of disengagement.

The planet gear carrier (7) (Fig. 27) is made of 40CHNMA [40KhNMA] steel and has the shape of a housing with openings in which are mounted planet gears (3). In the center, the carrier becomes a shaft with involute, copper-coated splines.

The splines of the shaft connect it to propeller shaft (52) (Fig. 19), and its copper-coated ends are centered in the special propeller shaft guide (8).

The rear portion of the shaft also has a centering boss (4) (Fig. 28) which forms a support for the countershaft housing. To improve resistance to wear, the boss (4) is chromium plated. The center portion of the boss has a hole for oil supply to the countershaft housing sleeve and then to the bearings and teeth of the countershaft gears.

On the planet gear shaft housing, from the side of the casing there is a surface for ball bearing (19) (Fig. 19) and threads for the mounting nut. The ball bearing (19) is prevented from axial shifting by the ring gear hub, countershaft gear (46) connected with it, and inner ring gear (40).

For lubrication of the spline coupling of the planet system hub and the countershaft sun gear, the planet gear shaft housing has nozzle (18) (Fig. 19). Inside the planet gear carrier cavity, sleeve (17) is inserted, creating a circular cavity for passage of oil. The sleeve is secured in its position by thrust ring (27). Nozzle (25) is in the rear portion of the sleeve and supplies oil to the spline coupling of the sun gear of the reduction gear and the drive shaft, and of the drive shaft and the compressor shaft.

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On the rear end of the planet gear case there is a surface and threads for mounting and fastening the ball bearing (29), in which is mounted the planet gear carrier. 50X1

The walls of the planet gear carrier, connected by six bridges, have six evenly spaced openings into which are pressed the planet gear journals (2) (Fig. 27).

On the outer side of the left wall is a cylindrical boss with six chamfers to prevent the journal from turning.

In the left side of the planet gear carrier there is a drilled opening for supply of oil to the planet gear journal cavity for lubrication of the roller bearings. The oil then passes through openings in the right wall and through the cavity between the special sleeve and the case to the six nozzles (2) (Fig 28).

[Page 7 of original text is missing]

in addition to the splines, there is a recess for the bearing and two circular grooves for the retainer rings.

Hub (41) (Fig. 19) of the planet gear system is prevented from axial shafting by means of ball bearing (19), the outer ring of which is mounted in the hub with a clearance and is secured by adjustable ring (21). From the other side, the forward end of the rim of the reduction gear sun gear, secured by an adjustable ring, presses against the outer ring of bearing (19) through ring (20).

The spline coupling of hub (41) of the planet gear system and sun gear (46) is supplied with oil under pressure from nozzle (18) through the planet gear shaft housing, through openings along the splined rim of sun gear (46).

1.2.4. Countershaft

The countershaft consists of the following parts:

-- Sun gear (11) (Fig. 27);
-- Countershaft tube (6) (Fig. 29);
-- Six planet gears;
-- Planet gear journals (2);
-- Inner ring gear (7);
-- Hub (8) and roller bearing components.

The planet gears, journals, the inner ring gear, and the roller bearing components of the countershaft are interchangeable with like parts of the planet gear mechanism.

The bearing of intermediate gear (3) differs from the bearing of the planet gear of the planet gear system only in that it does not a cage (28 rollers). 50X1

The countershaft sun gear is essentially the same as the reduction gear sun gear.

The rear portion of the teeth of the countershaft sun gear is separated from the remaining part by a circular groove (Fig. 27, pos [?] 11) and is used for coupling with the planet system hub.

On the teeth and in the central opening of the gear under the grooves there is a circular groove for passage of oil for lubrication and cooling of the spline coupling. The teeth are copper coated.

The countershaft planet gear carrier (Fig. 30) is box-shaped with ribs and is made of 40CHNMA [40 KhNMA] steel. The elements of design such as the mounting bolts, oil supply for lubrication and cooling of the bearings, and the recesses for the gears are the same as in the planet gear carrier.

In the central opening of the left side of the countershaft planet gear carrier there are grooves for coupling with the rim [plate?] of the torque meter mechanism; [these grooves] connect the carrier, by means of the cylinders and the pistons of the torque meter, with the reduction gear housing. The grooves are copper coated and have a groove for a flexible ring, which prevents the case from axial shifting in the grooves of the torque meter rim.

The right side of the countershaft planet gear carrier has a cylinderical terminal end, in the central opening of which are pressed two bronze sleeves which center the countershaft planet gear carrier on the sun gear case shaft.

Between the sleeves there is a groove to which oil comes through openings in the countershaft planet gear carrier. This oil cools and lubricates the details [components] of the countershaft.

To permit passage of oil in the central opening, there are three milled pockets connecting the circular groove with the oil channels in the left wall of the carrier.

Countershaft hub (8) (Fig. 29) is made of 12CH2N4A [12Kh2N4A] steel is heat treated, and has inner and outer hardened splines, on the profile. The outer splines are the same as on the hub of the planetary stage. The inner splines run the entire length of the hub. These splines connect the hub with the propeller shaft. The splines are lead coated for protection against abrasion during assembly.

1.2.5. Propeller shaft (Fig. 31)

The propeller shaft transmits the torque to the propeller, and also receives the forward thrust of the propeller, the bending moment of the propeller, and the gyroscopic moment.

The hollow propeller shaft is made of 40CHNMA [40 KhNMA[steel, is heat treated and mounted in the reduction gear housing on two roller bearings.

Front bearing (2) (Fig. 19) is of the roller, thrust type; rear bearing (5) is of the ball, radial axial type, and receives the forward thrust of the propeller, trasmitting it to the reduction gear housing through the steel bearing sleeve.

Mounted from the outer side of the central portion of the shaft are:

-- Bushing (55) under packing seal (58);
-- Oil slinger ring (1)
-- Ball bearing (2)
-- Oil distribution liner (3) with packing ring (53), which are pressed against the shaft thrust ring by nut (9).

On the end of the shaft are mounted: ball bearing (51), drive gear (12) of the torque meter oil pump, and countershaft hub (49), which are fastened with nut (14).

Inside the shaft are inserts (4) and (5) which carry oil for propeller pitch control and for lubrication of reduction gear components. In addition, the planet mechanism shaft seat (8) is inside.

The front section of the propeller shaft has a flange with front splines and openings for mounting the propeller. On the rear end are splines for mounting and fastening drive gear (12) of the torque meter oil pump and countershaft hub (49). Inside, the shaft has involute grooves for coupling with the planet gear housing shaft. In two places on the outer surface of the shaft there are threads for fastening the components.

To supply oil for controlling the propeller blades and for lubrication of the reduction gear, the wall of the shaft has four rows of radial openings, distributed against four sleeve recesses (3). From the first recess (from the propeller), through drilled openings in the propeller shaft and inserts (4) and (5), the oil passes to the "fixed" pitch [fully-featured] channel, from the second [recess] into the low pitch channel, from the third to the high pitch channel, and from the fourth to the cooling and lubrication of the reduction gear.

The recesses are separated by bronze packing rings (53), mounted in pairs in the liner grooves.

On the front end of liner (3), along the inner diameter, there is a recess for [lock] pin (54), mounted in the propeller shaft, which prevents the liner from turning in relation to the shaft. The inner surface of the liner is copper coated.

Packing rins (53) of the liner (3) run on the nitrited surface of sleeve (7), on whose outer surface are four circular recesses, connected by opening and channels of the reduction gear housing.

Along both sides of the recesses three are circular grooves for rubber packing rings which prevent the seepage of oil from channel to channel.

Sleeve (7) is prevented from turning by means of stops pressed into its housing (6).

Steel seat (8) and inserts (4) and (5) are mounted in the inner cavity of the shaft. The walls of the seats and the shaft wall form a circular cavity, from which oil passes through a hole into the shaft of the planet gear carrier.

Inserts (4) and (5) are cast from magnesium alloy and their front portion has a thrust section with grooves for rubber rings for coupling with the slide valve apparatus of the propeller sleeve.

The outer surface of the inserts has circular grooves which have rubber rings along their sides, preventing seepage of oil from groove to groove.

Insert (4) (Fig. 19) is prevented from turning in relation to the shaft by means of pin (54).

1.2.6. Torque meter (IKM) mechanism (Fig. 32)

Oil line (7) consists of six bent tubes, interconnected by threaded fittings. The ends of the tubes are soldered into openings of the threaded fittings.

Tube (4) (Fig. 20) is seated in openings [nipples] in the threaded fittings against the seating surface of the [cylinder] pivot (11) and of the cylinder (7), and is secured by nut (3). At the point of the connection of each threaded fitting with the pivot, there is a rubber ring seal (10).

A special high-pressure oil pump (Fig. 20, item 13) provides the necessary oil pressure (up to 90 kg/cm^2) for the torque meter cylinders. 50X1

The pump is driven by drive gear (2) (Fig. 20), which has 117 teeth, spline coupled to propeller shaft (12). This gear engages pump drive gear (1) which has 33 teeth. This gear shaft rests in two ball bearings (14) with spacer sleeve (15) secured by a nut.

The rear end of gear (1) shaft has inner splines into which the splined end of the pump drive shaft fits. The drive shaft bearings are seated in steel sleeve (16), mounted in a recess in the reduction gear housing and fastened by four bolts.

1.3. Reduction gear oil system

The reduction gear oil system (Fig. 33) lubricates and cools the components of the reduction gear [assembly] under pressure by spraying; supplies oil for propeller control; and [supplies oil] to the torque meter cylinder cavity.

The oil is delivered from the GMN-20 main oil pump to the reduction gear system pressure; the main pump is mounted in the front housing.

Through channel (20) in the reduction gear housing and through openings in parts (29, 28, 27, 26), the oil passes from the main pump to circular cavity (25), formed by sleeve (24) and the shaft of planet gear carrier (23); from there the oil is distributed as follows:

(a). through holes (22) in the planet gear carrier, annular groove (2), three recesses (3), and six holes (4), in the countershaft housing [the oil] is supplied for lubricating the roller bearings of the countershaft planet gears. At the same time oil is supplied through six holes in the planet gear carrier to nozzels (21) for lubrication and cooling at the meshing points of the sun gear and countershaft planet gears (6);

(b). with the aid of nozzle (7) in the planet gear carrier shaft for lubricating and cooling the spline coupling of countershaft sun gear (5) and hub (8);

(c). through channel (9) in the plug and through nozzles (15), the oil passes on to lubricate and cool the splined coupling of sun gear (17) and drive shaft (16), and the drive shaft and compressor;

(d). through six bores (10) [the oil passes on] to lubricate planet gear roller bearings (14); and through cavity (18) and nozzles (19) the oil passes on to lubricate the meshing points of sun gear (17) and planet gears (14).

Lubrication of ball bearing (1) is accomplished by a nozzle mounted in sleeve housing (29). The other parts are lubricated and cooled 50X1 the sprayed oil.

Oil for propeller control is delivered by the [propeller] governor through a system of channels in the front housing and in the reduction gear housing.

Oil passes from the governor through three upper channels (11, 12, 13) in the reduction gear housing to sleeve housing (29), and from there through openings parts (28, 27, 26, 30, 31) into the low pitch channels.

The torque pump is supplied from the main engine pump through channels (17, 18, and 23) (Fig. 20) in the reduction gear housing. From the torque meter oil pump oil passes through hole (24) in the reduction gear housing through pivot (25 into tube (4) of the torque meter [illegible] through pivot (5) into the operating cavity of cylinder (7). Through openings (19, 20, 21, 22) oil is carried on to the manometer, which measures the pressure in the operational cavities of the cylinders.

The return oil is [collected?] in the lower portion of the reduction gear housing cavity, from where it passes through a drilled opening into the [illegible] of the housing.

1.4. Supplement for series 02 and 03 engines

In the Series 02 and 03 engines the reduction gear [assembly] contains an automatic transmitter for [propeller] feathering reverse pull [negative torque].

Principle of operation of the transmitter

The automatic negative torque transmitter (Fig. 34) provides the impulse for setting the propeller blades into a feathered position when negative pull torque, exceeding the setting of the transmitter, develops during flight.

The transmitter is actuated by the axial shifting of the propeller shaft caused by the effect of negative torque on the propeller, developing during flight upon failure of the engine or of the propeller control system.

The negative torque shifts the propeller shaft and simultaneously the thrust ball bearing in the direction opposite to the direction of flight. Such shifting is impeded by the combined force of the springs and the pressure of the oil in space "Г" (Fig. 34), developed by cylinder (2) and piston (1) of the trasmitter, which is continuously supplied with oil by the main oil pump.

From space "Γ" the oil passes along groove "A" on the inner surface of the cylinder and along the control channel to the [propeller] governor. Blocking of oil to the control channel or a drop in its pressure to under 2.5 kg/cm^2 indicates an emergency condition of the engine or of the propeller control system. When shifting to the right, piston (1) with packing ring (6) covers groove "A" and blocks the supply of oil to the control channel. At the same time, ring (7) uncovers groove "B" which permits an immediate drop in oil pressure in the control channel. 50X1

Blockage of the oil supply is the control channel is the impulse for the automatic system in the governor, which ensures the setting of the propeller blades in the feathered position and the complete cut-off of the [engine] fuel supply.

The reduction gear is designed with equipment which controls the automatic feathering system by imitating the resulting negative torque on the propeller shaft. For this purpose oil is supplied from the "fixed angle" [full feathering?] channel under the piston (5), mounted in the ball bearing sleeve. Through the effects of the force resulting from the oil pressure, the level of which exceeds the maximum permissible negative torque, piston (5) is shifted to the right as are transmitter ball bearings (4) and piston (1). This also stops the supply of engine oil to the [propeller] control channel. In the course of this, an impulse is provide for setting the propeller, which is indicated by an signal light in the pilot's cabin.

Oil is delivered under piston (5) only during operation of the automatic feathering system. For the entire remaining period the oil supply channel is closed by an electromagnetic vale, located in the oil line from the full feathering channel under piston (5).

Design of the automatic feathering transmitter

The negative torque automatic control transmitter (fig. 35) consists of two basic parts:

-- the transmitter and
-- the control mechanism of the automatic feathering system.

The transmitter has the following main parts:

-- cylinder (19)
-- piston (22)
-- springs mounted in cylinder sleeves (13)
-- packing rings (11) and 12).

Cylinder (19) is made of 38CHA [38 KhA] steel, and together with piston (22) forms the oil cavity of the transmitter as well as a space for mounting the springs.

There are 20 openings on the cylinder flange, with 18 of these used for fastening cylinder mounting bolts to the reduction gear housing and two for passage inserts (10) and (20), connecting cavity "Г" of the cylinder through drilled holes and millings in the reduction gear housing, and in the cylinder itself, through the engine oil line and the control channel to the governor.

The cylinder wall has 18 openings, 15 of which are used for retaining springs (13) and three for guide pins (21), preventing the piston from turning.

The cylinder sleeves have 15 outer and 15 inner springs, mounted in pairs, one inside the other.

The inner spring has a guide (16). The total force of the springs averages 900 kilograms.

Inside the cylinder are two precision-machined cylindrical surfaces for rings (11) and (12). The surface of the smaller opening has three grooves: one of these supplies oil to the regulator transmitter control channel; the others are for drainage of oil from the cylinder when piston (22) shifts to the right.

Piston (22) is made of 38CHA [38KhA] steel. On its outer surface are four grooves, thre for packing rings (11) and (12). and the fourth center groove on the thinner porition [of the plunger] connects cylinder cavity "Г" with the control channel.

The wall of the piston has 15 recesses for springs and three holes for pins which retain the piston in the cylinder.

On the outer diameter the piston has a relief groove.

The apparatus for control of the operation of the automatic pitch control system consists of piston (25), packing spring (7), and 12 springs (26). Three pins (6) prevent the piston from turning.

All of these parts are mounted in front of ball bearing (24) in insert (28). The piston is made of 38 CHA [38 KLA] steel. Together with insert (28) and insert (27) it forms a cavity into which oil flows from propeller feathering channel (1) through a drilled hole in the housing during operation of the transmitter.

The piston has groove for packing ring (7), three holes for pins (6), and 12 holes for springs (26). The springs press the piston against bearing (24) when it shifts simultaneously with the propeller shaft.

Insert (27) is fastened to the wall of bearing insert (28) by bolts and the cylindrical portion is centered in it. 50X1

The surface of the insert has a groove for packing ring (8), preventing the outflow of oil from under piston (25). The oil is supplied under piston (25) from feathering channel (1), through a drilled hole in the housing and bearing insert (28) and through electromagnetic valve (37) which is fastened tothe outer surface of the reduction gear housing and connects with the oil channel through inserts (34) and (36).

The automatic control transmitter for negative torque is set at a reading of $1{,}800^{+180}_{+50}$ kilograms with the oil pressure in the system at 5 kg/cm^2.

In addition to the newly-mounted automatic feathering transmitter mechanism and the control apparatus, the [02 and 03 series] reduction gear has the following differences in design:

The front oil-passage insert (4) is made of magnesium alloy with a drilled hole in the central portion for return oil from the propeller to the engine.

The front end of the insert is located on the same plane as the propeller shaft flange.

Planet gear carrier ball bearing (17) is reduced in size [presumably in comparison to series other than the 02 and 03]. The seating diameters of the planet gear carrier, the bearing insert, and reduction gear partition were made in the same manner.

Ball bearing (17) is mounted with a clearance which permits it to shift freely in an axial direction in relation to the insert. For this reason the tolerance of the stop lug and groove with retaining ring in the insert are nil.

The planet gear carrier is axially secured by flexible rings (30) and (31), mounted in annular grooves on the planet gear carrier grooving. Permissible shift of the propeller shaft in relation to the planet gear case is 0.0 to 0.2 millimeters and is secured by a spacer washer (29).

The IKM pump drive gear (18) is fastened with bolts to the flange of the countershaft hub instead of being splined on the grooves of the propeller shaft.

Oil is supplied to reduction gear ball bearing (24) through hole (32) in the propeller shaft and through a recess in bearing space washer (5).

50X1

On the outer surface of the reduction gear housing is a flange for mounting electromagnetic valve (37) for automatic feathering control. The following supplementary channels are built into the reduction gear housing:

(a). For supply of oil (23) from the engine oil ine into the cavity of the automatic control transmitter for negative torque;

(b). For scanvenging oil (9) from the transmitter cavity through the front housing to the housing;

(c). For supply of oil (35) from the full feather channel to the electromagnetic valve of the automatic feathering control mechanism;

(d). For scavenging oil (33) from the electromegnetic valve under the control plunger.

2. FRONT HOUSING

The front housing (Fig. 39 and 40) is located between the reduction gear and the compresser, and serves as the mounting for engine accessories, accessory drives, front mounting bolts, compressor bearing inlet guide vanes and forms the air intake channel of the engine.

The front housing group consists of the following parts:

-- front housing (1), which contains all the parts of the drive;
-- propeller brake (2);
-- main gear (8);
-- drive housing (10).

The front housing contains the following accessory drives (Fig. 41 and 43):

(a). Propeller brake drive, [propeller] governor, and centrifugal deaerator, consisting of bevel gear (4) (Fig. 41) and horizontal Shaft (2), mounted in two ball bearings. At the same time the drive is connected, by means of the grooves (1) to the propeller brake shaft. Bevel drive gear (3) is engaged in the centrifugal deaerator gear, and splined shaft (5) transmits the rotating motion to the governor;

(b). Drive housing drive, consisting of bevel gear (6) and gear (8) with shaft, mounted on two ball bearings. The motion is transmitted by splined shaft (9). From the gear and shaft (10) motion is tramsitted to the main oil pump through splined shaft (7);

50X1

(c). Two drives to the starter-generator consisting of drive gear (14) (Fig. 42), intermediate gears (13) mounted on two ball bearings, and splined shaft (11);

(d). From the drive to the scavenge oil pump, composed of intermediate gear (21) (Fig. 43), gear (29), mounted on ball bearings, and splined shaft (19);

(e). From the drive to the oil separator and the oil supply pump, which consists of intermediate gear (18) and gear (17), mounted in ball bearings. Splined shaft (25) transmits motion to the separator, and by splined shaft (26), to the oil supply pump;

(f). From the drive to the alternating current generator which consists of two intermediate gears (22) and gear (23), mounted on two ball bearings, and generator drive couplings (24).

2.1 Schematic of the front housing drive

The schematic of the front housing drive is on Fig. 44. From the turbine rotor, rotating counterclockwise, motion is transmitted through the compressor rotor to drive shaft (1) and on to the reduction gear and the drives in the front housing.

Motion is transmitted to the reduction gear through reduction drive gear (28), splined to the drive shaft.

From the drive gear of the main drive, the transmission is divided to two [locations]:

(a). To the accessories located in the upper portion of the front housing: through upper drive bevel gear (3) of the main drive and gear and shaft (4) to bevel gear (5), located on the splines of the right end of upper horizontal shaft (6) which turns clockwise.

Inside upper horizontal shaft (6) is the drive, connected to the shaft andthe propeller governor by means of splines (drive I, turns to the left). On the central section of shaft (6) is the bevel drive gear of centrifugal de-aerator (7), which is engaged in the centrifugal de-aerator shaft drive gear (drive II. rotates to the right).

On the left end of upper horizontal shaft (6) is mounted bevel drive gear (9) of the starter-generator drive; engaged in these is intermediate starter-generator drive gear (10), rotating on fixed journals (11) and trasmitting rotating motion to the starter-generator drive gears and shafts (12). Inset within these gears are splined shaft of the starter-generator drives (drive III. rotates to the left).

The left end of upper horizontal shaft (6) constitutes the propeller brake drive (drive IV. rotates to the left);

50X1

(b). To the accessories located in the lower portion of the front housing and particularly; through the lower driven bevel gear of main drive (3), connected to gear shaft (13), to bevel gear (14).

Bevel gear (14) is mounted on the end of lower horizontal gear (15) and turns it clockwise. To the right of gear shaft (15), through two intermediate gears (16), rotating on fixed journals, motion is transmitted to gear (17), which constitute the drive for the alternating current generator (drive V. turns to the right).

To the left from the lower horizontal gear shaft (15), through intermediate gear (16), motion is transmitted to gear (18), inside which fits the drive cone [bevel gear?] of the oil scavenge pump from the rear compressor bearing and the turbine bearing and the turbine bearing (drive VI. rotates to the left).

Engaged in gear (18) is another intermediate gear (16), from which the motion is transmitted to gear (19), which has [inside?] splines on the ends of its center hole, and from it [the motion is] transmitted through transmission shafts to the accessories; from the rear end to the centrifugal separator (drive VII. turns to the left), and from the front end to the oil delivery pump (drive VIII. rotates to the right).

From lower horizontal gear shaft (15), through the drive housing shaft, dual drive housing gear (20) turns, with the left large ring [gear?] which is engaged in gear (21) of the drive of the main fuel pump (drive XI. turns to the right).

Engaged in the small right ring [gear?] from the left side is gear (22) of the fuel delivery pump (drive X, rotates to right) and from the right side, dual gear (23) [is engaged].

From the left large ring [gear] of the same gear motion is transmitted to gear (24) of the scavenge oil pump for the drive housing (drive XI. rotates to the right) and from the right small ring, through intermediate gear (25) to tachometer transmitter gear (26) (drive XII. rotates to right).

The center hole of dual gear (23) of the hydraulic pump has [inside] splines into which is fitted the hydraulic pump drive shaft (drive XIII. rotates to the right).

The hole of main gear (20) of the drive housing has splines, into which is fitted the KTA drive shaft, which transmits rotating motion to the KTA (drive XIV. rotates to the left). From the lower perpendicular shaft of gear (13), through the oil pump drive shaft, motion is transmitted to the main oil pump (drive XV. rotates to the left).

2.2. Design of the front housing

The front housing (Fig. 45, 46) is cast of ML5 magnesium alloy and has the shape of two truncated cones: inner (28) and outer (24), inter-connected by six ribs (9) (Fig. 45). 50X1

Between the inner and outer cones there is created an intake suction channel of the engine, divided into six sections (10) by ribs along its periphery. The upper and lower portions of the outer cone have lugs with flanges for mounting the accessories.

The drives are mounted to the accessories in the center cavity of the front housing, in the spaces of the perpedicular ribs and lugs.

Both cones have flanges on their forward ends:

-- from the front - [flanges] for mounting the reduction gear and the air filter (lapac),

-- from the rear - for mounting the compressor and the inlet guide vanes.

On the front end of outer cone (24) is the flange (8) with twelve holes for mounting the air filter, and on the forward end of inner cone (28) is a flange (1) with a central recess and thirty bolts for mounting the reduction gear to the front housing.

On this flange are:

-- oil supply holes for the propeller governor and the propeller;
-- oil drain holes (21 and 23) from the reduction gear to the front housing;
-- opening (22) for supply of oil from the main oil pump for lubrication and cooling of reduction gear components and also for supply of the torque meter pump;
-- opening (29) for supply of oil from the operating spaces of the torque meter cylinders to the pressure meter and transmitter for automatic pitch control;
-- opening (27) of the sleeve for the electrical cable for de-icing propeller blades.

Into all oil openings (except drain holes) there are inset adapter sleeves with rubber rings for sealing the oil channels.

In the central portion of the inner done there are two recesses for the front housing main drive with flanges with nine bolts (25) for mounting the main drive. In the lower portion of the front end of the flange there is a pin for securing the drive in the specified position. The front housing has an annular groove, covered by ring (26), for passage of heated oil from the right side ribs into the left.

From the front, on the upper housing projection, there are three flanges: the center one (6) for mounting the propeller brake and 50X1 flanking flanges (5) for the pivots of the intermediate gears of the starter-generator drives. Under the flanges is mounted a nozzle [sensor?] for measuring pressure in the sharp pitch channel.

In the upper portion of the box-like projection there is a flange (18) for mounting the oil delivery pump and hole (20) for mounting a drain cock for oil from the front housing [sic, located in lower projection on housing].

On the side walls of the outer housing there is also a number of lugs for mounting accessories and fastening engine components. There are, namely:

-- both flanges for fastening the engine mounts (45) (Fig. 46); and (16) (Fig 45);

-- on the front forward end of the outher cone, opposite the upper and lower diagonal ribs, there are flanges (11) (Fig. 45) and (44) (Fig. 46) with openings in the center for mounting tubing for passage of oil from the suction stage of the main oil pump to the centrifugal separator, through drilled openings in the ribs;

-- on the left side of the outer cone, opposite the upper diagonal rib, there is flange (12) (Fig. 45) for mounting the automatic pitch control transmitter.

The automatic feathering transmitter is supplied with oil from the torque meter piston, mounted in the reduction gear, through special opening (29) in the rib of the front housing. There is a nozzle on the transmitter housing to which is fastened the torque meter oil pressure meter.

The de-aeration tube, connecting cavity of the front housing with the special aircraft engine de-aeration tank through an opening in the rib, is mounted simultaneously with the transmitter.

Under the de-aeration [de-aerator?] on flange (15) is mounted an icing warning indicator. The flange has holes opening into the inlet channel of the front housing.

At lower left in the front housing are threaded holes for connecting the air removal tube from the "termopatron" of the KTA assembly. Through this hole ~~[and]~~ passes the end of the tube, which is bent into the air stream in the inlet channel.

On the upper part of lower box-like projection is flange (17) for mounting the oil scavenge line from the side ribs to the centrifugal separator. 50X1

Opposite the left upper diagonal rib a nozzle is mounted from the rear end of the flange to supply air to the labyrinth seal of the front compressor bearing. The air proceeds through the line from the nozzle behind Stage V. of the compressor.

On the rear end of the outer cone is flange (62) (Fig. 46) with a centering seat and thirty bolts for mounting the compressor housing. Inside the cone is a recess for mounting the compressor inlet guide vanes. On the front end of the the inner cone there is a similar flange with a center recess for mounting steel sleeve (59) for the front compressor roller bearing. The sleeve of the front compressor bearing is fastened to the front housing flange with three bolts (61). On the front end of the flange are eleven bolts (60) for mounting the inlet guide vanes and for tightening the bearing sleeve.

Opposite the upper rib on both flanges are pins (63) for securing the compressor inlet guide vanes and the front bearing sleeve in the proper angle.

The upper box-like projection in the rear has three flanges:

(a). Center (30) for fastening the propeller governor. On the flange are six holes: left lower (31) for oil supply from the main oil pump to the propeller governor; pump governor oil scavenge hole (32); oil passage hole (34) to the low pitch setting channel; oil passage hole (37) for pitch control; oil passage hole (36) to the "fixed" [full-feathering setting channel; and oil passage hole (38) for the high pitch setting channel.

The system of channels is designed with the aid of a special insert pressed into the flange recess and secure by threaded stop (35). In the center of the insert is hole (33) for centering the governor and coupling the drive shaft to the engine drive. At the upper right is oil fitting (39) from the feathering pump to the governor.

Under the flange are three nozzles -- the center nozzle for attaching the oil supply tube for lubrication of the turbine and compressor bearings; the left (65), for measuring pressure of oil in the low pitch channel; the right (66), for measuring pressure in the "fixed" pitch setting channel.

(b). Two starter-generator mounting flanges (40). The starter-generators are attached by quick-disassembly holders drawn together by bolts. The beveled grooves of each holder draws together the adapter flanges of the generator and the front housing flanges, in the course of which the adapter flange of the generator drive is fastened with b 50X1 to the front housing and the generator flange is bolted to the fro housing flange.

The lower box-like projection of the front housing has flanges located in the rear for attaching the following accessories:

-- on flange 57 (Fig. 64) is the air separator on [fastened by] nine bolts. Openings have been cast in the flange to permit oil to enter the separator. To lubricate parts of the separator, oil passes through holes (56); two holes (58) are service openings;

-- on the flanges (50) three bolts fasten the covers of the intermediate gear shaft covers. The covers have a lug for securing the shafts;

-- flange (54) with eight bolts is for mounting the adapter unit of the scavenge pump. The flange has a recess in the center for centering the adapter unit.

-- on the right side of the box-like projection is flange (48), to which is fastened the alternating current generator. Mounting on the steel adapter unit is by means of a quick-disassembly holder, just as in the case of the starter-generator. A rubber cup, pressed in the adapter unit, prevents seepage of oil from the drive into the generator and [also prevents] drainage from fitting (67). Above flange (48) is fitting (46) for drainage of oil from the air passage behind compressor stages V. and VIII;

-- in the central portion of the lower projection there is flange (53) with a central recess and ten bolts for fastening the drive housing to the front housing;

-- on the lower wall of the lug there is flange (52) with a center recess and bolts for mounting the main oil pump. From the right side, the flange of the main oil pump has a threaded oil fitting (51) to the KTA fuel control assembly;

-- on the right side of the outer cone of the housing there is a hole opposite the upper diagonal rib of the front flange; this hole is for electrical leads for heating the propeller. Adapter unit (43) for mounting the plug connector for the electrical lead is mounted on the flange; beside it is the second flange (42) with a hole which is connected to the inner space of the front housing.

Fastened on the flange is the tubing of the valve for the releasing fire-extinguishing substance into the front housing. The upper diagonal ribs have service openings (14) (Fig. 45) and (41) and (Fig. 46). The openings have covers. The cover mounting bolts have angle plates for fastening plug connectors of the electrical lead;

-- at lower right, on the outer cone, there is a specially cast flange for fastening the transmitter for over-all air pressure passing to the engine; the transmitter gauge extends into the engine's inlet channel. For protection against icing, the filter portion of the transmitter and the air tube from the [?] of the fuel control assembly are heated by air brought to them by a special tube; 50X1

-- in the lower projection are two chambers (49) for mounting of the oil filters. Above the filters is a flange witha hole for mounting the oil pressure transmitter at its entry into the engine;

-- on the upper left diagonal rib and right lower [rib] are flanges (13) (Fig. 45) and (47) (Fig. 46) for mounting the air supply tube from the space behind the compressor for heating the compressor inlet guide vanes.

2.3. Central drive

The central drive (Fig. 47) consists of housing (1) and three bevel gears mounted in it: bevel drive gear (2), engaged in two driven bevel gears; the upper (3) and the lower (4).

Drive gear (2), mounted in the housing in one bearing, has inner splines connecting with the reduction gear drive shaft. Upper driven bevel gear (3) is mounted in two bearings and its end has inner splines for connecting with the gear of the gear of the perpendicular shaft of the upper drives.

Lower driven bevel gear (4) is mounted in two bearings like the upper one, and likewise has inner splines for connection with the gear shaft of the lower drives. Central drive housing (1) is cast of AL 4 alloy, and is shaped like a truncated cone with two flanges on the forward ends.

On the end of the housing withthe smaller diameter there is a recess with flange (5) and eight bolts for mounting the flange of the drive gear bearing sleeve.

Flange (6), with nine holes for bolts and with one hole for a pin, is employed for fastening the housing to the circular flange of the center recess of the front housing. The following cylindrical surfaces are located on the housing for mounting in the front housing: surface (7) in the case of the larger and two surfaces (8) in the case of the smaller diameter.

Between the two cylindrical surfaces (8) are annular grooves (9) for passage of oil from the main oil pump to the governor and for lubrication of the upper drives. On the sides of groove (9) are two rubber seal rings (10), mounted in an annular recess.

The bevel drive gear bearings and front compressor bearings are lubricated by nozzles in the bearing enclosures [cages?], connected by holes drilled in the walls of the housing with annular groove (9). A hole is drilled from this groove, and through this hole flows oil for lubrication of the teeth of the bevel gear of the main drive.

On the side surface of the housing are four cut-outs (11) for the passage of the ring of the driven bevel gears.

2.4. Drive housing

The drive housing (Fig. 48) consists of cast housing (1) and cover (2), and a complex of gears and shafts mounted on ball bearings. Both parts of the housing are mutally centered by pins (3) and are tightened together by twenty bolts and nuts. The housing has the following drives:

-- drive to the KTA fuel control assembly, consisting of splined welded shaft (4), connected with two rims of gear (5); the housing with the drive shaft of the fuel control assembly; and tubular shield (6) with rubber seal rings on the ends;

-- fuel delivery pump drive, consisting of gear (7), driven by the small rim of gear (5);

-- main fuel pump drive consisting of gear (8) driven by the large rim of gear (5);

-- hydraulic pump drive, consisting of gear (11), having two rims and driven by the small rim of gear (5).

From the small rim of gear (11) the hydraulic pump drive leads to the tachometer transmitter, consisting of a complex of gears: intermediate gear (12), driven gear (13) mounted on two bearings, located in special steel housing (14). The transmitter shaft is sealed by a cup. The transmitter is mounted to housing (14) by means of a shifting [adjustment?] nut, which is a part of the transmitter.

The drive of the oil scavenge pump, consisting of gear (15) is driven by the large rim of hydraulic pump drive gear (11).

2.4.1. Drive housing

50X1

The drive housing is cast from ML5 magnesium alloy. Its front portion is fastened to the front housing by bolts passing through holes (1) (Fig. 49). To ensure alignment of the central gear of the housing drive and the lower horizontal shaft of the front housing, the front housing has lug (10) (Fig. 50) on the outer side of the housing wall. On the same wall, from the inside, there are two holes (Fig. 49), into which are fitted the stops of the front intermediate gear shafts.

In the center of the housing, in the mounting hole, insert (3) of the central housing drive gear is pressed. In the lower portion of the housing, insert (4) of the main fuel pump drive gear is pressed. Mounted in the right of center recess (3) is pressed insert (6) is fastened to the housing by two bolts and nuts.

For de-aeration of the drive housing into the front housing, there is a hole (11) (Fig. 50) in the housing wall.

For correct assembly there are two pins (7) (Fig. 49) located in the wall of the housing.

Nineteen bolts (8) are distributed along the periphery [of the housing] for fastening the cover to the housing.

Oil from the housing cavity is drawn out by a pump; for this purpose (12) (Fig. 50) is in the wall of the housing, beginning in the lower portion and ending in hole (13) in the wall to the cavity of the lower box-like projection of the front housing.

Nozzles (9) (Fig. 49) lubricated the gears of the drive housing; the nozzle is in the wall of the housing and serves as the terminal of a channel connected with the channel of the lower box-like projection of the front housing.

2.4.2. Drive housing cover (Fig. 51 and 52)

The cover is cast of ML5 magnesium alloy, and its shape resembles that of the housing. From the inside of the cover through a mounting hole in the center is pressed insert (7) (Fig. 52) of the central gear bearing; from the outer side it [the cover] has flange (1) (Fig. 51), which serves as a support for the ring of the KTA drive shaft shield.

On the left of the central recess is hole (6) with a square flange and four bolts for fastening the fuel delivery pump. In the hole, from the outer side, there is pressed an insert for the drive gear bearing.

Under the central recess is flange (5) with a hole and four b 50X1 for mounting the main fuel pump. From the inside, there is pressed into the hole, insert (11) (Fig. 52) for the drive gear bearing.

To the right of the central recess is flange (4) (Fig. 51) with a hole and four bolts for mounting the hydraulic pump. In the hole, from the outer side of the cover, there is mounted insert (12) (Fig. 52) for the drive bearing. Above flange (4) (Fig. 51), the intermediate gear of the tachometer transmitter drive is mounted in mounting hole (2) by means of the triangular flange and three bolts.

At the upper right end, the tachometer transmitter drive housing is mounted with five bolts. Nineteen holes (13) (Fig. 52) in special projections along the edge of the cover are used for fastening the cover to the housing; two holes (10) for the centering pin and three holes (9) with steel inserts for bolts, used in removing the cover from the housing at disassembly, are also on the edge of the cover. Inserts (11) and (7) are mounted on the cover by means of two nuts and bolts.

2.5. Propeller brake

The propeller brake (Fig. 53) is basically a single-disc friction coupling, preventing windmilling of the propeller (and all turning parts of the engine) as result of the torque developing on the propeller blades through the effects of the wind when the aircraft is parked.

The main parts of the propeller brake are: shaft (13); movable disc (16); steel housing (10); the movable tensioning apparatus consisting of plate (5) with solid disc (7) and a complex of springs (4); housing (3); transmission cover (2); and the brake control mechanism containing the shaft (18), brake switch, driven gear sector, and drive [gear] sector (20).

Brake shaft (13) is mounted in ball bearing (15) in the brake housing, and its splined end is connected to the upper horizontal shaft of the front housing. Movable disc (16) is mounted on splines on the opposite end of the brake shaft.

Operation of the brake is based on dry friction because its area is sealed against oil seepage by rubber cup (12). On the friction surfaces of discs (16) is pressed a metalloceramic facing with a high friction coefficient, wear resistance, and with good seating characteristics of the friction surfaces.

To prevent needless wear of the movable disc through friction with non-moving parts during operation of the engine, the brake has built-in equipment, permitting retention of the movable disc in a central position between the non-moving parts. This equipment consists of flange

(8) which is firmly connected to movable disc (16); solid stop sleeve (17); regulating sleeve (11), the movement of which is restricted by the thrust ring (9); and spring (14), which is in sleeve (11). 50X1

Braking occurs when disc (16) is compressed between the non-moving details [parts]; gide (8) pushes away regulating sleeve (11) toward the rear, eliminating clearances M and N.

The pressure mechanism is prevented from turning by the brake housing (10) by grooves (6). Longitudinal shifting of the pressure mechanism and engagement and disengagement of the brake is provided by shaft (18), hub (5), and solid disc (7).

The tension element of the pressure mechanism, consisting of the system of springs (4), under tension between hub (5) and disc (7) provides a constant and precisely limited pressure on movable disc (16). In this manner the possibility of deforming the movable disc at engagement of the brake is eliminated.

The brake is engaged at the time of parking of the aircraft and is disengaged before starting the engine by the MZK-2 electrical mechanism, mounted on adapter unit (2) of the brake cover.

Torque from the MZK-2 electrical mechanism is transmitted to brake shaft (13) by two gear sectors: drive [gear sector] (20) and driven [gear sector] (19), the extreme positions of which are fixed by set screws (22). These ensure constant setting of the brake during exchange of the electrical mechanism during operation. Retention of the brake in the engaged position is ensured by the self-locking feature of the MZK-2 electrical mechanism.

Adjustment of the propeller brake to the desired degree of friction is ensured by adjusting compression of springs (4) of spacer washers (1), clearances M and N, and setting the angle of engagement within a specified range. Clearances M and N are checked at the time of mounting the brake on the engine by simultaneous insertion of two gauges through the control opening which is closed by a cover.

2.6. Front housing oil system

Oil is supplied to the front housing for cooling and lubrication of the components both under pressure and by spraying.

Engine oil system channels are bored into the ribs of the special lugs of the front housing.

Mounted on the front housing are four oil pumps: the main [50X1 pump] (7) (Fig. 39) and the pressure oil pump (5); then, pump (11) (Fig. 40) which draws oil from the rear and center bearing, and pump (10) which draws oil from the drive housing.

Oil passes from the pressure stage of the main oil pump, located on the lower projection of the front housing, to two screen filters (9).

From the forward filter the oil passes through the channel for lubrication and cooling of the reduction gear components. Oil goes from the rear filter to the main front housing line, from where it proceeds to the governor and for lubrication of rotating components as follows:

-- to the propeller governor through hole (31) (Fig. 46), from the front housing distribution sleeve; from the governor through holes 34, 26, and 38 in the sleeve and then through the forward housing channels to the propeller;

-- through nozzle (64) and outer tubing to the bearings located in the combusion chamber;

-- through fitting (51) and an outer line to the KTA fuel control assembly;

-- to the flange of the remote pressure measurement [device] at the engine inlet located on the filter);

-- to the nozzles (65) and (66) for measurement of pressure in the high pitch and "fixed" pitch setting channel; and also to nozzle (3) (Fig. 39) for measurement of pressure in the high pitch setting channel.

-- for lubrication and cooling of rotating components of the drive, by means of nozzles; for lubrication of the central drive gear bearings, two nozzles with diameter of one millimeter; for lubrication of the compressor rotor roller bearing, one nozzle with 1.2 millimeter diameter; for lubrication of the teeth of thecentral drive bevel gears, one nozzle with onemillimeter diameter; for lubrication of starter-generator drive bearings, tow nozzles with diameter of 0.8 millimeters; for lubrication of drive housing gears, one nozzle with one millimeter diameter.

To extension (39) (Fig. 46) is connected the line for the feathering [?] pump.

The return oil is collected in the lower housing projection. Oil from the reduction gear, the drives, governor, oil from the centrifugal deaerator, oil drawn from the drive housing, and return oil from the bleed valves of the compressor collect in this projection.

50X1

The return oil is drawn fromthe front housing by suction stage of the main oil pump, and by means of outer line (12) (Fig. 40) the oil is supplied to the right diagonal ribs of the front housing. Further, oil comes through channels of the diagonal ribs and through the annular channel into the left diagonal ribs, from there through outer line (4) (Fig. 39) it comes to separator (13). The oil drawn from the bearings of the combusion chamber housing also goes to line (4).

Oil passes through the ribs to heat them. The upper and lower ribs are heated by oil going to the propeller and the reduction gear.

On the left lower side of the front housing is a cock (6) (Fig. 39) for draining oil from the housing.

The drive housing gears are lubricated by oil supplied by nozzle (9) (Fig. 49) in the housing wall, connected by hole (14) (Fig. 50) to the main oil channel of the forward housing, and also by the oil sprayed on the shield of the drive shaft of the fuel control assembly and partially coming through the central gear bearing from the front housing cavity. From the drive housing the oil is drawn off into the front housing through hole (13) (Fig. 50) by the scavenge pump, mounted in hole (5) (Fig. 49).

3. COMPRESSOR

3.1 General data

The compressor (Fig 54, 55, 56) is of the axial, 10-stage type, designed to compress and force air into the engine's combustion chamber.

The compressed and heated air very effectively causes rapid combustion of a large quantity of fuel in the small spaces of the burners.

At an average speed of 278 meters per second on the ground, the adiabatic efficiency of the compressor is 0.845.

The passage channel's constant outer diameter between the first and tenth stages is 433-433.4 millimeters, and the inner diameter of the channel is reduced from the first to the tenth stages.

The outer diameter of the first and second stages is reduced to the diameter of the third stage, the diameter of the first stage is 447.92+0.2 millimeters.

The compressor is subsonic. To reduce the relative speed of entry of air into Stage I blades of the compressor, the stream of air to the compressor is deflected by the inlet guide vane assembly (1) (Fig 54), mounted on the inlet of the compessor in the front housing cavity at the end of the inlet channel.

The vanes of the inlet guide assembly are set at the most suitable angle of intake to the blades of Stage I of the compressor.

The apparatus which brings air into the compressor, located in the forward housing, is basically a channel divided by six shaped ribs.

To ensure normal operation of the compressor on modes of up to 11,200 rpm, the engine provides for release [bleeding] of air behind Stages V and VIII of the compressor.

Bleeding air ensures the compressor's shift to the calculated mode without the impact resulting from the increase in the volume of air passage through the first and middle stages of the compressor. The bleeding of air takes the first and middle stages of the compressor from the zone of unstable performance and increases their level of compression and efficiency.

In this manner, air bleeding eliminates surging at the lower and calculated revolutions and makes it possible for the mutual operation of the stages to be in better relation, which leads to an increase in over-all compression and adiabatic efficiency of the compressor in calculated modes, expands the operating area of the compressor, and substantially eases starting and initial acceleration of the engine.

3.2 Compressor design

The compressor consists of rotor (2) (Fig 54), housing (3) with the stator and rotor of the inlet guide assembly (1) and air bleed valves (5) and (6).

The compressor housing is fastened by its flanges to the rear flange of the forward housing and to the forward flange of the compression chamber housing.

On the compressor housing (50) are mounted the rear engine mountings (3) and (8) (Fig ?).

To attain the high compressor efficiency, the radial clearance of the ends of the rotor blades and the clearance in the labyrinth seals of the stators are reduced. At the same time, contact is permitted between the "engine" [rotor?] blades and the labyrinth ridges of the rotor with the [compressor?] casting and the labyrinth rings of the stators, that are covered with soft material.

The mounting clearances on the ends of the rotor blades and in the labyrinth seal of the stators are indicated in the following table:

	I	II	III	IV	V	VI	VII	VIII	IX	X
Radial clearance at ends of rotor blades	0.4÷0.75		0.5÷0.65			0.6÷0.75				
Radial clearance in the labyrinth seal of stators	0.178÷0.273	0	0.25÷0.358			0.35÷0.458				

3.2.1 Compressor rotor

The compressor rotor (Fig 55 and 56) consists of 10 discs, on the rims of which are mounted blades; the rear compressor rotor shaft; and the baffle seals of the front and rear bearing.

The rotor is mounted in two bearings. The front bearing (7) (Fig 55) is of the roller type and supports the radial load and permits the axial shift of the rotor as a result of heat expansion and deformation due to axial forces.

Rear bearing (25) is of the ball, radial-axial type, supporting the radial and axial loads and retains the rotor in the axial direction.

The rotor is driven by the turbine. The mechanical energy used by the rotor is utilized for increasing the pressure and tempera 50X1 of the air and for driving air through the compressor.

The torque of the turbine is transmitted through the splines of the rear shaft and the discs of the compressor rotor. Pins, mounted radially in the disc grooves under the blades, transmit the torque from one disc to another.

The part of the mechanical energy which drives the propeller and the engine accessories is transmitted to the reduction gear splined drive shaft by the inner grooves [in the journal] of the front disc of the compressor rotor. At starting, the reduction gear drive shaft transmits the torque to the engine rotor.

The inner cavities of the discs are interconnected by openings in the disc walls. Air is supplied to the inner cavity of the compressor rotor through four holes on the cylindrical surface of the Stage IV disc from the compressor's [air] passage channel. In this manner the same pressure is provided in the entire rotor cavity, and the axial load on the disc partition is eliminated.

The discs, the rear shaft, and rotor blades of the compressor are made of CH17N2 [Kh17N2] stainless steel.

The disc of Stage I (11) (Fig 57, 58) has a journal at the front end; on the machined outer surface the following are mounted:

Baffle seal ring (22);

Baffle seal sleeve (20);

Spacer ring (19), setting one millimeter insertion of the inner ring of the roller bearing, bearing compressor, in relation to the outer [ring];

Roller bearings (4)

Nut (12) is screwed into the threads of the Stage I disc, tightening together the forementioned components to a torque of 30 ± 3 kilograms. Nut (12) is secured by lock (13), the lugs of which fit into the grooves on the journal and are bent across the edge of the bolt. To prevent shearing off of the lock lugs in tightening the nut, there is a thrust ring (14) between the nut and the lock.

Ring (22) and the baffle seal sleeve (20), thrust ring (14), and spacer ring (19) are made of 38 CHA [38KhA] steel; lock (13) is made of 1CH18N9T [1Kh18N9T] steels. 50X1

The baffle seal sleeve and the baffle seal ring, together with the aluminum-asbestos grafite surfaces of sleeve (23), prevent seepage of oil from the roller bearing cavity to the compressor.

On the inner surface of the Stage I disc journal are grooves for coupling with the splines of reduction gear drive shaft (5). In the inner cavity of the Stage I disc journal, lock housing (10) made of 38CHA [38KhA] steel, is pressed onto and secured to the groove stop. Inside the housing, steel pin (25) is pressed, serving as a guide for spring (8) of the splined coupling lock of the Stage I disc with reduction gear drive shaft (5).

The lock housing serves as a blind flange, preventing seepage of oil into the compressor rotor cavity.

The rear end of the reduction gear drive shaft is inserted into the splines of the Stage I disc to the stop on the front end of spacer ring (21) and is fixed in the axial direction by plug (9), screwed into lock housing (10).

Between the face side of the plug and the body of the lock is a regulator ring (6), securing the longitudinal clearance of the reducer drive gear to a tolerance of 0.2 to 0.4 millimeters.

If the clearance is not maintained, the face side of the plug rests against the face side of the reduction [gear assembly] drive shaft bushing. The plug is secured by sleeve (7) and spring (8). The securing sleeve has two outer hexagonal configurations, which fits into the hexagonal openings of the plug and the body of the lock.

In screwing in the plug, the securing sleeve is pressed aside by a special key. The securing sleeve is pressed into a working position by the spring, which is guided by pin (25) of lock assembly (10).

The regulator ring, plug and securing sleeve are made of type 38CHA [38KhA] steel, the spring of OVS steel.

The design of the discs on the II - IX stages of the compressor (Fig 59) is of disc and drum construction: the thin-walled disc with a rim for fastening the blades transforms it in its axial part to a thin-walled sleeve with labyrinth ridges and cylindrical surfaces serving to interconnect the discs.

On the cylindrical drum part of the discs of stages I - IX a 50X1 e rear shaft of the compressor, are four rolls of circular ridges, which move over an aluminum-graphite layer deposited on the seal ring of the stators, making up the baffle seal, which reduce the leakage of air between the stages of the compressor and increase the effectiveness of the compressor.

The discs of all stages and the rear shaft of the compressor are joined on cylindrical surfaces pressed together and secured by pins. The pins are made of CH17N2 [Kh17N2] stainless steel.

The discs of the rotor compressor are pressed onto each other with a shrinkage tolerances of from 0.095 millimeters (for stage I) to 0.4 millimeters (for stage X). Prior to being pressed on, the overlapping discs are heated to 180° - 200° centigrade, and the disc pressed onto the rear shaft is heated to 250° centigrade.

The selected tolerances assure mutual centering of the discs of the entire compressor during engine operation.

Radial openings are drilled at all discs connections for pins pressed in to secure the discs and to transmit torque. The pins are placed into position with a shrinkage tolerances ranging from 0.002 to 0.023 millimeters.

The rotor blades (Fig 60) of the discs of all stages of the compressor are secured by locks (Fig 61). The slots in the discs are elongated.

All discs and the rear shaft of the compressor are machined, statically balanced, and the assembled rotor is balanced dynamically to an accuracy of 5 gram/centimeters. The rotor is balanced by removing metal from areas (11) and (20) (Fig 55) of the front and rear compressor shaft. The compressor rotor is balanced dynamically in its bearings.

Compressor rotor blades (15) consist of the blade proper and root. The blade proper is made with great precision and with a high degree of surface finishs. The leading and trailing edges of the blade proper and of the transitional part of the blade leading to the root, are polished.

The number of blades on the individual stages is as follows: stage I; 25; stage II, 23; stage III, 31; stage IV, 45; stages V, Vi, VII, 53; and stages VIII, IX, X, 51.

The rotor blades of stages I - VII are secured at the front against longitudinal movement by locking pins (12) and at the back by pins (14), which are pressed into the openings in the discs with a tolerance of 0,023 - 0.002 millimeters.

The rotor blades of stages VIII and IX differ from the other stages in that they are secured at the front by pins (28), which secure the discs of stages VII and VIII, VIII and IX, and by locking pins (16) at the back. The locking pins securing the blades are bent on one end toward the face side of the blade, and the other end, in stages II - VII, they are placed into the openings of the pins which secure the compressor discs; on stages I, VII - IX they fit into the openings drilled into the discs under the blades. 50X1

The blades of stage X are secured on both sides by locking pins (17), which are made like little places, with their ends fittings into the openings located along the periphery of the disc. The ends of the locking pins are bent toward the face side of the blade.

The blade locking pins on all stages of the compressor are placed into the slots with tolerances of 0 + 0.02 millimeters. Seating the blades with a tolerance of 0 + 0.02 millimeters is secured by milling or grinding the lower part of the blade.

The pins are made of type CH17N2 [Kh17N2] steel, and the locking pins of type [1Kh18N9T] 1CH18N9T steel.

Rear shaft (19) of the compressor (Fig 55) is a [very slightly] cone-shaped disc, which terminates in the center part into a cylindrical tube. The outer surface is a thin-walled tube with ridges for the labyrinth [baffle] seal. The surface of the cylindrical tube is precision machined and seated upon it are the following: baffle seal bushing (4) (Fig 62), regulator ring (10), oil slinger (11), ball bearing (7). The regulator ring serves to adjust the tolerance between the rotor compressor discs and the inner rings of the stator blades.

Behind these components is a thread for nut (9) fastening ball bearing (7) and grooves for coupling the turbine shaft. Nut (9) is tightened to a torque of 80 + 100 kilogram meters.

Located inside the rear compressor shaft [tube] are the following: threads for coupling member (8) (Fig 63) connecting the shafts of the turbine and compressor, grooves for sleeve (7), locking coupling bolt, cylindrical recess for the seating and locking [?] of the guide pin (5), which is also a "blind" [cap ?] of the compressor's rear shaft. The guide pin is made of type 1CH18N9T [1Kh18N9T] steel. The baffle seal bushing, regulator ring, oil slinger, nut, and locking sleeve are made of type 38CHA [38KhA] steel.

Baffle seal bushing (3) (Fig 62) is fastened to the tapered end of the rotor's rear shaft by six bolts; it is made of type CH17N2 [Kh17N2] steel and is seated, together with baffle seal bushing (4), on the rear shaft of the compressor. Its annular ridges turn on an aluminum-graphite deposit on the surface of baffle seal bushing (6) of the combustion chamber casing. This seal reduces air leakage from the area behin 50X1 compressor into the oil area of the combustion chamber and thus reduces the axial force of the rotor compressor resulting from the air pressure behind the compressor.

The outer splines of the compressor's rear shaft engage the splines of the turbine shaft and transmit torque of the turbine to the compressor rotor.

The rear end of the compressor shaft is connected with the turbine shaft by threaded coupling member (8) (Fig 63), made of type 45 steel. The dowel pin [of the threaded coupling member] is screwed into the threaded orifice at the rear end of the compressor shaft and its face side, passing through thrust bushing (9), rests against the turbine shaft.

The thrust bushing is splined to the turbine shaft and is clamped between the turbine shaft and the end of the compressor shaft.

Spacer sleeve (4) is fitted over the outer spline of the rear of the compressor] shaft, and its two forward teeth fit into the groove of the nut which tightens and secures the ball bearing.

Between the faces of the spacer sleeve and the shaft of the turbine, there should be a tolerance of 0.3+0.5 millimeters selected and set by the spacer sleeve and the thrust bushing. The spacer sleeve and the thrust bushing are made of type 38CHA steel.

Threaded coupling meember (8), connecting the turbine rotor and the compressor, is secured in a longitudinal position by a sleeve and spring. The securing sleeve has two sets of grooves engaging the grooves at the rear end of the compressor shaft and the grooves of the pin, connecting the turbine rotor and the compressor. While screwing in the pin, the securing sleeve is held by a special wrench. The securing sleeve is pressed into position by a spring made of type OVS steel which is guided by a pin seated in the compressor shaft.

Front bearing (4) of the compressor (Fig 57) is of a roller type. It supports the load resulting from the balance and imbalance of the rotor and permits the axial shifting of the rotor resulting from heat expansion and distortion by axial forces. The outer race of the roller bearing is set into sleeve (2) of front housing (1) with a tolerance of 0.032 to 0.011 millimeters. The outer race is secured in an axial position by spacer insert (16) and flexible ring (15).

The front bearing sleeve (2) is locate [redacted] the rear flange of front housing (1) with a tolerance of from 0.011 to 0.04 millimeters. In order to secure this setting, the diameter of the mounting is made in two sizes. 50X1

The front bearing sleeve is fastened to the flange of the front housing by eleven tap bolts which, together with three bolts (18), also secure the inner ring of the inlet guide vanes. The sleeve is aligned by a pin. The front bearing is equipped with a baffle seal preventing seepage of oil from the area of the roller bearing into the air passage space [air intake duct?] of the compressor.

The baffle seal [assembly] of the compressor's front bearing is three-fold and consists of baffle seal sleeve (23), baffle seal ring (22) and baffle seal sleeve (20). It is [pressure ?] sealed by air bled from the area behind stage V of the compressor.

The compressed air passes through a tube, channels in the forward housing, air supply channel to front roller bearing seal (17), the air supply channel (24) in the sleeve of the front bearing and the baffle sleeve into the area of the seal, thus preventing the seepage of oil into the air area of the compressor.

Three sets of ridges on the sleeve, the rings, and the baffle seal sleeve move along the inner surface of the sleeve; the seal rings have a built up aluminum-graphite layer. On the surface, under the aluminum-graphite layer, is a step tap of 0.75 millimeters. During assembly a diametral clearance is maintained on the surface of the thicker seal ranging from 0.15 to 0.348 millimeters, and on the two other surfaces from 0.12 to 0.289 millimeters.

At operational engine rpm, the radial clearance of the seal approaches zero, so that a slight contact is possible between the ridges of the seal and the easily removable layer. The ring and sleeve of the seal are mounted on the [foward] journal of stage I of the compressor together with the roller bearing, the regulator and stop ring, and the lock, and these are secured by lack nut (12).

The baffle seal sleeve is fastened to the sleeve of the front bearing by six bolts and is centered on the cylindrical surface of the front bearing sleeve with a tolerance of from 0.05 to 0.13 millimeters.

Oil for lubricating the compressor roller bearing is supplied through openings in the front drive housing. Oil from the roller bearing area flows into a sump in the front housing as does oil from the baffle seal, which flows there via three grooves (3) of the front bearing.

The front bearing sleeve, the spacer sleeve, and the baffle seal sleeve are made of type 38CHA [38KhA] steel. The flexible ring 50X1ade of type U7A steel.

Rear bearing (7) of the compressor (Fig 62) is ball type, radial-axial. In addition to the radial load of the rotor, the bearing also carries the entire axial load acting on the rotor, equalizing the difference between the axial forces of the compressor and the turbine.

The outer race of the bearing is set into the combustion chamber with a tolerance of 0.01 millimeters up to 0.032 millimeters. The ring is held in an axial position by being clamped between oil ring (8) and baffle seal sleeve (6).

The baffle seal sleeve is set into the combustion chamber with an outer sleeve clearance of from 0 to 0.067 millimeters. The oil ring, the outer race of the ball bearing, and the baffle seal sleeve are tightened by nut (13) secured to the combustion chamber to a torque of 55-65 kilogram meters.

The nut is secured by safety lock (14), fastened to it by two bolts (15). The outer lock of the safety lock falls into a groove and into the forward groove of the combustion chamber and in this way secures the nut.

The ball bearing is lubricated with oil supplied under pressure from the engine's oil system through three openings in the lubricating ring, one and two millimeters in diameter.

The oil flows from the area of the bearing into oil sump (12) of the combustion chamber from which it is removed by the oil pump. The inner ring of the bearing is seated on the shaft of the compressor rotor with a tolerance of from 0.015 to 0.013 millimeters.

The inner ring together with baffle seal bushing (4) regulator ring (10) and disc (11) of the slinger ring are fastened by nut (9).

The rear bearing of the compressor is equipped with a baffle seal with reduces air leakage from the compressor into the oil area of the combustion chamber. The baffle seal is three stage, consisting of baffle seal bushings (3) and (4) with three rows of ridges and seal rings (1), (2), and (4) (Fig 64, 65), joined together into a single unit with six bolts. The three rows of baffle seal sleeves, turning simultaneously with the rotor of the compressor, move over the soft surface of the seal rings.

During operation, the radial clearance of the seal is reduced so that the baffles can come in contact with the soft layer. In assembling the equipment, the following diametric clearances are maintained on the surface of the seal: for seal ring (2), 0.15 - 0.365 millimeters; for seal rings (1) and (4), 0.12 - 0.305 millimeters. Seal rings (1) and (2) on the rear surfaces have six baffles each. An aperture (3) forms between the baffles of the forward side of the labyrinth sleeve which is connected with dearation space (5) (Fig 62). 50X1

Air penetrating through the two rows of seals passes, via the aperture, into the deaeration space and is carried off by the discharge nozzle.

Oil slinger (11), located between the inner race of the ball bearing and the regulator ring, throws the oil towards the periphery and the discharge opening located there and prevents its seepage onto the packing.

Safety lock (14) and seal rings (1) and (2) (Fig 64) are made of type 38CHA [30KhA] steel; baffle seal bushing (4) and lubricating ring (8) (Fig 63) are made of type 38CHMJUA [38KhMYuA] steel.

Nut 13 is made of type 12CHN3A [12KhN3A] steel. The contact face of the nut is carburized. All of the above mentioned components are protected against corrosion.

The inner surface of seal rings (2) and (4) and the outer surface of seal ring (1) (Fig 64) contains threads with a pitch of 0.75 millimeters on which is deposited a layer of aluminum-graphite.

In order to achieve uniform clearance over the periphery between the seal ring and the baffles of the seal sleeve, the seal ring grinds in on the packing layer.

3.3 Inlet guide vane assembly

The inlet guide vane assembly (Fig 66) is mounted at the compressor intake and directs the stream of air onto the vanes of the compressor's first stage.

The inlet guide assembly is mounted in the area of the front, housing and consists of the following main components: 23 guide vanes (4), front outer ring casing (3), rear outer ring casing (5), inner ring casing (15) and flanged spacer ring (17).

The vanes of the inlet guide assembly are cast of type CH17N2 [Kh17N2] steel.

On the top and bottom of the vane are precision machined pins (11) and (16), used to set it in the outer and inner rings.

The bottom pin has a cut-out, which serves to secure the vanes in the channel.

50X1

The inlet guide vanes vary in height and configuration. In the forward section, the vanes have channel (9) along their entire length which is created by milling and by welding (electric or argon weld) the forward edge and the upper face edge of the vane. After being welded, the leading edge is polished to reduce resistence to air flow.

Top pin (11) is hollow and has two openings (12) for admission of hot air into the vanes. The small channel (10), made from the forward edge of the vane by an spark erosion machining connects the forward channel of the vane with openings.

Air, taken from behind the compressor for heating the inlet guide vanes; passes through a tube into the annular area (22) between the front casing and the outer rings of the inlet unit. From annular area (22) the air passes through openings (12) into channel (9), and on leaving the vanes it mixes with the inlet air entering the compressor. This heats the guide vanes and prevents them from icing.

The outer ring [casing] of the inlet guide vane unit consists of two halves: forward (3) and rear (5) joined by 12 bolts (25). In connection with this, the forward part of the ring has 12 threaded openings and the back part has 12 smooth openings. The fastening ties on the two halves are secured by locks (23). The outer casing's two halves are centered together by three pins (18). Spaced around the outer ring casing are 23 openings with a diameter of $12 = {}^{0.04}_{0.06}$ millimeters for the upper pins of the vanes.

The outer ring casing is centered in the forward casing by two precision machined lugs located on the front and rear parts of the casings. The outer ring casing is secured in an annular position by pin (2), seated in the forward casing. The front face of the ring casing rests against the forward casing and its back side against the regulator ring (6). The outer ring casing is made of type ML5 magnesium alloy, and the inner ring (15) of type D1T aluminum alloy. The inner ring has 23 openings with a diameter of 12 + 0.012 millimeters for the bottom pins of the guide vanes.

On the forward side of the inner ring are 11 openings for bolts (20) which screw into the forward casing and secure the inner ring and spacer flanged rings (17). The inner ring casing is secured by pin (13) which is set into the forward casing and the inner diameter is aligned with the front bearing sleeve (14).

The forward face of the inner ring casing is against the flange of the front bearing sleeve.

50X1

Ring (17), made of type 38CHA [38KhA] steel, secures the guide vanes with its forward face in a certain position with regard to the compressor axis.

3.4 Compressor housing

The compressor housing (the static part of the compressor) (Fig 67-69) consists of the part between the front casing and combustion chamber unit. The compressor assembly has ten stator and ten rotor rings. Mounted on the outer surface of the compressor assembly are the following: four [bleed] valves for releasing air behind the V and VIII stages, the valve for bleeding air to heat the vanes of the inlet guide unit with electro-mechanism MP-5, and the KTA control combustion assembly.

The compressor assembly is of welded steel construction and consists of two parts joined in a horizontal plane which permits simple assembly of the engine.

The main components of the compressor assembly are the following: housing (6), front flange (4), and rear flange (12), and four longitudinal flanges (14), (17) (Fig 67).

The housing is cylindrical and made of steel plate, two millimeters thick. The housing is divided into two halves along a horizontal plane which are joined by flanges. The "fibers" of the housing material run parallel to the axis of the compressor. Flanges are welded to each end of the housing.

In order to achieve the necessary alignment of the compressor rotor bearings, the surfaces of the front and rear flange are made as accurately as possible and their centering indents are made with the least possible relative disalignment.

"Angle shapes are welded to the housing and also to the front and rear flange in a horizontal plane. Along the surface of the housing are 64 openings used for bleeding air to the collector and 60 openings for bolts to fasten the stator blades.

The front flange (4) is made of type 20 steel, it is shaped like a truncated cone and fastens to the forward casing. From the front, the flange has 30 openings for the mounting bolts of the forward casing and 30 milled countersunk recesses for the nuts.

On the inner surface, from the forward side, is a cylindrical recess for centering the compressor assembly on to the forward casing. 50X1 inner surface also has two shoulders with a precision seating diameter for the rotor collar of stage I and the forward collar of the outer ring of the stage I stator vanes. From the back, the flange has a round collar which is used to center it on the casing prior to welding.

The compressor housing (12) (Fig ?] is made of type 20 steel; it is aligned with the combustion chamber housing and fastened to it by 36 bolts. The bolts and nuts are secured by lock washers.

From the front, the flange has a collar by which it is aligned with the housing prior to welding. The four longitudinal members (14) and (17), welded to each half of the housing on a horizontal level, are made of type 20 steel. The longitudinal members have an angular shape which broadens out towards the back to accomodate the bolts for mounting the engine.

The two halves of the compressor housing are joined together by 42 bolts (16), of which five on each side are centering bolts which serve to position both halves of the housing.

Two gaskets (15) of AVA-M material, four millimeters thick, are placed between the flanges of the two halves of the compressor housing. The connecting bolts are made of 38CHA [38KhA] type steel. The nuts for these bolts are tightened to a torque of 2 ÷ 2.2 kilogram meters.

The bolts are secured by lock washers placed under the main bolts and nuts. Welded to the inside surface of each half of the compressor housing are 12 T - shaped (1) and three U- shaped (24) semi-circular stiffeners.

The semi-circular stiffeners are made of type 10 steel and serve to center the rotor blades and the stators.

Welded to the outer surface of the assembly housing are 60 bosses (5) and (7) for fastening the stator [rings] of the compressor's I - X stages (three bosses for each half of the stator). The bosses are made of type 10 steel.

The stator fastening bolts are secured by lock washers (12).

The bosses, located in a vertical plane, both on the upper and lower halves of the housing have precision openings for the centering bolts fastening and securing the stator halves in an axial and radial direction.

The stator mounting bolts are made of [redacted] maintain an even tension and to prevent overstress in assemblying, the fastening bolts of the compressor stators in stages I - III are tightened to a torque of 0.6 + 0.8 kilogram meters and in stages IV - X, to a torque of 1 + 1.2 kilogram meters. The face surfaces of the bosses, lock washers, and the contact surfaces of the fastening bolts are tightened to insure a sufficient tightness of the interior area of the compressor housing. For bleeding air, canister collectors, made of type 20 sheet steel (upper strength 1.5 millimeters, bottom strength 2 millimeters), are welded to both halves of the compressor housing.

50X1

The upper and lower collectors are welded together from two halves, while rear halves (11) and (23) are welded by two side walls to the compressor housing and the front wall becomes a hermatically sealed barrier separating the areas of the bleed valves of stage V from the area of the bleed valve of the compressor stage VIII. Forward halves (8) and (20) are welded to the compressor housing and to the rear halves of the collectors.

Welded to the central part of the upper collector, under one of the bosses of the stator fastening bolts, is insert (10) of type 20 steel plate. Six inserts (10) are welded in a similar fashion on a vertical plane of the lower collector. In order to achieve an even collection of air along the periphery, the collectors take up a sizeable portion of the housing, while their diameter increases progressively to the place where the bleed valve is secured.

Two flanges (9) of type 20 steel are welded on a vertical plane to the upper collector for fastening the bleed valves behind the V and VIII stages of the compressor. The flanges have eight threaded openings for the bleed valve fastening bolts.

Welded to the front of the upper collector is coupling (6) (Fig 68) which is used to bleed air from behind stage V for the baffle seal of the compressor's front roller bearing. Welded to the sides of the rear half of the upper collector are bosses with a threaded opening for fastening the clamps of the starter cables from the KPN-4 coil to the igniters. Four flanges (2) and (5) (Fig 69) of type 20 steel are welded to the sides of the lower collector, two on each side. The flanges have eight threaded openings. Mounted on two of the flanges, from the right side, are the bleed valves behind the compressor stages V and VIII and behind flanges (2) (Fig 69) of aluminum alloy from the left side.

Welded to the lower level of the collector are two mounting bars (6) (Fig 69) for fastening the KTA fuel control assembly. The KTA assembly is fastened with eight bolts screwed into the mounting bars and bosses welded to the bars. The mounting bars and bosses are made of type 20 steel. Four plates are welded to the housing and collector to increase the rigidity of the lower collector in its area around stages V and VIII under the mounting bars of the KTA assembly.

Boss (4) (Fig 69) with a threaded hole is welded at the front of the lower collector for fastening the clamps holding the air tube le 50X1 from the sensor located in the forward casing to the KTA control assembly.

Two bosses (1) with threaded holes are welded to the lower half of the compressor housing on the left side for the bolts holding the supports of the VE-2 hydraulic switch of the starter generator. Boss (3) with a threaded hole for fastening the clamp holding the wires to the KTA fuel control assembly is welded to the lower half of the compressor on the right side.

Two bosses (4) (Fig 68), with threaded holes for bolts securing the hot air bleed valve for heating the vanes of the inlet guide vane unit, are welded on the right side to the upper half of the compressor housing. Welded to the same side of the upper half of the housing is a support plate (3) of type 10 steel with two threaded holes for fastening the clamps of the tube carrying off air from the oil area of the turbine shaft channel to the centrifugal deaerator.

On two of the bosses (1), welded to the upper half (placed close to the forward flange), are fastened the clamps for holding the collector lead to the MP-5 electro-mechanism.

One rear mount for the engine, made of type 40CHNMA [40KhNMA] steel, is fastened from the right and left sides of the compressor housing rear flange and is secured by three bolts to the longitudinal members of the compressor housing and by two bolts to the rear flange. Fastened by four bolts to the same flange of the upper half of the housing are two mounting bars for fastening by three bolts are also two mounting bars for fastening the cover. They are made of type 38CHA [38KhA] steel.

The starting fuel valve is fastened to the longitudinal members on the right side.

The compressor housing is tested under air pressure of one kilogram per square centimeter for a period of one minute.

3.5 Stator and rotor rings

The compressor stator rings (Fig 71,72, 73) convert a part of the kinetic energy of the air, acquired from the compressor's rotor blades, to pressure energy, and direct the stream of air at the desired angle.

The outer and inner rims of the stator and rotor rings form the narrowing duct of the compressor.

The construction of all the stator rings is the same; they differ only in their geometric shapes and the number of blades.

The stator rings are welded and consist of outer rim (2), inner rim (4), labyrinth ring (5), and pins (1) fastening the stator ring to the compressor housing (Fig 71). 50X1

The outer and inner rims are rolled from steel sheet 1.5 millimeters thick and have shaped openings into which blades are placed and welded from the face side so that a rigid component is created which cannot be disassembled. Labyrinth ring (5) of steel sheet, 2 millimeters thick, is welded inside.

The labyrinth ring together with the ridges on the compressor rotor form the fir seal which prevents the seepage of air between the stators. In order to secure the seal with a zero clearance, an soft layer of aluminum with graphite (7) (amount of graphite 6 to 12 percent) is deposited on the seal ring. The thickness of the layer, afterthe completion of the milling, must be at least 0.7 millimeters. Special ridging (6) is cut into the ring to achieve a better union of the layer with the seal ring.

The sealing layer is deposited in the stator rings to assure the clearance between the surface of the rotor and the layer.

These clearances are achieved during the operation of the engine, when the rotor is affected by centrifugal forces and the material has expanded as a result of the heat, the ridges of the rotor cut into the layer and thus assure the necessary sealing.

The stator vanes are cast of type CH17N2 [Kh17N2] steel and are polished. All of the stator rings are cut in two and marked "Upper" and "Lower." The beads of the outer rings are precision milled and serve to seat and center the stator rings.

Three pins (1) (Fig 71) with threaded openings are welded to each half of the stator ring to secure it to the compressor housing.

The stator rings behind the stages V and VIII have 80 and 40 openings in the outer rim for bleeding air.

To prevent corrosion the parts are eloxal coated. The number of stator vanes in the individual stages is presented in the table below:

Stage	I	II	III	IV	V	VI	VII	VIII	IX	X
Number	32	38	44	62	62	74	74	74	74	82

The compressor rotor rings (Fig 73) are positioned between the outer stator rings and assure a maximum clearance between the tips of 50X1 rotor blades and the inside diameter of the rings. The rotor ring is rolled from 10KP steel sheet 1.5 millimeters thick. The ring is centered the same way as the stator ring alongside the reinforcement rings of the compressor housing and for this reason the beads of the rings are precision milled. The ring is prevented from turning by stop (1), welded to the outer surface of each rotor ring, which fits against the packing located in the separation plane of the compressor housing on the left side. The axial position of the rings in the housing is secured by the outer rim of the stators.

The rotor ring of stage I is secured at the front in an axial direction by a seal ring, which rests against the outer rim of the inlet guide vane unit. The rotor rings of stages I and II have a tapered inside diameter; half of the angle is $2^{\circ} 52'$. The rings of stages III - X have centering bosses of the same diameter.

To secure the minimum radial clearance between the rotor blades and the inner surface of the rings, the inner surface has a deposited film, which is easily worked on contact with the tips of the blades. Deposited on the inner surface of the rotor rings of stages I - V is a sealing layer consisting of an aluminum, asbestos, and talc mixture having a minimum thickness of 0.7 millimeters.

Deposited on the inner surfaces of the rings in stages VI - X is a layer consisting of an aluminum and a 10 to 14 percent graphite mixture, and having a minimum thickness of 0.7 millimeters. To achieve a better seal between the deposited layer and the surface of the ring, the inner surface is grooved to a depth of 0.35 millimeters at intervals of one millimeter and a profile angle of 60°. To prevent corrosion, all rings are phosphated, and the surface is coated with a protective material.

3.6 Bleed valve

The bleed valve (Fig 74, 75) assures the stable operation of the compressor during starting and during low RPM and thus reduces the load on the starting mechanism during the starting period.

The four valves are on flanges welded in pairs on the collectors behind the stages V and VIII of the compressor and are secured by 8 bolts.

Automatic control of the bleed valves is carried out by the KTA fuel control assembly, which controls oil [pressure] to the on the bleed valve piston, according to engine RPM. This piston opens the valve [under pressure], and after the oil [pressure] has been cut off, the valve is closed by a return spring. The pressure of the oil entering the cylinder above the piston is 13 to 15 kilograms per square centimeter; the maximum pressure of the air in the collector, at which the valve can be opened, is six kilograms per square centimeter.

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50X1

During engine starting, the bleed valves open when the oil pressure reaches three kilograms per square centimeter, at 1,000 ± 1,200 engine RPM; they close behind compressor stage VIII when n (nominal = 9,000 ± 150 RPM, and behind the compressors stage V when n = 11,200 ± 150 RPM.

The bleed valve [Fig 24] consists of the following components: body (16), cover (8), piston (5), valve (17), plate (7), spring (14), and safety locks (6).

Body (16) is cast of ML5 megnesium alloy. On the lower part of the body is a flange by which it is fastened to the collector. The flange has eight bolt holes. The three extensions from the flange support the cylinder, while the openings between them permit the escape of air. Cover (8) with a pipe fitting for the intake of oil is fastened by four bolts to the cylinder's upper flange. A "fabric" type gasket is placed between the flanges of cover and the body.

The lower cylinder cavity serves as the valve's (17) guide. In order to prevent oil seepage the cavity has a circular groove with an inserted rubber ring seal (18). The upper cylinder cavity serves as a guideway for piston (5). On the outside is a boss with a threaded opening for pipe fitting (12) to drain off oil seeping between the piston and the packing. The pipe fitting seals on aluminum gasket (13). The cylinder cavity is terminated by a horizontal surface which stops the piston in the down position. On the inner surface of the body, near the lower flange, is a precision machined tapered surface into which the valve seats in its extreme upper position.

To secure a dependable tight seal, the tapered valve seat in the body is milled concentrically with regard to the inner cylindrical cavity and the valve is self seated by gringing action. Filter screen (21) is placed in the openings between the lower flange supports. The screen, which is secured by four dural rivets, prevents foreign objects from entering the compressor housing.

The screen is made of 1CH18N9T [1Kh18N9T] steel. Cover (8) is cast of AL-5 aluminum alloy. The cover has a boss on the side surface with a threaded hole for pipe fitting (19) for oil pressure to the valve. Between the cover and the hexagonal pipe fitting is an aluminum gasket....

[page 41 of text is missing. Begins discussion of hot air bleed valves for heating intake guide vanes [Fig 76]

The casing has two holes for bolts to secure it to the compressor housing, four holes for bolts (1) to hold casing (11) together, flange (10), angle plate (18) and flanges (7) and (20). On each face side of the housing is a single hole for pins to secure the flange and angle plate on the casing.

The casing has two bronze bushi[redacted] butterfly valve shaft (8). Bushing (17) is fastened to the casing by two bolts; the face side of bushing (19) rests against the butterfly valve and it is tightened by a castle nut (24), screwed on to the threaded end of the butterfly valve shaft. The nut is secured by a cotter pin. The butterfly valve shaft has two precision worked surfaces which fit into the openings of the futterfly valve bushings. Attached at the end of the shaft by screw (13) and nut (12) is pull rod (26). The butterfly valve and its shaft are made of type 38CHA [38KhA] steel.

Flange (10) has holes for mounting to the casing; four holes for fastening the flange to the casing and one for lock pin (31). It also has holes for guide screw (29) of the MP-5 electro-mechanism, round recesses for centering the electro-mechanism unit, four holes for pins and four for the bosses of the pins securing the MP-5 electro-mechanism.

Angle plate (18) has holes in its vertical walls for centering on the casings, four holes for the bolts holding the unit together and one for lock pin (30). Angle plate (18) and flange (10) are made of type 20 steel.

Cover (14), stamped of AVAM aluminum alloy sheet 1 millimeter thick, is fastened to the horizontal walls of the angle plate by five screws (25) (with one screw to the casing). On the left the cover rests against the flange with its face side. The cover fastening bolts are safety wired.

Fastened with two screws in the horizontal wall of the angle plate is forging (15), that guides two rollers (2), (3), which make up the axle connecting pull rods (26) and (27). The forging is made of type 45 steel, and the rollers of 38CHA [38KhA] steel. Pull rod (26) consists of a covering, the pull rod itself, spring and two washers. The casing and washers are mde of type 45 steel, the pull rod of type 38CHA steel, and the spring of type OSV steel wire. The pull rod, with a washer fastened to the end, is able to move over the inner surface of the casing to a position in which the spring is completely compressed. The spring rests against the face side of the washer. The other washer is secured to the end of the casing. The casing and pull rod have eyes by which pull rod (27) is attached to the butterfly valve shaft arm.

[The last paragraph of page 42 is illegible.]

The tubes for bringing in and carrying off the hot air to the valves couple into flanges (7) and (20). Flanges (7) and (20), made of type 45 steel, have four openings each for bolts to secure them to the casing and a thread for securing nuts (4) and (21). Inside the flange are openings for air intake and the centering recess for the tubes.

Asbestos packing cord (6), (23), seal rings (5), (22) and a lock nut are used in coupling the tube and the flange. The nuts are made of type 38CHA steel, the seal rings of type (45) steel.

The nuts are safety wired, for which purpose the nuts and flanges have holes 1.5 millimeters in diameter. 50X1

4. COMBUSTION CHAMBER

The combustion chamber (Fig 78) consists of the following parts: inlet section (1) (Fig 79) with air casing (4); burner (5); main fuel nozzle (2); igniter (3); starting fuel nozzle (?); housing (6) of the rear compressor bearing; housing (7) of the turbine roller bearing; oil supply tubes (9) and (10) for the bearing, oil drainage system and air sealing, tightening and sealing details.

The combustion chamber is that part of the engine in which the temperature of the air supplied by the compressor is increased by burning fuel. Simultaneously it catches the elements of force resulting from the turbines' weight and motion, originating in the combustion chamber and turbine during the operation of the engine and the forces originating on the aircraft.

4.1 Inlet section of the combustion chamber

The inlet section of the combustion chamber is welded of type 1CH18N9T [1Kh18N9T] heat resistant steel 1.5 2.5 millimeters thick, with flanges made of the same material, and bearing bushings of type 25 and 20 steel. The inlet section of the combustion chamber consists of the outer casing (1) (Fig 80) with welded flanges (2) and (3), inner tapered supporting section (4), and the rear outer end guide casing.

Inlet outer casing (1) (Fig 80) and the inner tapered supporting section (4) are mutually joined to ten equally-spaced streamlined frames [cans], welded, with reinforcements, to the outer surface of the tapered supporting section and the forward casings. The frames are reinforced by strengthening members (7) located in the stream of air supplied by the compressor.

Welded to the inlet outer casing of the combustion chamber is front flange (3), by which the intake casing is joined to the compressor housing, and on the rear end is flange (2) for coupling the casing to combustion chamber [proper].

Welded to the outer casing are the following: flange (8) for the line which carries off the oil emulsion from the area of the compressor's rear bearing and the turbine bearing to the centrifugal deaerator; flange (9) for the line which carries off the air used for heating the inlet guide vanes of the compressor; flange (10) for the deaeration line of the D_1 and D_2 areas of the baffle seal leading to the [word illegible] nozzle.

Welded to the outer casing are the following: flanges (11), (12) and (13) which serve as mountings for the device conducting air from 50X1 (14) which is utilized for the needs of the aircraft. Flange (15) serves as a mounting for the oil filter through which the oil is drawn off to the front housing. Lines (16), welded to flange (15), carries off compressor bearing oil from sump (33), and line (17) carries off turbine bearing oil from sump (32).

[Paragraphs 2-7 of page 44 are illegible.]

[Word illegible] burner

The engine burner (Fig 81 and 82) is of a canannular type located inside the combustion chamber. It is welded of type E1435 heat resistent plate.

The forward part of the burner consists of ten domes (Fig 82) located between the frames of the chamber casing. For fastening to the chamber casing, eight heads have welded bushings (2) for securing pins which permit the free expansion of the burners when heated.

[Paragraphs 1 - 5 of page 45 are illegible.]

The block of burner domes welded to the rims is riveted to the outer casing (15) and inner casing (16), of the burner. The casing is riveted with rivets three-millimeters in diameter and made of type 1CH18N9T steel.

To reduce the rigidity of the joint between the casing and cans, longitudinal slots are made in the outer and inner casing in places where the rivets are located.

Spacer plates (17), placed between the casing and domes create apertures through which air passes for cooling the inner surface of the casing.

Secondary air is brought into the burner through 50 mixing extensions (18) welded to the outer casing and through 40 mixing extensions (19) welded to the inner casing. The extension consists of flange (20) and inserts (21), welded to the flange. The front edge of the insert is bathed with air which passes between the flange of the extension and the insert.

For equalizing the heat field behind the chamber and cooling the walls of the inserts between the extensions, the outer casing has pairs of openings, and where the domes come in contact there is one opening.

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For increasing rigidity, grooves are milled into the outer casing. Two flanges (22) are welded to the inner casing, between which is a third flange (23) with 50 openings, four millimeters in diameter. The inner diameter of this flange rests on the cylindrical surface of the "distribution unit" -- [probably, the nozzle guide vane assembly]....

[Page 46 of text is missing]

The outlets of the fuel manifolds are made of type 1CH17N9T [1Kh18NT] steel and the joined with PZL-500 braze. The fuel system manifolds are joined to each other by aluminum couplings (7) (Fig 83). With regard to the bridging, the surface under the couplings is cleaned.

The fuel manifolds are fastened to the combustion chamber by six steel mountings (6). Each steel mounting has two grooves so that the manifolds may be set in the desired position.

Fuel is carried from the manifold to the primary fuel nozzles via lines (3) and (4).

The lines supplying fuel to the main fuel nozzle of the main circuit [flows] are marked with black painted rings, the other circuits is marked with two painted rings.

4.7. Main fuel nozzle

To assure correct burning in the combustion chamber, the fuel is delivered in an atomized state for better mixing with the air. 50X1

The dispersion and distribution of fuel to the burner domes of the combustion chamber is assured by the ten main FR-20 fuel nozzles, which are mounted on every dome of the combustion chamber and which are fastened by flanges to the casing of the combustion chamber.
[Paragraphs 1 - 6 of page 48 are illegible]

Impurities in the fuel and metal particles which get into the fuel as it passes through the individual parts of the fuel system assembly are trapped in the area between the filter screen and the flange. Impurities and other small particles are easily removed during the disassembly and cleaning of the filter components. To prevent the seepage of fuel by the filter into the channels of the fuel nozzle unit, casing (15) [Fig. 84] is placed on bushing (14) of (filter) insert (9) with a maximum tolerance of 0.113 millimeters and casing (15) is placed into body (18) of the fuel nozzle with a maximum tolerance of 0.103 millimeters.

Aluminum gaskets are placed under the collars of tube fittings (1), (2) and [hex heads], (8). The body of the fuel nozzle is made of type 12 CHN3A [12 KhN3A] eloxal [?] coated steel.

When starting the engine, the fuel enters only the first manifold of the fuel nozzle [assembly]. It progresses to the central area of adapter (19) and from there through openings into vortex generator (20)....
[Paragraphs 1 - 5 of page 49 are illegible.]

The face side of the atomizer, on the head of the fuel nozzle unit and on the sleeve, has three channels (32) [Fig. 84] for the passage of air to cool the main fuel nozzle and to remove its carbon deposit. The air passes through the clearances between the sleeve and the shroud it blows through the face of the atomizer and the casing via twelve openings (33) of 1.5 millimeters in diameter in the casing. In order to prevent the sleeve from turning while putting on the casing, its boss (34) fits into one of the recesses on the head of the fuel nozzle unit and collar (35) of the shroud is bent into the other recess. Sleeve (29) is made of type 38CHA [38 KhA] eloxal coated steel; the shroud (30) is made of type 1CH18N9T [1Kh18N9T steel.

The cylindrical surface of the shroud has ten holes (36), 2.5 millimeters thick, for discard of fuel, which can flow out from the side of the atomizer. Flange (37) of the fuel nozzle is made up of two halves from type D1T duraluminum it is joined together by bolts (38) and nuts (39). The nuts are secured by safety locks (40). Set into the recess of the flange is ring (41) consisting of two halves whose inner surface encircles the cylindrical surface of the fuel nozzle unit with the tolerance of 0.0008 / 0.045 millimeters. Rubber ring (42) is placed into the recess in the ring.

[Paragraphs 1 - 7 of page 50 are illegible.]

The starting fuel nozzle (A) [Fig. 85] is fastened to casing (B) of the burner by flange (4) with bolts and three nuts locked by spring washers. Body member (2) of the starting fuel nozzle with sleeve (3) welded to it and flange (4) is made of type 20 cadmium plated steel. Tube fitting (5) is screwed into the orifice of sleeve (3) for connecting the fuel lines. Aluminum washer (6) is placed under the tube fitting.

In body member (2) of the starting fuel nozzle, the collars of atomizer sleeve (8) and cap (9) are secured by nut (7). The collars are sealed with gaskets (10) and (11). Gasket (10) is aluminum and Gasket (11) is brass. Sleeve (8) of the atomizer is bronze, and cap (9) is made of type 1CH18N9T [1Kh18N9T] steel. Nut (7) is made up type 45 steel and has four keyways. The nut is secured by safety lock (12) for which five grooves have been made on the face side of the starting fuel nozzle. The safety lock is pressed against the nut by spring (13).

Slot filter (14) is set into sleeve (8). The upper plate of the filter is pressed to the face of the atomizer sleeve (8) by spring (15). Set into plate (16) and rolled is core (17), which has nine logitudinal grooves along its periphery and a thread cut on its outer surface.

[Paragraphs 1 - 6 of page 51 are illegible.]

Welded to the body member [of the auxiliary starting fuel nozzle, Fig. 86] is casing (3) made of type 1CH18N9T [1Kh18N9T] steel, with opening (A) for air from the compressor. The air passes between the body member and the casing and cools the fuel nozzle. The fuel comes in through fitting (4) secured by bolt (2), which has two openings 2.5 millimeters in diameter located opposite each other for the passage of fuel from the tube fitting to the fuel nozzle member. The fitting is sealed with an aluminum gasket.

The fuel nozzle is mounted on the casing of the combustion chamber by a flange and two bolts. A "paronite" packing is placed under the flange.

[5. TURBINE]

[Paragraphs 1 - 8 of page 52 are illegible.]

5.2 Turbine Rotor

The turbine rotor (Figs. 89, 90, 91) consists of the rotating discs of stages I, II, III and the shaft. The turbine shaft (10) (Fig. 63) is made up type 40CHNMA [40KhNMA] steel and its front end splines onto the compressor's rear shaft (1). It is secured against axial displacement by threaded coupling (8) inside the turbine shaft.

A thrust bushing (9) on grooves [redacted] inside of the shaft to assure the necessary alignment in an axial direction, of the turbine shaft flange and the flange of the outer housing of t 50X1 stator vane unit of the turbine's I stage....
[Paragraphs 1 - 4 of page 53 are illegible.]

The tightness of nuts (22) [Fig. 89] is checked, after the turbine rotor has been assembled, according to the size [word illegible] of the tie bolts, which may have a tolerance of 0.4 0.02 millimeters. The tie bolts are reinforced where they come in contact with the discs, which reduces the clearance between the bolt and the sleeve (15) and prevents an even greater possible oscillation during operation. The reinforced part of the bolt has radial recesses in which are set, with the aid of a heavy lubricant, two-piece guides (21).

In the disassembly of the turbine, discs (16) and (19) are rested against the turbine shaft bolts through guides (21) and sleeve (15). This construction permits the dismantling of the individual turbine discs.

The forward part of the tie bolt is strengthened with flat surfaces, which are used for tightening the bolt. The flat surfaces for strengthening the bolt, where it comes in contact with the discs of turbine stages I and II, are also used for the same purpose.

The rear end of the tie bolt has a square head by which the bolt is held to prevent it from turning when the nuts (22) are being tightened or loosened. The nuts are secured by safety locks (1) (Fig. 92) of type 10 KP steel, 1.2 millimeters thick. To prevent the safety lock from slipping out, shims (2), 1 millimeter thick and made of type U9A material, are placed under the nuts. The nuts are copper plated. Every nut has two openings into which kerosene is poured prior to unscrewing. The nuts and bolts are made of type E1437B alloy.
[Paragraphs 1 - 6 of page 54 are illegible.]

√The mounting of the turbine buckets is shown in Fig. 90. The buckets are inserted freely into the disc. The grooves in the disc for fastening the buckets are cut at a 20° angle to the axis, so that the bucket proper does not exceed the contour of the lock. The buckets are guarded against longitudinal displacement by safety locks (∂) (Fig. 90) made of type E1435 steel 2 millimeters thick. Lug (2) of the safety lock fits into slot (4) of the bucket's lock and the protrusions (23) are bent down after the bucket has been seated, against the face side of the disc. A longitudinal movement up to 0.3 millimeters is permitted the buckets in the grooves.

The buckets of the turbine's I and II stages are cast of type ZS6K [ZhS6K] alloy, slightly oversize for milling and a minimum amount of mechanical working. The buckets of the III stage are mechanically worked from stampings made of type E1437B alloy. The cross section shape of the buckets is lemniscatic. The transitional part of the buckets in all three stages, which make up the inner surface of the rotor ring channel, has a

fillet (5) from the side of their leading edge, which assures a full entry of air to the disc. The outer edge of the buckets used on the discs of all stages are worked into a tapered configuration.
[Paragraphs 1 - 5 of page 55 are illegible.]

Balancing the turbine rotor is done with special equipment by removal of material from the periphery of the discs of stages I and II (17, 18,) (Fig. 89) up to a 15 GCM maximum on each support.

After balancing, the position of the discs and the spacer rings is marked with an "0" with relation to the zero pin of the rotor shaft. Marked in the same manner, with regard to their pins, are sleeve (15), guides (21) and nut (22).
[Paragraphs 1 - 6 of page 56 are illegible.]

The inner body (9) [Fig. 93] of the turbine nozzle assembly of stage I has the following main components: supporting cone (8), to which a flange (7) is welded from the face side for fastening the turbine nozzle assembly to the casing of the combustion chamber and the deflector rim (10) of type E1435 steel, welded to supporting cone (8). The deflector rim (10) protects the nozzle guide vane locks and set rim (11) with cups against excessive heat and makes up the inner contour of the gas channel. In addition, the deflector rim together with the forward part of outer rim (1) makes up the support for combustion chamber.

The stage I stator assembly has 47 guide vanes, cast of type ZS6K [ZhS6K] alloy, which are machined slightly after being cast.
[Paragraphs 1-8 of page 57 are illegible.]

The inner rims (4) are slotted in their outer surface to receive the ends of the stator vanes.

Circular insert (5) is placed into the inner rim and welded there, thus covering the outlet area of the vanes face side and preventing the seepage of gas through the clearances in the slots under the vanes. At the front of the inner rim is a flange with openings for the baffle seal fastening bolts.

Seal rings (6) serving as inter-stage packing (2) (Fig. 95), are of three-ridge construction and are fastened by bolts to the forward flanges of the inner rims. The larger-diameter openings on the flanges of the inner rims enable the seal rings to move freely and thus regulate the radial tolerance between the face of the turbine disc and the seal ring.

To assure an axial clearance between the face side of the seal and the turbine disc, the seal can be adjusted by the spacer rings. The axial tolerance between the discs of the turbine rotor and the inner rim of the turbine stator stage can be adjusted by inserting a spacer ring between the discs.

The stator vanes (3) (Fig. 94) of t[redacted] type VL7-45U alloy and are machined. The stator assembly of the II stage has 51 vanes and the III stage 53 vanes.

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One end of the vane is set into the slots of the outer rims and welded; the inner rim (4) is centered according to the other end of the vanes, which freely expand in the slots when heated.

The stator assemblies are mutually joined to the casing of the combustion chamber and the exhaust nozzle with bolts and nuts made of type EI388 steel, secured by locked plates.

[Paragraphs 1 - 7 of page 58 are illegible.]

[Paragraphs 1 - 10 of page 59 are illegible.]

After passing through the circular cavity (9) [Fig. 98] above the housing of the roller bearing, the secondary air insulates the bearing (6) against the effect of the hot gas.

A part of the secondary air passes through the clearances in the labyrinth seal and the opening (7) into the deaerating area (8) .

The secondary air passes from the casing of the combustion chamber through 50 openings (11) in the seal ring and through clearances (12) over the inner contour of the gas channel and it cools the inner rim of the stator assembly and the bottom part of stage I buckets.

The secondary air passing through clearances (13) between the combustion chamber of the outer rim of the stator assembly of stage I, cools the outer rim of the stage I nozzle assembly.

[Paragraph 1 - 9 of page 60 are illegible.]

Chapter IV.

THE OIL SYSTEM

[Note: Except for a few brief paragraphs and partial lines, the text comprising this chapter is obliterated to a point where no continuity of meaning can be developed.]

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Chapter V.

THE FUEL SYSTEM

1. GENERAL DESCRIPTION

The fuel system (Fig. 138) operates automatically under normal conditions, and needs no special attention by the crew.

The fuel system is divided for the right and left engines. Each pair of engines is supplied from its own tanks, i.e., engines No. 1 and No. 2 are supplied from the left wing tanks, and engines No. 3 and No. 4 are supplied from the right wing tanks.

A total of 22 tanks are located in the wings, 20 of which are soft and unshielded, and 2 tanks are in the detachable parts of the wing (tank No 8).

Tanks Nos. 1 to 8 belong to the main group of tanks, forming group I. The tanks are located behind the inboard engines and are sufficiently removed from the fuselage.

Tanks Nos 9 to 11, forming group II, are added to increase range. The tanks are located between the fuselage and inboard engines. These tanks are emptied first. No tanks are located in the fuselage.

Tank capacities:

Main group - group I	8,200 liters (6,315 kilograms), of which 3,800 liters (2,540 kilograms) are in tank No 8;
Auxiliary group - group II	3,650 liters (2,810 kilograms).
Total capacity in one side of the wing ..	11,850 liters (9,125 kilograms)
Total capacity of the fuel system	23,700 liters, minus 2 percent (18,250 kilograms, minus 2 percent)
Projected specific weight equals	0.770.

The tanks of each side of the wing contain 10 PNV-2G fuel pumps. The pumps are located in the following tanks:

Four overflow [?] pumps in the service tanks No. 1;

four transfer pumps in tanks No 9; and two transfer pumps for the amount of fuel remaining in tanks No 2.

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The following instruments and accessories belong to the fuel system in addition to the tanks and PNV-2G pumps:

KTA-5F fuel control [throttle] assembly - installed on each engine;

661A (3481) high-pressure pump - one per engine;

7071 supply pump - one per engine

12TF-15 fine fuel filter - one per engine (mounted on the left support of the engine bed);

TF-6 coarse fuel filter - one per engine (mounted in the firewall);

No 762700 fire shut-off valve - one per engine, in inboard engines on the firewall (side nearest the landing gear), and in the outboard engines on the firewall in the area of the oil cooler;

No 762700 cross-over valve - one mounted on the front girder of the fuselage center section;

Drain valve for the I and II groups of tanks - 4 on the right and left edges of the inboard nacelles in the landing gear area;

No 662600 check valve - eight units under the tanks next to the fuel pumps. The flaps of the check valves have a 0.3 millimeter opening in each; SDU-3 transmitter - 0.35 of the minimum fuel pressure of 7071 supply pumps - one unit per engine (fixed to the right support of the engine bed); SDU-2-0.18 transmitter of the disengagement (VYSAZENI") of the overflow pumps - two units behind the pumps on the right edge of the inboard nacelles in the landing gear area; SDU-2A transmitter - 0.18 of the fuel transfer from the II group of the tanks - two units behind the transfer pumps on the left edge of the inboard nacelles in the landing gear area; SDU-2A transmitter - 0.18 of the transfer of the fuel remaining - two units behind the pumps transferring the fuel remaining, located under tanks No 2; EMI-3R three hand indicator for measuring the fuel pressure at the nozzles - 4 complete sets, the P-100 transmitters are located on the right supports of the engine mount, and the indicators are located on the control panel; SETS-280 fuel gauge - transmitters and SU-2 fuel quantity signals are located on the tanks, two UTO indicators and the CG-5 change-over switch are located on the control panel; two UTO indicators and two NG-3 change over switches are in the nacelles in the landing gear area on the maintenance boards for pressure fueling; two UTS-54 measuring relay boxes, two BAS-52-25 automatic relay boxes, two PD2-2 remote control change-over switches, and commutation equipment are found in the front cargo area on the right side; RTMS-1.2 B1 consumption gauge (complete unit for the airplane) - transmitters, located on the firewall of the inboard engines and on the left support of the engine bed of the outboard engines, four indicators are on the left pilot's panel; four PT-56 "thyratron" breakers and two TRP-52 transformers, located under the navigator's table; system of intake tubing, jettison, and fittings; and system of pressure fueling. 50X1

1.1 Fuel system operation and checking

The fuel system is checked and operated from the crew cabin. The check instruments are located on the instrument panel and the left pilot's panel, while the control instruments are on the central panel.

The instrument panel contains: four indicators (of the EMI-3R complete unit). The housing contains a fuel pressure gauge to the nozzles; two indicators and one fuel gauge change-over switch (from the SETS-280 complete unit);

four red signal lamps indicating a drop in the fuel pressure below 0.4 kilogram per square centimeter, located in front of the high-pressure 661A pump;

two red signal lamps, indicating disengagement of the overflow pumps;

two green signal lamps, indicating the operagion of transfer pumps;

two red signal lamps, indicating 800 liters of fuel remaining.

The left pilot's panel contains: four RTMS-1, 2-B1 indicators of amount of fuel consumed. The fuel consumption gauge shows the amount of remaining fuel in kilograms for each engine, and the scale shows the consumption in kilograms per hour.

The central panel contains:

four fire shut-off valves disconnect switches for the cross-over valves;
four disconnect switches for the overflow pumps;
four disconnect switches for manual control of transfer pumps;
two disconnect switches of the pumps transferring the remaininf fuel;
two green signal lights, indicating the operation of the pumps transfering the remaining fuel.

1.2 Fuel supply to engines

Supplying fuel to each pair of engines (Fig. 138) is handled from service tank No 1 by means of two PNV-2G overflow pumps. All of the other seven tanks of the main group are connected with the service tank, and the fuel supply from them to the service tank is done by gravity flow. To prevent fuel from escaping, check valves are inserted in some connections between the tanks. Service tanks No 1 and tanks No 3 have check va50X1 inserted in all four connections.

Two pumps are provided for greater reliability. In case one pump is put out of service, the other assures sufficient fuel supply to two engines.

After the engine is started, the fuel is drawn from the main group of tanks, and after 200 to 200 liters is drawn off, the signal from the guel gauge transmitter of tank 6 automatically turns on 2 PNV-2G transfer pumps, located in the tank No 9 of group II of the tanks (if these tanks are filled). The green signal light "pumping from auxiliary tanks," lights up on the instrument panel.

The transfer pumps are turned on after 200 to 300 liters of fuel are withdrawn from the tanks of the main group (group I), and fuel proceeds into tank No 6 only when the float valve in tank No 6, opens after 500 to 600 liters is withdrawn.

If the transfer pumps are not automatically turned on within 15 minutes after the engines are turned on (i.e., if the lights do not go on), the shut-off valves are turned on manually at the central panel.

The float valve located at the end of the transfer pump tubing in tank No 6 maintains a constant level of fuel in group I of the tanks, and prevents overfilling.

After fuel is pumped out of group II of the tanks, the transfer pumps are automatically turned off by the transmitter of the fuel gauge on tank No 9 and the SDU-2A - 0.18 pressure indicator, during which the green signal light goes off, and the fuel again is drawn from group I of the tanks.

In case the transfer pump was turned on manually, it must also be turned off manually. To alleviate the stress in the wings, a float valve, mounted in tank No 6 on the connection to tank No 8 prevents any fuel from being pumped [prematurely] from tank No 8. With this valve, fuel is withdrawn from tank No 8 only when the quantity of fuel in the other tanks drops to 3,500 liters.

After the fuel from tank No 8 is withdrawn, the remaining fuel continues to be pumped out. Should the quantity of fuel in the group I drop to 800 liters, a red signal light, "800 liters remaining," lights up on the instrument panel.

The PNV-2G pumps, located in tanks No 2, assure that the remaining fuel is completely pumped out. The pumps are turned on by a switch on the central panel. Green lights, located near the switches, light up at the same time. After the transfer pumping is completed, the green lights are turned off by an impulse from the SDU-2A-0.18 transmitter, and the pumps must be turned off manually.

If necessary, all the engines may be supplied from the tanks in one half of the wing. To do this, the switch opens the cross-over valve, and the overflow pumps are turned on according to the appropriate instructions. The cross-over valve should be closed normally.

The fuel under a pressure of 0.8 plus 1.3 kilograms per square centimeter passes from the overflow pumps through two check valves and through tubing with an inside diameter of 32 millimeters to a "T" fitting located on the front girder of the center section, and subsequently through tubing with an internal diameter of 25 millimeters to the two engines and to the cross-over valve.

2. ENGINE FUEL SYSTEM (Fig. 142)

2.1 Operating Principle

The fuel supplied to each engine passes through fire (shut-off valve) No 762700 to the TF-6 coarse fuel filter, and thence to the 707-I low pressure pump located on the engine.

From the 707-I pump the fuel flows at a pressure of 2.5 plus [to?] 3 kilograms per square centimeter and proceeds through the 12 TF-15 fine filter and fuel gauge to the 661-A (348-I) high pressure pump. Part of the fuel is conducted from the 717-I pump to the solenoid valve which automatically opens when the engine is started. During starting, the fuel passes through this valve to the igniter nozzles.

The fule pressure ahead of the 661 A pump is in the 0.4 plus 3 kilograms per square centimeter range. When the pressure drops below 0.4 kilograms per square centimeter, the red warning signal "minimum fuel pressure" lights on the instrument panel.

The 661 A (348-I) pump supplies fuel to the KTA-5 F fuel control [throttle]. If the KTA does not use all the fuel supplied by this high pressure pump, the unused amount returns to the pump intake. The fuel proceeds from the KTA fuel control assembly to the I and II fuel collector [manifold.]

The fuel needed is supplied by adjusting the KTA assembly control lever assuring the specific consumption.

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3. ENGINE FUEL SYSTEM ASSEMBLIES

3.1 348-I Fuel Pump

The 348-I fuel pump (Fig. 112) is a gear pump powered by a special drive from the engine. The pump supplies fuel to the fuel control assembly [throttle] from which it flows through the fuel nozzle to the engine combustion chamber.

Technical Specifications of the Pump

Model	348-I
Pump power supply	from the engine
Direction of rotation (looking from the of the power supply)	to the right
Maximum rpm	4,840
Minimum rpm	450
Maximum pressure (kg/cm^2)	110
Absolute pressure of the operating fluid when entering the pump, (kg/cm^2)	1.5 ≠ 3.9
Pump delivery (liters/minute)	
a. When "N" equals 4,840 rpm, pressure is 90 kg/cm^2, and intake pressure is 1.5 to 3.9 kg/cm^2	minimum 46
b. When "N" equals 450 rpm, pressure is 15 kg/cm^2, and intake pressure of 3.3 plus 0.6 or minus 0.5 kg/cm^2	minimum 2
Operating fluid	LRX-55, T-1 or TS-1 fuels, or similar grade fuels
Permissable temperatures (degrees centigrade)	
a. Operating fluid	from minus 60 to plus 60
b. Ambient air	from minus 60 to plus 60
Weight of pump (kg)	five

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The pump consists of the following principal parts: body, mounting flange, two gears, roller bearings, power supply seal, movable guides, and power supply.

The housing (29) (Fig. 112), made of a special alloy, contains gears (9) and (18), bronze fixed guides (8) and (19), movable guides (10) and (17), two front (7) and (20) and two rear (14) and (27) roller bearing inserts (26), and bearing cage (15).

The housing is oval shaped and has transverse ribs. The mounting flange (2), cast from AL 3 aluminum alloy, is attached to the housing flange. On the side of the housing are two tube fittings for fuel intake (21), and discharge (22), to which the appropriate tubing is connected. Soft aluminum washers are under the fittings.

Grooves, into which rubber sealing rings (12) are inserted, are cut in fixed guides (8) and (19), and in the rear roller bearing inserts to reduce the overflow of fuel into other parts of the pump. Fuel which soaks through the forward surfaces of the pump junction is returned through channels in the housing to the intake side.

Movable guides (10) and (17) can move along recessed in the pump actuated by spring (16) and the hydraulic forces developed by the pressure of the fluid on the face of the guides while the pump is operating.

The guides are pressed steadily against the face of the gears, and this sets the clearance between the contact surfaces of the gears, guides, and front inserts.

The movable guides have a number of splines on their forward surfaces by which the spaces between the gear teeth are connected with the spaces formed by the forward surfaces of the guides and rear inserts.

To equalize the pressure of the fluid in this area with the variable pressure in the spaces between the gear teeth, the space between the face of the guides and the rear inserts is divided into several secotrs. The sectors are mutually separated by radially distributed brass rollers (11) while inserts separate the sectors on the seals smooth surface of the guides.

Roller and insert are situated in the splines of the movable guides which contain openings into which springs (16) are set.

Since movable guides, which are hydraulically lifted from both face surfaces, and roller an insert seals are used, the clearance of the front surfaces between the gears ans guides is compensated.

The amount of the clearance is minimal, so that during the designed period the hydraulic parameters of the pump are constant.

The constant value of hydraulic parameters of the pump at various ambient temperatures and operating fluid temperatures helps to protect the cast housing.

The case-hardened gears of the pump are made in one piece with the pins which are seated in single row roller bearings.

50X1

Drive gear (9) has a central through-opening with splines for connection with drive shaft (1). To prevent axial displacement, the shaft is fixed by washers (3) and (23) and thrust ring (24), inserted into the circular recess of flange (2).

The drive seal consists of two seals (4) with spring washers (25), pushing the seals against the cylindrical part of the shaft, and drainage [ring ?] (5), through which the fuel from the pump area and the oil from the drive area are taken off to the drainage system of the engine through fitting (28).

Washers (3) and (6) also serve as stops preventing the seals from sliding along the drive (1). Drain ring (5) is tapered on two sides, and the seals rest on it. This arrangement assures the seals from turning inside out under the pressure of the fuel and oil coming from the area of the pump and the drive.

Flang (2) is of AL 3 aluminum alloy, and is fixed to the pump housing (14) by pins. The tight locking of the housing and the flange together is done by two check sleeves. Lead plated foil is used for sealing in the contact.

To assure constant hydraulic values, movable guides (10) and (17) in the pump are pushed against the gear faces by springs (16) and by hydraulic pressure.

The pump is mounted on a flange of the power housing [gear box] lower part of the engine in a horizontal position, with the outlet tube fitting at the bottom.

3.2 707-I Fuel Pump

The 707-I fuel pump (Fig. 113) supplys fuel to the high pressure pump. The pump has two valves, a reduction valve and a by pass valve, which are located in the reduction chamber.

The pump has a 70 by 70 millimeter flange and a splined shaft which couples to the engine.

Technical Specifications of the Pump

Direction of rotation .... To the right

Number of rpm

a. maximum 2,280

b. minimum 1,855

50X1

Operating fluid	LRX-55, T-1, TS-1, or other equivalent fluid
Absolute pressure on entry to pump (kg/cm^2)	0.23 plus 2.05
Discharge pressure, (kg/cm^2)	2.5 to 3
Temperature of operating fluid (degrees centigrade)	plus or minus 50
Required power input (horsepower)	one
Weight of the dry pump, (kg)	four

3.2.1 Pump Design

The pump is on centrifugal design, with four nitrided blades set at right angles to each other, set in slots in the rotor. One end of the blades rests on a floating hardened steel pin, and the other rests on the inner surface of the nitrided casing. The chamber of the casing is cylindrical.

The steel nitrided rotor is inserted in the bronze guides by its pins. The "cerpaci usel" [literally "pumping junction," possible "pump chamber" or "pump coupling"] is sealed by a rubber ring (14) (Fig. 113) around the outside edge of the front face, which is pressed to the pumping chamber by the face side of the nut of cuft 13.

Pumping chamber (7) is set in the cylindrical resess of housing (25) cast from AL3 aluminum alloy. The position of the pumping chamber in the body is secured by a pin.

To prevent the fuel from leaking from the pumping chamber to the power drive, and the oil from leaking from the power drive area to the pumping chamber, the power drive area in the body has sealing around it. The sealing [or packing] cuff consists of duraluminum nuts with a 68 by 1.5 millimeter threading into which rubber cuffs are pressed.

Splined steel nitrided shaft (10) transmits the rotary motion from the engine drive to the pump rotor clearance.

Rubber seal ring (11) is inserted in between the pump body and the nut cuff (13). The nut of the cuff is secured by rings (8) and (9). Drainage ports are located between the seals to check whether fuel is leaking from the pumping chamber and oil is leaking from the drive box.

A reduction chamber, cast in one piece with the housing, is located on the side opposite the flange. The chamber contains a reduction valve and a by-pass valve integrated into one unit.

The operating cone of the reductio[redacted] the seating in the reduction chamber, and the cylindrical part engages into the recess of the guide feed head.

The by-pass valve releases fuel filling the lines before the engine is started so that in case the 707-I pump should stall, the overflow pump could deliver through the by-pass valve sufficient fuel for the normal operation of the engines.

Nine 7.5-millimeter diameter openings are in the valve cone to allow the fuel through when the line is being filled. The by-pass valve is constrained by a spring resting on a support which is held by a thrust ring.

Flat diaphragm (16) of rubberized fabric, is fixed between the disk of reduction valve (6) and spring (18) with the aid of springs (4). The outer edge of the diaphragm is clamped between housing (25) and cap (5) of the pump by six bolts secured by lock washers.

The reduction valve is adjusted by [threaded disc ?] (3), by means of screw head (2), secured by protective cap (1). The cap [cover-(5)?] contains a plug with an air passage [17?] to the space above the diaphragm. The K1/8 tube fitting is screwed in instead of the plug in case the pressure must be brought in to the area over the diaphragm. The fitting has a 42 by 1.5 millimeter threading for assembly of the inlet and outlet elbows.

The fuel for the engine ignition nozzles is drawn off by fitting (19) screwed into elbow 20, drawing the fuel off to the 348-I high pressure pump.

Pump rotor (21) with vanes (24), and floating pin (22) divides the internal area of casing (23) into two sections: the intake side A and the output side B (Fig. 113). Since the rotor of the pump is set eccentrically in the internal recess of the casing, the volumes of the intake and output sides change continually.

If the rotor turns in the direction of the arrow (Fig. 113), the area formed by the moving vanes is filled with fuel from the intake side.

Figure 113 illustrates the moment when a specific quantity of fuel, which will be pushed out by the vanes to the outlet side with further rotation of the rotor, is held between the blades. During a single revolution of the rotor, four such quantities are pushed out. When the pump is not operating (and also during checking of the full output of the pump) reduction valve (6) is pushed to the seating, and separates the output and intake sides.

When the pump is operating, a positive pressure of fuel builds up in the output area, which reacts on the surface of the reduction valve, opening it, and compressing spring (18). As a result of this, the output and intake sides of the pump are connected and part of the fuel from the pressure area flows through the opened ports to the intake area. The supply of fuel is automatically reduced by this, and the selected pressure, which depends on the amount of loading on the spring of the reduction valve and the excess quantity of fuel (which must be transferred), is maintained in the supply tubing.

50X1

Constant delivery pressure is maintained by diaphragm (16) of the reduction valve. The area above the diaphragm is connected with the atmosphere by opening (17). With a drop in fuel level in the tanks or with a change of atmospheric pressure, the pressure in the intake lines will be changed by some extent. If diaphragms were not used, the pressure of the fuel being supplied would drop by the same amount, because the pressure acting upon the reduction valve from the intake side would be reduced by the same amount. If diaphragms are used, the delivery pressure does not drop, because with the drop of pressure in the intake line, the diaphragm delivers additional pressure to the reduction valve. The amount of this pressure is proportional to the effective area of the diaphragm, and since this area is about the same as the area of the reduction valve, the forces which act upon the valve and diaphragm balance out.

At higher altitude, the 707-I pump operates with intake pressure produced by the overflow pump installed in the fuel tanks.

3.3 KTA-5F Fuel Control Assembly [Throttle]

Requirements set for Throttle Unit KTA-5F

1. It limits the maximum output of the engine by limiting the supply of fuel. 2. It limits the supply of fuel when the engine is started so that the temperature should not exceed the permissible limit before entering the turbine. Supply of fuel according to the prescribed characteristics curve is done by the engine automatically in the idling phase. 4. The automatic limitation of fuel supply limits the idle RPM (10,400 revolutions per minute). 5. Supply of fuel according to the prescribed characteristics curve with the rapid shift of the throttle lever to the "start" position automatically puts the engine in the starting phase. 6. The automatic limitation of fuel supply limits the maximum permissible revolutions of the engine. 7. The throttle automatically corrects fuel consumption according to altitude. 8. It automatically corrects fuel consumption according to plane speed. 9. It automatically corrects fuel consumption according to the temperature of air entering the compressor. 10, It automatically maintains the constant output of the engine in each mode to the point of maximum output. 11. It delays a change in fuel supply during rapid withdrawal of gas [sic]. 12. It transmits the hydraulic signal to the VE-28 assembly to turn off the starter generator according to the revolutions of the engine. 13. It automatically maintains constant gas inlet temperature at the turbine at each mode above the amount of limited output. 14. It controls the opening and closing of the compressor air bleed valves. 15. Beyond 0.7 nominal mode it prepares the electrical system of the

engine for automatic feathering when t[redacted] 0.1 of the nominal output. 16. It automatically turns on and off fuel supply to the fuel manifold of the second stage of the operating nozz 50X1 17. It stops the supply of fuel to the engine during feathering. 18. It locks automatic feathering system during negative torque in phases, according to UPRT [abbreviation unidentified] under 18 degrees plus 2 degrees.

Basic Technical Spefifications of the KTA-5F Throttle

Operating fluid:	control part	Oil from the engine system
	fuel part	type of fuel prescribed for the engine
Power input (maximum)........................		6 horsepower
Control of the unit:	Lever controlling the fuel supply	Shifting the lever from the "idle" position to the "start" position changes the engine mode
	Ignition electromagnet [solenoid?]	When energized the fuel supply to the starting nozzles starting of the engine is cut.
	Electromagnet for stopping the engine	When stopping the engine and when feathering the electromagnet is energized and the fuel supply is interrupted
	Emergency engine shut-off	Accomplished by bringing in nitrogen to the gate valve for emergency engine shut-off
Maximum pressure of fuel upon entering the KTA-5F when L = 100 degrees plus 4 degrees		95 kg/cm^2
Maximum pressure of fuel from KTA-5F when α= 100 degrees plus 4 degrees		78 kg/cm^2

KTA-5F Oil Pump	Gear type powered by the engine, the revolutions of the pump corresponding to the working revolutions of the engine-5,250 rpm; output at 5,500 rpm is a minimum of 3,500 liters per hour; oil pressure on leaving the pump at 5,500 is a constant 15 ± 1 kg/cm^2, and is controlled by the reduction valve, while the pressure of the oil entering the pump is the same as the pressure in the engine oil system.
Oil Filter	Screen type, with 0.025 millimeter openings, consisting of 34 ± 39 [ond?] disks.
Fuel Filter	Screen type with 0.02 ± 0.035 millimeter openings, consists of 32 ± 37 disks.
PT-10 Heating Element Insert..................	Hydraulic
Aneroid [Presumably barometer] reacting to change (P^{*}_{H} - P_H) and P_H (upper)	A)-4, capsule type, consisting of two cells
Aneroid Reacting to P^{*}_{H} (lower)	ADT-2A, capsule type, consisting of two cells
Throttle Position Indicator	The position of the throttle is determined on a scale located on the KTA-5F. The scale has a 105 degree arc, divided into two degree segments.

The supply of fuel to the KTA-5F is controlled by a fuel positive pressure governor on the feed setting section of the throttle valve. The governor elements are moved by the oil supplied by a pump with a centrifugal governor.

A diagram shows Nos 1-50 as the gov[redacted] of the governor elements is used in the instructions concerning the regulation and use of fuel control units. No 51 and above are used in 50X1 text of the description below.

Individual Parts of the KTA-5F Throttle, and Their Operation

3.3.1 <u>Fuel positive pressure governor</u>

An impeller pump, which is specially mounted on the engine, supplies fuel to the KTA-5F. The fuel passes through check valve (163), filter (164), and proceeds to the governor which regulates the supply of fuel to the nozzles by releasing the fuel supplied by the pump. A change in the supply of fuel according to the prescirbed regulations, is done by changing the feed setting openign (51) while a constant difference in pressure before and behind the opening is maintained.

The body of throttle valve (52) has a square shaped opening (51). The size of the opening changes by overlapping of the openings in the throttle valve in the slide motion as well as the rotary motion. The square shape of the opening does not change meanwhile.

The constant difference of pressure in front of and behind the feed setting opening in the throttle valve is maintained by gate valve (53). The pressure before the throttle valve acts on one side of the gate valve, while the pressure bheind the throttle valve, brought in by channels (54) and (55), acts on the other side of the gate valve.

The pressure of spring (56) determines the difference in pressure while the fuel flows through the throttle valve. If the difference in pressure increases, gate valve (53) moves to the right, and reduces opening (57), through which the fuel passes to the throttle valve. In reducing the difference of pressure, opening (57) is enlarged on the other hand.

Excess fuel delivered by the pump is released by gate valve (58) through opening (59) at the fuel pump intake. Fuel, under pressure, behind [?] the throttle valve, which is brought in by channels (54) and (60), comes into this gate valve from one side. The force on gate valve (58), resulting from the difference of these pressures, is controlled by spring(61).

If the difference in pressures increase[redacted] the right, and the outflow of fuel from the KTA-5F through opening (59) increases.

When the difference of pressures diminishes, the gate valve shifts to the left, reducing opening (59) and reducing the amount of fuel released from the KTA-5F.

Attenuates (62) and (63) restrict the pulsation in the pressure of the fuel in the system. To restrict the leakage of fuel through the clearance between gate valves (53) and (58) and their liners into area (64), and from area (65), the gate valves contain slots (66) and (67) to which fuel under pressure is brought from passage (54) i.e., behind the throttle valve.

Without these slots, the pressure of the fuel in area (64) could be greater, and that in area (65) could be lower than that in passage (54), [as a result of] fuel leaking through the clearance and the throttling effect in attenuators (62) and (63) which would thus complicate normal positive pressure and regulation of fuel. Screws (1a) and (1b) serve to adjust the amount of positive pressure.

The governor maintains the minimum unbalance both for the difference in pressures of the fuel supplied, and the pressure of the fuel in the system. To attain the same weight consumption of fuel, it is necessary to change the difference in pressures in the throttle valve. This is done by a corrector for standard weight situated on screw (1a). When screw (1a) is screwed into threaded sleeve (9) the loading on spring (56) is varied. The scale indicates standard weights from 0.73 to 0.85 kilogram per square centimeter, with graduations at 0.03 intervals.

3.3.2 Oil pump with centrifugal governor

The KTA-5F oil pump increases the oil pressure, and delivers oil through screen filter (168) to the working mechanisms. The reduction valve (69) maintains a constant pressure (15 - 16 kilograms per square centimeter) in the oil system of the KTA-5F.

The pump shaft contains a fork with weights of the centrifugal transmitter of revolutions (70). The centrifugal force of the weights changes the operating pressure to the control pressure of oil P_p, which is transmitted to the governor elements. The conversion of centrifugal force to control pressure is done by gate valve (71).

Weights in the shape of angular lever arms act on gate valve (71), moving it to the right, when the number of revolutions increases. At the 50X1 same time, the middle collar on the gate valve opens orifice (72) through which oil from the pump, at a pressure 15 - 16 kilograms per centimeter, flows through the system of passages shown on diagram P_p. As soon as the pressure in these passages (and in area 73) increases, and the force acting upon gate valve (71) overcomes the centrifugal force, the gate valve is shifted to the opposite side, and occupies a central position, in which the force of the weights and of the oil is in equilibrium. The collar of gate valve (71) has axial play in the liner for smooth change of the control pressure P_p.

This method maintains the oil pressure P_p in the system, proportional to the number of revolutions of the oil pump. The character of changes of the control pressure P_p is shown on Figure B.

3.3.3 The regulation of fuel supplied at various engine modes

The fuel control unit provides programmed regulation of fuel supply to the engines according to the following parameters: a. according to the static pressure P_H, total pressure P_H^*, and temperature T_H^* of the air entering the compressor; b. according to engine mode.

Figures C, D, E, F, and G illustrate the characteristics of changes in fuel supply at all these parameters.

The analytical expression of delivery of fuel G is given in the following equations:

1. $$G = \left\{ G_o \left[a + b_{ph} - v \left(b_{vst} P_H^* - p_H\right)\right] - \Delta G \right\} C;$$

2. $$G = \left(\frac{G}{P_H^*}\right) \cdot A \cdot b_{vst} P_H^* C;$$

where $\Delta G = d\,(t_H^* - 25^\circ C)$ (for $t_H^* \leq 25^\circ C$, $\Delta G = 0$)

$\frac{G}{P_H} - 1$ when $t_H^* = 21.77^\circ C$

a, b, v, d are constants.

The other values are given by the above-mentioned characteristics [curves]. 50X1

Regulation according to the first law assures supply of fuel to maintain constant engine performance (to the point of maximum output). At higher altitudes, when the supply of fuel is limited by the temperature of the gases in front of the turbine, the regulation is done according to the second law.

As was mentioned, the change in fuel supply is done by throttle valve (52) which overlaps the fuel opening in liner (51) while a constant difference in pressure before and behind this opening [is maintained].

The consumption of fuel passing through the throttle valve is determined by the position of the control lever (74) at the various phases, turning by means of the transmission in the liner of the throttle valve.

The change in the fuel supply according to pressure P_H and p_H^* and temperature t_H^* of the air entering the engine is done automatically by movement of the throttle valve. The transmission from the control lever (74) to the throttle valve is done through a retarder.

The retarder is turned by shaft (75). Cam (76) on the shaft (75) turns the system of levers (77, 78, and 79), the last of which turns the throttle valve. The cam is necessary to change the consumption of fuel according to the prescribed relationship "C equals f (α_v) (see figure D), where α_v is the angle of alignment of the control lever.

Spring (80) secures contact of the lever system with the cam (76) by a tie rod. Screw (8), shifting tie rod (81) with the roller, permits limited changes in the relationship $C = F(\alpha_v)$. The throttle valve is shifted along the axis by servo-piston (82), which follows the movement of gate valve (83).

On the right side, the pistons is actuated by oil flowing to the cylinder of the servo-piston through "a" nozzle, and on the left side is actuated by the force of spring (84).

The position of the piston is determined at each instant by an equilibrium of forces on both sides of the piston which is possible only with imperceptible release of oil from the cylinder of the piston by opening (85), formed by throttle edges of the gate valve and piston.

Gate valve (83) is controlled by two aneroid instruments and a thermal insert (88). Instrument (86), regulating the supply of fu 50X1 according to the equation $G_T = G_{TO} [a + b_{PH-v} (b_{vst} P^*_H - P_H)]$, consists of two capsules, the barometric and manometric. It is located in the chamber connected with outside pressure (P_H). Pressure (P^*_H) is conducted into the barometric capsule.

The capsule, through rocker arm (89), limits the movement of gate valve (83) to the left, i.e., to increase fuel supply. There is play between gate valve and the lever which corresponds to the phase in which the fuel supply is regulated by instrument (89). In this way the position of the lever is changed according to the air pressure P_H and difference in air pressure $P^*_{H*} - P_H$. A smaller fuel supply, and conversely, corresponds to lower pressure P_H and greater difference $P_H - P_H$ respectively.

The thermal correction (Δ G), during regulation according to equation one, is done by thermal insert (88). The thermal insert is fanned by the air stream from an air intake located behind the cover. The thermal insert picks up the air temperature, and reacts to changes in temperature by shifting the tie rod in regard to the body. Lever (91) is held in contact with the tie rod by spring (90). A lug on the lever (91) is connected to guide (92), which turns on axis (93). At the same time, by means of spiral splines on the axis, the lug [?] shifts to the right, and changes the position of shackle (94) with rocker arm (89).

With a rise in temperature, rocker arm (89) shifts gate valve (83) to the right, and reduces the supply of fuel, over the entire characteristic [curve ?] according to phases, to the maximum output of the engine.

The direction and lead of the spiral splines on the axis (93), correspond to the size and sign (Δ G) of the prescribed correction according to temperature. Screw (36), with screw transfer, handles the initial regulation of fuel consumption for the phase up to the limited output. Screw (37) adjusts temperature $t^*_H = 25^oC$, above which correction is necessary.

Aneroid instrument (87) changes the supply of fuel according to the total pressure of the air entering the engine. The instrument, with the help of lever (95), acts upon gate valve (83). When the air pressure in the chamber of aneroids (87) falls, the aneroids expand, and the lever, containing fulcrum (26) in the center, shifts gate valve (83) to the right, cutting the fuel supply. At this time, rocker arm (89) is not in contact with gate valve (83).

Fulcrum (26) is a sliding type. It is fixed to cam (96), and can be shifted, changing the transmission from the aneroids to gate valve (83). Cam (96) is moved by thermal insert (88) through lever (91). The shape of the cam is calculated so that the shift of fulcrum (26) corrects the supply of fuel according to the air temperature, according to the prescribed equation $A = f(t^*_H)$. (Figure E).

With regulation according to equation (2), the supply of fuel at high altitudes might be very small. To make the operation of fuel nozzles reliable, the KTA-5F does not cut the supply of fuel below a certain limit. Therefore, located here is a regulating stop (5), which limits axial displacement of the throttle valve when reducing the supply of fuel.

3.3.4 Restricting maximum RPM

The maximum engine rpm is limited by cutting the supply of fuel to the engine. The KTA for this end contains gate valve (97) and piston (98) controlled by the gate valve. Control pressure P_p, which depends on the revolutions, is brought into the cylinder of gate valve (into area 99). When the revolutions of the engine are at their maximum, the control pressure depresses spring (100), shifts gate valve (97) to the right, and opens the intake of the operating oil to passage (101). Through passage (101), the recesses, and openings in piston (98) oil flows to area (102) and moves the piston to the right. The piston, by means of tie rods, lever (78), and guide (79), rotates the throttle valve for a reduced supply of fuel. As soon as the number of revolutions drops, the pressure of the control oil drops, and gate valve (97) shifts to the left, blocking the supply of fuel to area (102), while at the same time opening the drain of oil from this area, spring (103) shifts the piston to the left, and spring (80) shifts the throttle cock for more fuel. Screw (14) regulates the prescribed maximum revolutions.

3.3.5 Regulation of idle rpm

The idle mode is regulated by control lever (74) being set at stop (44), corresponding to angle $\alpha v = 0$. At the same time, the governor for maximum revolutions is set to regulate idle rpm. The setting is done by cam (105), which through lever (106) reduces the prestressing of spring (100). Lever (106), when the control lever in the idle position, contacts stop (15), which is used to precisely adjust idle rpm. To avoid over-regulation, there are limits to the changing of fuel consumption at idle rpm.

Maximum consumption cannot be greater than the consumption afforded by cam (76) when $\alpha v = 0$ (Figure F). Minimum consumption is afforded when piston (98) is checked hydraulically, i.e., when the piston is in the position when the supply of fuel is reduced, to cover the duct (101), and the supply of oil from area (102) is blocked, while the supply of fuel is not reduced. Screw (19) makes it possible to adjust the amount of this consumption.

3.3.6 Changes fuel supply with mode change

The fuel control unit makes possible delayed reduction and graduated supply of fuel to the engine when the setting of lever (74) is quickly changed. The delayed reduction of phase from control lever (74) to cam shaft (75) is done by a retarder.

Gradual acceleration is actuated by shifting stop (135). In moving lever (74), attached to the shaft with wheels (107), bar (108) is relocated.

Guide (109), containing gate valve (110) controlling the supply of fuel to the cylinder of the servo-mechanism, is fixed to the end of the bar. The fuel is brought to the servo-mechanism by gate valve (112) which maintains constant pressure, of 10 - 12 kilometers per square centimeter, in the retarder. If the pressure in the valve exceeds 10 + 12 kilograms per square centimeter the gate valve is shifted upwards, and shuts off the supply of fuel from the retarder. When the pressure of the fuel is below 10 - 12 kilograms per square centimeter, the gate valve moves downward under the pressure and opens the fuel intake. A constant pressure of fuel is necessary for the stable operation of the retarder.

Fuel passes from the passage through an opening in liner (113), and an opening in piston rod (114), to slots (115) on gate valve (110).

From the slots, the fuel can pass through openings (116) and (117) to the cylinder either from the right or left side of the piston, according to the shifting of the gate valve in regard to openings (116) and (117). If guide (109) shifts gate valve (110) to the left, slot (115) is connected to opening (116), and the fuel under pressure advances to cylinder (111) from the right side of the piston, and the fuel from the left side of the piston passes freely through passage (118) and openings (117) to slot (120), and from there to the outlet. Under the pressure of the fuel, the piston and piston rod (114) also shift to the left.

Under pressure of the fuel, the piston will continue to move as long as opening (116) is connected with slot (115). If gate valve (110) is shifted to the right by guide (109), the fuel flows under pressure from slot (115) through opening (117) to cylinder (111), left of the piston. The fuel in the cylinder right of the piston is pushed out through the throttle insert to outlet. Piston rod (114) has teeth into which the small gear (124), attached to shaft (75), engages. The diameter of wheels [presumably gears] (107) and (124) fixed to shaft (75) [sic]. The diameter and number of teeth of gears (107) and (124) are identical. Therefore shaft (75) according to the size of the angle and the sense of rotation, follows lever (74), but with a time delay.

The period of delay during withdrawal of gas is controlled by the resistance of throttle insert (122), and is about 8 - 10 seconds. The delay in shifting shaft (75) causes the delayed supply of fuel. 50X1

3.3.7 The control of fuel supply during starting

When starting the engine, control lever (74) is in the idle position (44) ($\alpha = 0$). The position of lever (74) for low fuel feed at the characteristic of $G = f(\alpha v)$, when $\alpha v = 0$. (Figure D) corresponds to a specific supply of fuel. However, up to the moment of ignition, and when the starter is actuated, as long as the revolutions of the engine are less than 1,000 to 1,400 rpm, throttle valve (52) is closed.

The throttle valve is held in this position by a strong spring (126), through tie rod (127), lever (70), and guide (79). When the number of revolutions increases, the supply of oil from oil pump (68) also increases, and the operating pressure increases to the point where valve (123) opens, and oil from area (129) flows to area (133) through passage (130) and recess (131) in the casing of gate valve (125) of passage (132).

Electromagnetic valve (153) connects this area with the outlet. After 15 seconds, electromagnetic valve is turned off, and the outlet from area (133) is closed.

Piston (134), under oil pressure, forces down spring (126) and shifts to the left, releasing lever (78). Spring (80) opens the throttle valve, and fuel supply to the engine begins.

As soon as piston (134) opens throttle valve (52), stop (135) which does not permit the supply of fuel to rapidly increase consumption for the free running phase, starts to control it. The stop limits the supply of fuel for each engine speed, because its position depends on the revolutions of the drive. Stop (135) is found in piston (136), which shifts under the pressure of the oil entering the cylinder through nozzle "d".

On the right side, the piston is shifted by the strong spring (137). The movement of the piston controls gate valve (138) which opens or closes the oil outlet from the area of the cylinder. One side of the gate valve is affected by the pressure of the controlling oil P_p and spring (139), while spring (140) acts from the other side.

The toothed rod on the piston rod of piston (136) turns cam (142), through gear (141), which through lever (143) depresses spring (140) 50X1 brings the gate valve to a position of equilibrium. For example, with the higher number of revolutions, the control pressure also increases, and gate valve (138) shifts to the right, blocking the outlet of oil from the cylinder of piston (136). The piston with stop (135) shifts to the left, and spring (80) shifts the throttle valve for a larger supply of fuel.

Cam (142) at the same time depresses spring (140) and shifts gate valve (138) to the position where the outlet of oil in the cylinder area will be equal to the intake of oil through nozzle "d".

The position of stop (135), and simultaneously the supply of fuel according to the revolutions of the engine depends upon the pressure of the cam (142), and the position of piston stop (136). The characteristics curve of fuel supply according to revolutions is shown on Figure H.

After idle revolutions are achieved, the supply of fuel is limited by the previously described idle governor. Nozzle "b" and screw (22) serve to regulate the revolutions, during which the intake of oil to the control part of the assembly is opened.

The "b" nozzle releases oil supplied by the pump, and the oil pressure above the valve drops when valve (128) is shut. The revolutions of the pump when valve (128) opens, depend upon the size of the nozzle in this method.

Adjustment of the unit according to the characteristics curve on Figure H is done by turning stop (135), which shifts the prescribed characteristics curve upward or downward. This screw is No 16. Screw (17) changes the compression of spring (139), and shifts the characteristics along the axis of rotations.

When the engine is stopped, electromagnetic valve (153), which opens the outlet from area (133) is energized. Spring (126) shuts the throttle valve, stopping the supply of fuel.

3.3.8 The restriction of fuel delivery on intermediate modes

When the engine is started, stop (135) limits the supply of fuel for bringing the engine to the idle mode α v = 0...

The same stop limits the supply of fuel when bringing the engine into a working mode (α v $\geq$ 15°, according to UPRT [not identified]).

Movement of stop (135) to the left with increasing revolutions of the engine will continue until the stroke of piston (136) is checked by the stop on piston (173). 50X1

This position of stop (135) will correspond to a consumption of fuel equal to (60 - 70) percent of the starting consumption. Further shifting of stop 135, which entails greater consumption of fuel with the increased number of revolutions, is blocked as long as the closing of valves does not go beyond, [presumably valves do not remain closed beyond] the fifth stage of the compressor.

Piston (173) is the movable stop of piston (136), and its position is controlled by the pressure in area (175). The pressure is brought from the system controlling valves bleeding air from the compressor. Up to the moment of shut-off of valves bleeding air beyond the fifth stage of the compressor, piston (173) is depressed up to the recess of casing (172). At the instant of shut off of the air bleed valves beyond the fifth stage of the compressor, oil under pressure is released from tubing (176) by gate valve 160 to the outlet. Oil from area (175) will also flow to the outlet through the throttle insert of retarder (174). The throttle insert [flap ?] assures the smooth shifting of piston (173) in 3 to 6 seconds, from the stop on the insert recess (172) to the stop on the adjusting washer " ". At the same time, piston (136) with stop (135), follows the movement of piston (173), and assures, after shutting off air bleed valves at the fifth stage of the compressor, a smooth increase in fuel supply up to the initial consumption in 3 to 6 seconds. After the maximum revolutions are attained, the governor (gate valve (97), piston (98)), starts operating, and cuts the supply of fuel.

The governor increases the supply of fuel and thus the rotor torque.

3.3.9 Turning on and turning off the second stage operating nozzles

Engagement of the second stage of the operating nozzles is done according to the pressure of the fuel behind the throttle cock in passage (144). In addition, the second stage operating nozzles is turned on and off independently of the pressure of the fuel behind the throttle valve, according to the C.A.P_H^* valve. Because the air temperature (coefficient A) does not change noticeably at higher altitudes, the turning on and off of the second stage will depend chiefly on the altitude of the plane.

The change-over switch is made in the shape of a valve (145) with 8 to 10 kilograms per square centimeter, the valve compresses the spring, and, on opening, switches on the second stage of the operating nozzles.

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As a result of the difference in areas on which the pressure acts up to and after the opening of valve (145) the valve closes at a lower pressure. 50X1

Screw (2) adjusts switching on of the second stage at the prescribed pressure. Turning off the second stage nozzles according to the planes altitude is done by the same valve (145), with the help of gate valve (147), which shifts the same time as the throttle valve. When the plane is climbing, the throttle valve shifts to the right, and when gate valve (147) opens passage (148), fuel under pressure flows from passage (149) (from the area in front of the throttle valve) to area (150), and gate valve (145) closes and switches off the second stage nozzles.

Screw (3) adjusts the turn off at the prescribed consumption of fuel and αv [angle-setting of control lever, possibly].

3.3.10 Automatic feathering system and fuel cut-off when feathering

For all types of automatic and emergency feathering, the supply of fuel to the engine is automatically shut off.

The supply of fuel is stopped by draining oil from area (133) of the hydraulic arrestor. At this time, piston (134) shifts to the right under the pressure of spring (126), and closes the throttle valve.

The oil is drained from area (133) either by gate valve (125) (during emergency feathering) or by electromagnetic valve (153) which is energized (during automatic feathering).

The throttle assembly operates the automatic feathering system with the help of shaped cam (154), according to the IKM [torquemeter] (according to the output of the engine) at phases below 0.7 of nominal, and the system of automatic feathering during negative torque at phases $\alpha_v < 18^{+2^{\circ}}$.

The automatic feathering system according to IKM at phases less than 0.7 of the nominal, is operated by disconnecting the contacts of disconnect switch KV-9 in the circuit of electrical automatic units of the feathering system, according to IKM over $\alpha_v < 56^{\circ}$. Screw (9) sets the instant of contact of the KV-9 circuit breaker contacts.

The automatic feathering system, during negative torque at angles $\alpha_v < 18^{\circ} + 2^{\circ}$, is operated by diverting oil from area (171) through openings in liner (170).

When the control lever is turned to the $\alpha_v \geq 18^{\circ} \mp 2^{\circ}$, cam (154), through lever (169), and tie rod shifts the gate valve to the right, the outflow of oil from area (171) is stopped, and the gate valve [which actuates] automatic feathering during negative torque of the rpm governor is set into the position where it is ready for automatic feathering at the start of negative torque on the propeller shaft. 50X1

3.3.11 Reduction of fuel supply during ignition

The normal supply of fuel during starting is controlled by the previously described stop (135), according to the relationship on Figure H. In individual cases, it is necessary to reduce this supply for a brief period. Therefore, electromagnetic valve (156), which, when the current is turned on transfers part of the supplied fuel from the first stage operating nozzles back to the intake of the fuel pump, is set in the throttle assembly. Nozzle (157) limits the amount of transferred fuel. This amounts to about 25 percent of the supply.

Fuel passes through check valve (158) on the way to electromagnetic valve (156). The check valve opens the fuel intake to the electromagnetic valve during starting. After ignition, valve (158) shuts off fuel intake to electromagnetic valve (156), under fuel pressure. Without valve (158), valve (156), having a weak spring, would allow part of the fuel to enter the low pressure passage.

3.3.12 Control compressor air bleed valves

Two gate valves, (159) and (160), which switch on or block the supply of oil to each valve, are located in the KTA to control the air bleed valves on the compressor when starting and running up the engine to maximum rpm.

With a small control pressure (at lower number of revolutions) the gate valves are depressed, and openings (161) and (162) stay open. As soon as valve (128) opens, oil passes through these openings to the valves and these open. At high rpm, gate valves (159) and (160) move downward, block openings (161) and (162), and connect the valves with the outlet (they close).

Compression of springs under the gate valves (screws 20 and 21) govern the number of revolutions at which the valves that bleed air from the compressor are closed.

The valves at the 8th stage of the compressor close at 8,500, plus or minus 150, revolutions per minute.

Survey of KTA-5F Adjusting Screws and Their Functions

50X1

Screw 1a	Conducts proportional change of fuel supply for the entire characteristic curve (by change of positive pressure). Screw 1a adjusts only the altitude characteristics curve above the value of the limited output.
Screw 1b	Changes the positive pressure of fuel at the throttle valve (change in the transfer of fuel from the KTA to the outlet).
Screw 2	Sets the moment of switching on the second stage operating nozzles (according to the fuel pressure).
Screw 3	Sets the moment of switching off the second stage operating nozzles according to consumption of fuel (depending on the altitude of the airplane).
Screw 5	Sets the minimum fuel consumption during climbing.
Screws 6 and 44	"idle" stop
Screw 7, 45, and 46	The "start" stop. It changes the consumption of fuel at the starting phase.
Screw 8	Changes the pitch of the fuel characteristic curve
Screw 9	Sets the moment of turning on the circuit for automatic feathering according to the torque in relation to engine mode
Screw 14	Sets maximum engine rpm
Screw 15	Changes the idle rpm
Screw 16	Changes the minimum fuel consumption during starting since it changes the opening of the throttle valve by rotating it
Screw 17	Changes the time needed to bring the engine to the idle mode during starting
Screw 19	Handles the change in the minimum consumption of fuel during the operation of the limiter of maximum revolutions.
Screw 20	Changes the instant of closing the air bleed valves of the compressor, stage VIII

50X1

Screw 21	Changes the instant of closing the air bleed valves of compressor stage V
Screw 22	Changes the start of supply of oil to the KTA mechanism in relation to rpm
Screw 23	The reduction valve of the KTA oil pump. It handles the change in operating pressure in the KTA
Screw 24	Handles the change to the point of the limited output
Screw 36	Handles the change of consumption of the engine to the point of limited output of the engine
Screw 37	Handles the change at the start of correction of fuel consumption according to the temperature of the air entering the engine

Comment: Screws 3 and 5 are jound under the same cover (screw 3 is inside screw 5)

3.4 Fuel tanks venting

The fuel tanks have a dual venting system

The primary venting is done by a 22 by 20 millimeter tube, leading to the upper points of tanks 6, 8, and 10, and the auxiliary venting is done by a 22 by 20 millimeter tube leading to tanks 2, 8, and 10.

Check valves are located on the auxiliary venting to prevent fuel from being sprayed or any siphoning from developing.

In addition, all the tanks of a group are interconnected with internal air vents. To prevent fuel from spraying from the venting of the first group of tanks, tank 6 is vented to tank 8, in which the venting tubing forms a loop. Therefore, the main venting of tank 8 is conducted out from the wing, where it is covered, by a loop.

The tips of the air vent tubes have an inside diameter of 32 millimeters, and have an outlet under the bottom skin of the wing behind the rear spar. The tips are adjusted at an angle less than 45 degrees to the direction of flight. As a result of the large diameter of the venting tubes and the bias arrangement, the danger of icing is lessened, and the negative pressure rubber valve, located on the wenting tubing within the wing, serves as additional protection. The valve opens when there is negative pressure in the tanks, and draws air in from within the wing.

The fuel and venting tubing is made from AMgM and S20 tubing. The tubes are joined by "durit" [duraluminum ?] joints with [two] slee 50X1 t both ends. The "durit" joints have metal bridging-over.

Connection with the engine is accomplished by flexible hosing with heat insulation, consisting of two layers: the inner layer is made of AT-7 asbestos cloth, and the outer of ANCM fabric. Both ends of the hoses have yellow colored circular slips.

3.5 Fueling the tanks

Filling of tanks in both halves of the wing is done separately, and can be done in two ways: from above, and under pressure from below.

3.5.1 Gravity fueling

Fueling (138) is done through six necks, three on each half of the wing. The main Group I, tanks are fueled through necks in tanks No 6 and 8. The auxiliary Group II tanks are fueled through a neck in tank 10.

Access to the necks is through openings on the top surface of the wing. To dump overflow fuel from the housing which insulates the neck from the wing, a tube with an inside diameter of 10 millimeters, is led out under the wing.

The necks contain a screen to prevent foreign materials from falling into the tank during fueling. Rubber lids are on the necks to prevent dampness from entering the necks.

A measuring rod is screwed in besides the fueling neck. With full fueling, free space must be left to permit expansion, in the following manner: in tank 6 about 60 liters, and in tank 10 about 40 liters, which means that the level of the fuel must be 30 to 40 millimeters below the edge of the neck.

To total volume left unfilled in all the tanks is about 200 liters. Tank 8 is filled up to the edge of the filler neck, and therefore about 60 liters of free space still remains.

3.5.2 Fueling under pressure from below

Fueling the tanks of the right and left halves of the wing is done separately (Figure 139). The fuel enters through a neck, located on the right side in the landing gear wells. A control panel, which has a cover, is found beside the necks.

50X1

The panel contains: the main disconnect switch, three cross-over switches controlling the valves, the fuel gauge cross-over switch, and six signal lights, of which three are green to signal opening of the valves and [three] are red to signify closing of the valves.

Tubing, 50 by 48 millimeters leads from the neck, from which three tubes, 40 by 38 millimeters, separate to the N1 760400 and 760600 shutoff filling valves, controlled by the MZK-2 electro-mechanism. Fuel passes through these to tanks 6, 8, and 11.

To prevent the tanks from overflowing in case of valve malfunction and to ensure that fuel delivery automatically slows down at the end of the fueling operation, a floating valve, which after reaching the maximum level cuts the supply of fuel to the tanks, is located on the intake filler pipe couplings of these tanks.

Group I tanks, and tanks 1 to 7 are filled through tank 6. Tank 8 is filled separately through its own tubing and valve. Auxiliary Group II tanks are filled through tank 11.

In the crew's cabin, the change-over switch located on the ignition panel is set on the "fueling from below" position, and then the electrical system is switched on by the main disconnect switch [sic] on the control panel in the landing gear shaft [well ?], and the red signal light "valve closed" lights up.

The remainder of the fuel in the tanks is checked according to the indicator of the fuel gauge. The cross-over switch opens the filler valves of the groups of tanks which are supposed to be filled. The appropriate red lights are turned off, and the green ones light up.

The fuel supply [unit] on the tank truck is turned on. The fuel is delivered at a pressure of 1.5 to 3 kilograms per square centimeter. The time required to completely fuel the aircraft from two tank trucks is 16 to 20 minutes. Complete fueling of the tanks is automatically ended with the signal of closing of the valves. This is done by the following method: in tanks 6 and 8, by signals of transmitters of the fuel gauge, and in tank 10 with [signals] from the SV-2 level indicator the electro-mechanism of the filler valves is automatically switched over to the closed position. The lights of "cocks closed" shine on the control panel.

With partial fueling, the valves are turned off manually by cross-over switches on the control panel, and the amount of fuel is checked by the fuel gauge and by the meter on the tank truck.

With fueling completed, the cross-over switches of the valves are set in the "valves closed" position, and the electric current is shut off.

The pump on the tank truck draws off the fuel from the loading tubes and hoses, and then the filler hoses are disconnected, and the neck re-capped.

50X1

The cross-over switch in the crew cabin is then set at the "fuel gauges in cabin" position.

The accuracy of the fueling is checked on the fuel gauges in the cabin.

Comment:

The total amount of fuel loaded during complete fueling from below is 1,000 to 1,300 liters less than with fueling from above. If complete fueling is required, the rest of the fuel is loaded through the top necks.

3.6 Fuel drainage

Drainage of fuel from the tanks is done through drain valves with 30 millimeter through-openings, mounted in the inboard engine nacelles in the landing gear section (two discharge valves of group I and two of Group II).

The fuel is drained by gravity flow; and it is possible to switch on the overflow and transfer pumps to speed the operation.

Sediment is drained in the following locations: from tank 8 through the drain valve on the bottom of the wing - two spots for discharge; through the drain valve on the T-piece under tank 9 - two spots for discharge; from transfer tubing through main drain valve of the group II - two spots for discharge; from the feed and circulation tubing through the drain valve located on the tubing in the front part of the center section bordering the fuselage - two spots for drainage; from the fuel filters and tubing of the engines through drain valves on the filters - eight spots for drainage; from the transfer pump of the remining fuel in tank 2 by the drain valve of the PNV-2G pump - two spots for drainage; and from tank 1 by drain valve located on the fastening plate for the PNV-2G pumps - two spots for drainage.

The plane has a total of 22 locations for draining sediment, and 4 drain valves. About 200 liters of fuel, which cannot be drained through the drain valves, remain in the plane.

3.7 Operation of the fuel system in flight

1. Four transfer [?] pumps are switched on before the engines are started, and operate for the entire time the engines are in operation.

2. The by-pass valve, as was said, must be closed.

The engines on the right are supplied with fuel from the tanks in the right half of the wing, while the engines on the left are supplied from tanks in the left half of the wing. The by-pass valve is opened according to the appropriate instructions.

3. Fuel is pumped from the tanks automatically. Likewise, fuel from the Group II tanks is transferred automatically.

4. If the transfer pumps of the group II tanks are not turned on automatically within 10 to 15 minutes after the start, the pumps must be turned on manually. Likewise, they are turned off manually.

5. In the case of uneven fuel consumption with the shut-down one or two engines, it is necessary to open the by-pass valve, and close the fire shut-off cock of the dead engine. To balance the withdrawal of fuel from the tanks of the right and left halves of the wing, it is necessary to switch off one or two overflow pumps in the tanks of the half of the wing opposite to the idle engines, and to check the equal consumption of fuel from both halves of the wing, in which the difference in weight of fuel should be no greater than 500 to 600 kilograms.

6. In flight, it is necessary to carefully check the instruments and signaling operation of the fuel system: the pressure of the fuel at the nozzles [shown] on the EMI-3R pressure gauge on the instrument panel must not exceed 78 kilograms per square centimeter; when the fuel pressure is reduced to 0.4 - 0.35 kilogram per square centimeter before the high pressure pump, the red signal light inscribed "minimum fuel pressure" is illuminated; with the disengagement of two transfer pumps of any service tank, the red signal "disengagement of pump" is illuminated; when transferring fuel from the auxiliary group II tanks, the green signal "transfer of auxiliary tanks" is illuminated; when the remaining supply of fuel is 800 to 900 liters, the red signal "remaining fuel 800 liters" is illuminated; the amount of fuel in the tanks in kilograms is checked on the two SETS-280 fuel gauges with one cross-over switch; the amount of remaining fuel in kilograms for each engine is checked on the counter of the overall consumption of fuel, and the consumption in kilograms per hour is checked on the scale of momentary consumption on the RTMS-1.2-B1 consumption gauge, located on the left pilot's panel; and with the transfer of the remaining fuel, the light "transfer of remainder to service tanks" is illuminated on the central panel.

4. FIRE-EXTINGUISHING SYSTEM (FIGURE 141)

50X1

The fire extinguishing system protects the engine and exhaust sections against the outbreak of fire. A mixture designated "3.5" is used as the extinguishing material. Discharge of the contents of the bottles of the fire extinguishing equipment to the engine affected is handled in two groups, with three bottles in each group (series). The bottles of the first series are put in operation automatically through the fire sensor and the bottles of the second series are put into operation manually.

The fire extinguishing system for the engines consists of these parts; of six OS-8 extinguishers with seals controlled by cartridge actuators. two OSUZ-ls signal disks ("eyelets"), indicating the spontaneous discharge of extinguisher devices; two connecting tubes; two blocks [units] of electromagnetic [presumably] distributor valves, type No 781400; 12 sprayer tubes (three in each nacelle); for spray nozzles for conducting the extinguishing mixture to the crankcase, one per engine; appropriate tubing and electric lines; the SSP-2A fire signal system (aircraft of the older series had type Tl thermal signals); four signal lights showing outbreak of fire; sirens signalling the outbreak of fire; control panels for the fire protection system; and two emergency mechanisms for switching on the extinguisher system.

4.1 OS-8 Fire extinguisher

The OS-8 extinguishers are located on bulkhead No 1 inside the nacelles. Each nacelle has three extinguishers installed in it.

The OS-8 extinguishers have a threaded neck for connection to tubing from the signal disk. The necks of the three extinguishers are joined into one steel connection ring with a 6 x 1 millimeter inside diameter, which is connected to the neck of the OSUZ-ls signal disk.

The signal disk is located on the right side of the inboard nacelle, and the inscription "spontaneous discharge" is written around the disk. The connecting tubing combines the delivery of the extinguisher mixture from three extinguisher devices into one tube. A check valve, which during the switching on of the devices of the second series prevents the extinguisher mixture from entering the emptied bottles of the extinguishers, is attached to the connecting flange at the inlet end of the connecting tubing.

The block of type No 781400 electromagnetic distributor valves distributes the supply of extinguisher mixture through two valves to the inboard nacelle, or through two other valves to the outboard nacelle built into this half of the wing.

50X1

The tubing from each two distributer valves is connected into a single steel tube with a diameter of 27 x 25.5 millimeters, which conducts the extinguisher mixture to the sprayer tubing. Two sprayer tubes in the engine section are located: in the front - on the bulkhead of the front part of the cover; and in the rear - in the nacelle on bulkhead 1. The sprayer tubing in the exhaust section is located in the nacelle on bulkhead 3.

The manifolds are equipped with very small openings, with a 0.8 millimeter diameter, for spraying the extinguisher mixture. The front and rear sprayer tubes in the engine section have 525 openings, while the sprayer tubing in the exhaust section has 200 openings.

A sprayer nozzle [atomizer], into which the extinguisher mixture from the main tubing leads through the T-fitting to the engine, is located on each engine. A tube, with 12 x 1 millimeter diameter and a flared end, is fixed to the T-fitting. An attenuator insert with through-opening of 3 millimeters diameter, to reduce the pressure of the extinguisher mixture conducted to the engine to 2 kilograms per square centimeter, is inserted between the pipe union and neck of the T-fitting.

The control panel for the fire extinguisher system is located on the pilot's electric panel above the console panel. The control panel for the fire protection system contains: four cross-over switches (under the protective hinged safety caps for releasing the extinguisher devices); four green lights, signaling the opening of the appropriate valves for supply of the extinguisher mixture; and brief instructions for using the fire fighting equipment.

The control panel contains a cross-over switch for checking and testing the SSP-2A fire signal system. Four red signal lights are located on the instrument deck panel.

The siren and its disconnect switch are located on the right pilot's panel. The DPS-1A transmitters of the SSP-2A fire signal system are placed into special caps, fixed in the engine nacelles.

A total of 48 transmitters, 12 in each nacelle, [with] 9 transmitters in the engine section and 3 transmitters in the exhaust section, are located in the airplane.

The transmitters of each nacelle are divided into four groups: three groups for the engine sector, and one group for the exhaust section.

50X1

Each group has three transmitters and one relay. In this way, [redacted] nacelle has four independent groups of transmitters. So, if some [redacted] should break down, the operations reliability of the system is not destroyed.

The transmitters of the inboard nacelles are divided into groups in the following manner: group 1 - are the transmitters located on the right side of the lower cover of the enclosure, and on the right side of bulkheads 1 and 3; group 2 - are transmitters located on the left side of the lower cover of the cowling and on the left side of bulkheads 1 and 3; and group 3 - are transmitters, located on the support for attaching the extinguishers devices, and on the upper part of bulkheads 1 and 3.

The transmitters of the outboard nacelles are divided as follows: group 1 - are the transmitters located on the right bias strut supporting the engine, and on the right side of bulkheads 1 and 3; Group 2 are transmitters located on the right bias strut and on the left side of bulkheads 1 and 3; group 3 are transmitters located at the bottom and top of bulkhead 1, and on the top of bulkhead 3; and group 4 has two transmitters located on bulkhead 4, and one transmitter behind bulkhead 5. The group is identical for all nacelles.

The transmitter relays are located in the BI-IIA relay boxes (output block); and each of these three groups of transmitters of the engine section in each wing can be connected. To connect the transmitters of the exhaust section, also included are two BI-IIA relay blocks (the blocks are not fully utilized -- only one third utilized). The airplane contains a total of four relay blocks.

Two BI-IIA transmitter blocks of the engine section are located in the lower cargo area between bulkheads 22 and 23 on the left side. Two blocks for the transmitters of the exhaust section are also located in this cargo area.

The mechanisms for emergency activation of the fire fighting equipment are located on the main struts of the landing gear. The mechanism consists of the VK2-2A-I limit disconnect switch with lever devices, and a clamping bracket with a sleeve.

4.2 Operation of the fire extinguishing equipment

When fire breaks out in an engine, the equipment turns on the fire signal system, and sends an electric impulse to the control winding of the relay; consequently the red signal light of the proper engine shines on the deck instrument panel, and a siren goes on.

At the same time, the electric circuit for opening both electromagnetic valves, type 781400, of the proper engine is closed. On the control panel of the fire fighting equipment, a green light shines showing the opening of the valves. The valves are in tandem in case one might break down.

After the valves are opened, the limit disconnect switches are turned on, these are located in the valves, and only then is the current conducted to the cartridge activator cartridge protective covers of the three extinguisher devices of the first series.

Activation of the circuit by firing the cartridge actuators by the limit disconnect switches of the cocks is done to avoid discharge of the extinguisher devices before the cocks are opened. In case the extinguisher devices should be discharged before the cocks are opened, the high pressure of the extinguisher mixture would jam the valves, and they would not open.

With the current closed, the "pyropatron" blows the safety covers of the bottles. The force of the blast of "pyropatron" opens the valves of the safety covers, and the extinguisher mixture is conducted to the damaged engine on which it is sprayed.

This is the manner of the automatic activation of the extinguisher devices of the first series. Through openings in the sprayer tubing, the extinguisher mixture "3.5" very quickly reaches the bays in the engine nacelle and in the exhaust bay forcing air out of these which makes it impossible for combustion to continue, and the fire is extinguished.

The aircraft crew must proceed in accordance with the instructions and regulations, which means that when the red light and the green bulb (opening of the valves) are illuminated, the crew must immediately stop the proper engine, shut off the fuel system valves and institute feathering.

If the fire is extinguished, the red light must go off. If, 6 seconds after the green light goes on, the red light signal does not go off, it is necessary to turn on manually the second series of extinguisher devices. To do this it is necessary to move the cross-over switch on the control panel of the fire fighting equipment to the "II series" position, and to activate the other three extinguisher devices.

After the fire is extinguished, the change-over switch must be returned to the central position so that the valves will close. I50X1 extinguisher devices do not turn off spontaneously, the red signal disk goes off. The empty extinguisher is recognized by the pressure gauge hand of the extinguisher standing at zero.

Testing the serviceability of the fire signal system is handled through the cross-over switch located on the electrical equipment panel next to the fire protection system control panel. The cross-over switch gradually closes the circuits of the control relay in the relay block. If all elements of the system are in order, the red fire signal light on the deck instrument panel must light up.

Testing can be done only with the system of automatic release of extinguisher devices of the I series in disengaged position, which is helped by turning on the automatic disconnect switch on the distribution board of the nacelles.

To prevent the outbreak of fire during emergency belly landing, the main landing gear struts have an attached mechanism for emergency activation of the fire fighting equipment.

When the ground is hit, the lever of the mechanism turns on the limit disconnect switch, and this activates emptying the six extinguishers in the engine bays of the inboard nacelles.

AL-20 Engine
IL-18 Aircraft

Chapter VI

ENGINE ELECTRICAL AND AUTOMATIC STARTING EQUIPMENT

The individual automatic components, which are part of the electrical equipment of engine AI-20, take care of the following operations of the engine:

Automatic engine ground starting;
Cranking engine on ground without fuel;
Cold engine cranking;
Air restarting of engine;
Feeding direct current to aircraft power system from starter generators mounted on the operating engines;
Indication of engine icing conditions.

The engine is started by two starter generators, type STC-12TM. The starter generators are fed either by 20 batteries of type 12SAM-28 (starting based on internal power sources) or 20 batteries and an airfield power source with a nominal voltage of 24 volts (starting with the assist of airfield power sources) which, during the course of starting, are series connected.

After starting process, the starter generators automatically change to the function of generators and can be cut into the aircraft network.

1. ELECTRIC EQUIPMENT OF ENGINE

The set of electrical equipment of the engine includes the following components:

2 starter generators, type STG-12TM;

1 starter housing, PSG-2A for starter generators;

1 automatic starting device, APD-75 (the Aircraft has one such device for all engines);

2 low-voltage starter coils, KPN-4, with 2 power plugs SPN-4;

2 voltage regulators, type RN-180, with 2 reostats for the adjustment of regulated voltage, VS-20 (1 set for each starter generator), mounted within the aircraft;

1 electromagnetic starter fuel valve;

1 electric switch, VE-2S;

1 electric mechanism MZK-2, mounted on the propeller brake;

1 icing indicator SO-12AM (SO-4);

1 mechanism MP-5;

Limit resistors (located within the aircraft);

Position indicators for control handle to regulate fuel mixture, KTA-5F (UPRT-2);

Tachometer, ITE-2;

Generator, SGO-8;

Electromagnetic propeller pitch [feathering?] control valve;

Transmitter for pitch control when RPM exceeds maximum.

1.1. Starter-generator, STG-12TM

The starter generators serve to start the engine and, later, act as generators for feeding the aircraft power system with direct current.

The starter generator STG-12TM is essentially a 6-pole direct current generator. During starting, the output at the shaft is at the ratio of $i = 3.167$. When acting as a generator, the output is at a ratio of $i = 1$.

By this method, a greater torque is realized during starting and, when acting as generator (at a ratio of $i = 1$) the load factor of the generator is improved. Power feeding of the starter generators during the starting phase is accomplished directly through control box PSG-2A.

1.1.1. Technical data specifications

Generator regime

Rated voltage (in volts)	26.5 + 30 (adjusts itself automatically)
Rated power at temperatures of 20 ± 50 (in amperes	400
Range of operating revolutions (in rpm)	3500 + 9000
Type of operation	constant

Remark: All characteristics of the starter generator correspond to those of a derivative generator with a compensation winding. When the exciter winding is cut in, the generator voltage is regulated by a variable resistor in the exciter winding.

Starter regime

Load on output shaft . . . . Engine rotor

Type of operation. . . . . Repetitious, short duration

Maximum permissible revolutions of armature (in rpm). 11,000

Average power during starting (in amperes) 450

The starter generators operate reliably under the following conditions:

a. At temperatures of 20 + 5°C and a relative humidity of 95 to 98 percent.
b. Under conditions of ambient temperature from +100°C to -60°C (long term) and at +140°C (short term)
c. They withstand, without sustanining damage, acceleration stress of 4G's and between 60 to 100 frequency oscillations per minute.
d. When hot, they must withstand a load of 600 amperes at a minimum of 6,000 rpm within a period of 10 seconds.

Without supplemental cooling through intake air, it is permitted, to load the starter generators with current of 200 amperes on the ground for a period of 20 minutes within the limitation of 3700 to 9000 rpm. The starter generator must withstand 11,000 rpm for a period of 2 minutes without becoming deformed.

The drive mechanism protects the roller clutch of the starter generator against the penetration of lubricant because it does not have its own oil slinger.

1.1.2. Description of individual components

The starter generator STG-12TM has a semi-closed housing with openings for the entry and exit of cooling air. The air passes through a hose to a nozzle at the rear end of the starter generator. Part of the air then passes over the armature, cools the commutator, the iron core of the armature, and the coils at the poles and passes out of openings in the forward part of the generator. The second portion of the air passes through channels along the axis within the armature and also passes out of the generator through the front.

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Within the STG-12TM, a centrifugal ventilator cools the device while operating on the ground and when no air is forced through the starter. The starter generator (Fig. 114) is composed of the following main parts: housing, covers, armature, and planetary reduction gear with free wheeling device.

Housing (1) is made of electrical steel; the main poles (2) and the communtator poles (3) are mounted on the housing with bolts.

The main poles are made of electrical steel; the commutator poles are of one-piece construction and made of low-carbon steel. The main poles have coils with derivative exciter winding (4); compensation winding is inserted in the splines of the poles. The winding of the commutator poles (5) is made of copper.

Covers (6) and (7) are made of aluminum alloy and are mounted on the housing with bolts. Six brush holders (8) are mounted on the cylindrical part of the cover (6). Each holder has three brushes (9) of type MSG-7.

The brush cable is silver plated. The brushes are pressed against the communtator by coil springs, having a tension of 800 to 1,000 grams.

Panel (10) is bolted to cover (6) and its terminal screws are used to attach the ends of the windings of the armature and the exciter. On the side wall of the cover (6) is nozzle with a clamp for fastening the shielding. Union (11) with a nozzle for feeding cooling air is mounted on cover (6).

Armature (12) is composed of silicon-steel sheet sections which are press-fitted onto the casing. In the recesses of the armature, the winding is of copper wire; its forward portions are held together with steel-wire bindings. Armature shaft (13) is made of alloy steel. An aluminum hub is located between the housing and the shaft, has elongated slits, and serves to bring in cooling air.

The armature is mounted on ball bearings. Shaft (13) is connected with drive shaft (15) by idle roller clutch (16), which assures a firm connection between the armature shaft and the drive shaft when the generator is functioning as a generator and takes care of the uncoupling of this connection when the generator is functioning as a starter.

At the end of the shaft, mounted from the end of cover (6), there is a special port which has eight steel rollers located within a textolite cage of separater (18) and which run along the interior surface of the shaft.

On the opposite end of the shaft, there are 24 gear-teeth, which firmly connect the shaft with the reduction gear carrier (19). The shaft has 16 splines on its end which facilitate connection with the engine drive.

When the device functions as a starter, torque is passed on from the armature, via the reduction gear, to the drive shaft, during which time the idel roller clutch is uncoupled. 50X1

If the shaft [drive shaft] attains an rpm greater than that of the shaft of the armature, the idle roller clutch locks and torque is then transmitted from the above mentioned drive shaft to the shaft of the armature, during which phase the reduction gear is by-passed.

The reduction gear is mounted on the foreward cover, on the drive end, and serves to increase the moment of torque delivered from the aramture shaft to the drive shaft when the device is functioning as a starter (i = 3.167).

The reduction gear is composed of a ratchet clutch and the actual reductor. The reductor is of the planetary gear type, has a drive [sun] gear (30) connected to the armature shaft, and planet gears (21) each of which is mounted on two single radial ball bearings. The shafts of the planets are firmly connected with the guide (19). The satellites engage with the ring gear through internal gear teeth (22). Three dogs (23) of the ratchet clutch are mounted on three shafts and are firmly connected with the rim of the gear wheel.

Coil springs (24) push the dogs against the gear wheel and cause them to engage with ratchet (25) which is firmly connected with the body. By this method, the ring gear is blocked in one direction (when the device is working as a starter). Centrifugal force reduces the tension in the coil springs which cause the gos to cease engaging the ratchet and gear wheel (22) is allowed to move freely.

The function of the reduction gear is as follows: electric power is fed to the starter generator; the armature rotates and transmits torque through the sun gear to the planet gears which in turn rotate along the inner surface of the ring gear and turn the planet gear positioning plate which is firmly coupled with the drive shaft. This shaft is in turn firmly coupled with the rotor of the engine and begins to turn it. As soon as the drive shaft revoltuions exceed the revolutions of the armature shaft, the idel roller clutch is disengaged.

When the revolutions of the engine exceed those of the starter generator armature, the roller clutch locks and the armature shaft rotates at the same number of revolutions as the drive shaft. During this phase, the planet gears do not rotate; they drag with them, in a counter-clockwise direction, the inner ring gear, which is now no longer engaged into the ratched wheel, and the reduction gear rotates at the same number of revolutions as the drive shaft. When the engine is stopped, the ratchet dogs engage the ratchet wheel, the roller clutch is disengaged, and the starter generator is ready to begin another starting phase.

1.2. Automatic starter control APD-75 (Fig. 129)

The automatic starting control APD-75 controls the time sequence of starter generator action and the actions of starting assemblies. Simultaneously with control box PSG-2A, the APD-75 ensures the following:

Starting the engine on the ground;
Cold cranking of the engine.

In addition, where the need arises, the device assures the interruption of the starting process and the accelerated return of the starting mechanism to the starting position in a maximum of 9 seconds.

1.2.1. Technical data

Rated load . . . . 24 volts DC

Number of sequence cycles. 2

Total time for each cycle:

Starting engine on the ground . . . . . 71 ± 3 seconds
Cold cranking of engine . . . . 30 ± 2 seconds

The automatic device closes and opens the circuits of starting devices within the limits set forth in the following Table:

Designation of Operation	No of Operation	Individual Operations	Duration Begin	Duration End	Remarks
Starting the engine on the ground	1.	Feeding of exciter circuit, starting regime	0	71+ 3	Starter devices can also be switched off by centirfugal switch
	2.	Activiation of starter resistors	0	9± 1	
	3.	Closing the starting resistor for a short time by action of the main switch	3.5± 5	E-(1+03	"E"--Actual time from instant of starting sequence to instant of subsequent disconnect of output regulator (executed by

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Designation of Operation	No of Operation	Individual Operations	Duration Begin	Duration End	Remarks
					insert E of the program mechanism)
	4.	Activation of output regulator RUT-600D	20± 1	70± 3	
	5.	Switching of feed sources frm 24 to 48 volts	15± 1	E-(2±03)	
	6.	Activation of blocking circuit DMT-400AM	0	71± 3	
	7.	Turn-on of ignition	0	25± 2	
	8.	Turn-on of electromagnetic starter fuel valve	9± 1	25± 2	
	9.	Signal to stop valve	0	20± 1	
	10.	Full workingcycle of APD - 75	0	71± 3	
Code cranking of Engine	1.	Feeding of exciter circuit while functioning as a starter device	0	30± 2	
	2.	Activation of starting resistors	0	9± 1	
	3.	Closing of the starting resistor for a short time by action of the main switch	3.5± 0.5	29± 2	
	4.	Switching over of power sources from 24 volts to 48 volts	15± 1	29± 2	
	5.	Complete working cycle of APD-75 panel	0	30± 2	

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Type of Operation — Repetitive -- short duration; consists of 4 complete c 50X1 each lasting 71± 3 seconds. Intervals between closing of switches are 3 minutes. Following 4 cycles, it is necessary to allow complete cooling off.

1.3 <u>Starter control box for starter-generator PSG-2A</u> (Fig. 130)

The starter control box for starter generator PSG-2A assures the action of the two starter generators during various phases of engine starting with the assistance of a relay and a contact. The control box is attached to the components of the starting system.

Power sources are connected to terminals "+ P1" and "+ P2". The armature of the starter generator is connected to terminals "+ 1" and "2", and the excitor winding of the starter generators is connected to terminals 11 (S5) and 2 (S5).

The remaining terminals of the connectors are connected to the components of the starting system and to the automatic starting sequencer APD-75.

The action of the starter control box PSG-2A during various phases of starting is controlled by the introduction of signals from the APD-75 tothe terminals of connector S4.

1.3.1. <u>Technical specifications</u>

Rated voltage . . . . 24 volts DC

Type of Operation . . . . Short duration -- repetitive, consisting of 4 phases, each lasting 90 seconds. Intervals between cycles are 3 minutes. Following 4 cycles, complete cooling off is required.

<u>Note</u>: In starting four engines on the aircraft the following is permitted:

a. Eight starting attempts followed by 3-minute intervals between switch-on times and subsequent full cooling off periods.

b. Five uninterrupted starting attempts with complete cooling off to follow.

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1.4. Low voltage starting coil KPN-4

Coil KPN-4 operates simultaneously with a surface discharge electro-erosive plug of the SPN-4 type and is designed to ignite air and fuel mixtures in starting operations of the engine, on the ground as well as while airborne.

The coil receives its power from the aircraft power system with a rated voltage of 24 volts. The coil KPN-4 consists of an induction coil with the vibrator, two condensors, and a selenium rectifier.

1.4.1. Technical specifications

The coil assures uninterrupted sparking of the plug (type SPN-4) which is screwed into the igniter, during starting on the ground and while airborne, under the following conditions:

When the voltage across the terminals of the coil changes from 18 to 28.6 volts;

When the length of the shielded lead from the coil to the plug is a maximum 2.5 meters;

Upon delivery of fuel to the igniter no sooner than 8 seconds following the turning on of the coil;

When the pressure in the combusion chamber is less than 5 kilograms per square centimeter under normal temperature conditions;

Voltage in the secondary winding must be at least 3,000 volts when the voltage across the terminals of the coil is 18+1 volt.

1.4.2. Layout and principle of operation

Starter coil KPN-4 (Fig. 115) chages low voltage direct current to high voltage alternating current. Essentially, it is an induction coil with dual windings.

A vibrator -- an electrmagnetic circuit breaker -- is cut into the primary winding. The primary winding is accomplished with a single lead, the negative pole of which is connected to the coil former. Positive current is supplied to the coil through a connector and through the terminals of the electromagnetic circuit breaker. Capacitor C_1 is connected in parallel with the terminals of the circuit breaker.

The secondary winding is wound over the primary winding and is composed of two interconnected and counter-wound portions. The end of one portion is connected across a selenium rectifier to the coil former; the end of the second portion is connected to the high voltage lead which leads to the coil through the KU-20B contact device. The lower pole of capacitor C_2 is connected with the same pole of the secondary winding.

The core of the coil is composed of electromagnetic steel sheets. The vibrator is mounted on the panel and has two platinum-irridium terminals, one of which is soldered to the terminal screw which is connected with the power source, as well as with one covering of capacitor C_1, and the other terminal is connected to the armature spring which is connected with the beginning of the primary winding and the second covering of capacitor C_1.

The selenium rectifier VS is composed of 20 selenium plates mounted on an insulated post. The side of the selenium rectifier marked "+" is connected with the coil former.

Capacitor C_2 serves to increase the capacity of the discharge and partially also filters the pulses of the secondary winding which simultaneously increases the ignition capability of the spark. The selenium rectifier limits the discharge current in the event the coil should feed low resistance current to the spark gap of the plug or when the load is increased.

The secondary winding does not create its own magnetic flow D_2 which would weaken the magnetic flow of the primary winding D_1 which acts upon the circuit breaker. This is because the secondary winding is executed in two sections, the directions of which are opposed to each other (they are wound in a bifilarly manner). Thus, the magnetic flows of the sections are opposed to each other and cancel each other out.

1.5. Electroerosive aviation plug with surface discharge SPN-4

Spark igniter plug SPN-4 works simultaneously with starting coil KPN-4 and is a part of the low-voltage ignition system. A special characteristic of this system is that the discharge in the plug occurs between the electrodes of the working surface of the insulator, which is covered with an electro-erosive layer of electrode material.

The plugs cannot be dismantled, have a ceramic insulator and are shielded. The sparks jumps on the surface of the ceramic insulator between the interior and the exterior electrodes, which have been coated with electrode material by an electro-erosive method. This material is consumed along with the fuel and the preliminary switching on of ignition coil KPN-4, during the phase before the starting fuel is turned on at the beginning of each starting sequence, carries out the conditioning of the plug, that is to say it renews the layer of electrode material upon the working surface of the plug insulator with the assistance of spark discharges by the electro-erosive method.

1.5.1. Technical data

Distance between electrodes (width of belt in ceramic device) -- 1 ± 0.1 millimeters.

After conditioning, the plug must work reliably along with coil KPN-4 when the latter is set for the minimum primary current (2.8 amps) and at a fuel pressure of up to 5 kg/cm^2. 50X1

Length of threading of the threaded part of the plug body -- 11 millimeters.

Weight of plug with gasket -- maximum 0.08 kg.

After conditioning, the maximum value of the spark voltage in the plug may not exceed 2,000 volts under normal conditions with a power source of 24 + 1 volts.

The plug is mounted on the engine together with the jet, contactor KU-10 and knee UE-110-18R with a safety nut and 18 x 1 threads, assuring reliable contact with the head of the central electrode.

In operating the engine, fuel must be withheld until 8 seconds after ignition turn on.

1.5.2. Description of design

Spark igniter plug SPN-4 (Fig. 116) is not dismantleable, is shielded, and consists of the following principal components: body (3), insulator (4), electrodes (5) and (6), shielding sleeve (2) and setting ring (1).

Body (3) is made of stainless steel and has two 18 x 1 millimeter threads for connecting with the igniter and for connecting the high-tension lead.

Insulator (4) with the central silver electrode (6) is located in the lower portion of the body on a copper case and touches the external electrode. A ceramic shielding sleeve (2) is located in the upper portion of the body.

Setting ring (1) serves to secure the plug on the engine and gasket ring (7) serves to assure a tight fit between the plug and the igniter.

1.6. Starter fuel valve

The starter fuel valve (Fig. 117) serves to transmit the fuel from pump 707-I to the starting and auxiliary jets. The entrance to the starter fuel tank is closed off by the valve.

The electrical part of the starter fuel valve has a coil with a movable cylindrical core, which is connected with the needle of the valve, and a connector. The coil winding is of copper wire with a diameter of 0.38 millimeters and has enamel insulation. The number of turns in the winding is 760, with 50 turns per layer. The surface of the former of the coil and the face are covered with a shellacked fabric

which is 0.3 millimeters thick. The w
with a bakelite lacquer and covered with a lacquered fabric which is 0.3 millimeters thick. The entire coil is impregnated with a bakelite la50X1 quer. It is also possible to impregnate the coil with shellac. The output leads from the coil are 45 millimeters long and are insulated by a shielding tube. One end of the coil is soldered to the coil former, and the other end terminates in connector.

The coil is made of ST-A12 [steel?]

In operation, the coil draws down the core, overcoming the spring tension which is endeavoring to keep the core in a position which would close off the fuel port.

1.7. VE-2S electric motor switch

The VE-2S electric motor switch is essentially a single-lead electro-hydraulic relay which opens its contact points when the oil in the chamber under the corrugated bellows attains a certain pressure.

The VE-2S has standard covered contact points. The interruption of the electric circuit is caused by pressure of the oil on the bellows, connected with the contact points via a rod linkage.

The electric motor switch is designed to work within the circuit of the accelerated termination cycle within the SPZ-24.

1.7.1. Technical specifications

The VE-2S switch works reliably under the following conditions:

Type of current . . . . DC
Power at the plug connector
of the aggregate (in volts). . . . . 18÷28.6

The winding of relay TKE 21 PL or RP-2, which is cut into the circuit of the contact points [no other data given]:

Working fluid . . . . Engine oil
Pressure to open contact points
(in kilograms per square centimeter . . 1.6÷2.0
Type of operation . . . . Repetitive, short duration

1.7.2. Principle of operation

The principle of operation ofthe VE-2S (Fig. 118) is as follows:

During the engine starting phase, oil fills chamber (12) at a certain pressure. Corrugated bellows (3) is located within the chamber. The oil attempts to push on the bellows in an axial direction. The

The pressure of oil on the corrugated bellows is counter-acted by a cylindrical spring (6), the upper face side of which rests against set screw (8) and the lower side against plate (15) of the bellows. Upon reaching a pressure of 1.6 to 2 kilograms per square centimeter, spring (6) is compressed and rod (4), which is connected with plate (15) moves upward to open the contact points of the electric circuit. As the pressure drops below the above value, the switch points are closed through the action of spring (6).

1.7.3. Design

The switch consists of the following parts: housing (1), shoulder (2), metal bellows (3) with plate (15), push rod (4), spring (6), lever (5), connector (7), set screw (8), gasket (9), and protective cover (10).

The housing (1) is made of aluminum alloy holds the principal components of the switch. On the upper face side of the housing, there are four threaded openings, three of which serve to hold reinforcement (11) and one of which is used for the holding screw of the lock. The lower face side of the device has six evenly-spaced bolts which serve to tighten down shoulder (2), and the center of the housing has a fairly large threaded opening to hold the set screw (8).

To protect the device against corrosion, it has been anodized. Shoulder (2) is cast from aluminum alloy AL-1, and one end of it has 12 x 1.5 millimeter threads; the other side has 14 x 1.5 millimeter threads. On the sides of the shoulder there is a special boss with two openings of 5.5 millimeter diameter through which the bolts that hold the device onto the engine are passed. The Metal bellows (3) is fabricated from special alloy L-80 and separate the high pressure oil chamber from the area of the contact points. In essence, this is a flexible element which transmits the oil pressure via its plate (15) to push rod (4).

Push-rod (4) is made of No 25 steel and transmits the motion of the bellows to lever (5) with its movable contact point (16). Lever (5), which is stamped from L-62 brass, is intended for opening the contact points. On one end, the lever has an attached contact point and on the other end an opening for attachment to reinforcing strut (17).

Spring (6) is made of high grade OVS wire and assures the action of the switch in response to a preset pressure. The setting of the spring tension is accomplished by set screw (8), which is secured.

Contactor (7), of the SR12U1ES2 type, serves to connect the aircraft power net with the switch. Gasket (9) protects the contact chamber against the seepage of oil from the bellows chamber. Protective lid (10) is cast from aluminum alloy (5) and protects the individual components against damage and dirt.

The adapter in the upper part of the lid serves to connect the plug connector, which feeds power to the device. The bottom of the lid h[redacted] 50X1 three openings for anchoring to the reinforcing struts of the device. Four openings on the side surfaces are used to attach the name plate.

For protection against corrosion, the lid is galvanized and its exterior surface is painted black.

Brace (11) is made of type 25 steel and serves to fasten cover (10) to body (1). Rubber packing ring (19) protects the contacts against the penetration of the liquid from the nearby area.

Disconnect switch VE-2S is fastened to the engine by two bolts with a diameter of 5 millimeters, passing through the openings in the flange of the extension. During assembly, the disconnect switch adapter must make positive electrical contact with the frame.

1.8. <u>Electrical mechanism MP-5</u>

The MP-5 electrical mechanism operates a value [Fig. 76] to bleed [hot] air. Control of the switching mechanism for extenions and retraction of the actuator rod is handled from the control board panel by a two-pole cross-over switch for the electric motor.

1.8.1. <u>Technical Specifications</u>

Rated voltage	27 V ± 10%
Rated forc for actuator rod acting counter to its movement (kg)	5
Maximum travel of rod (mm)	40 - 1

<u>Note</u>: Travel of the rod must be set within a range of 5 to 41 mm.

Speed of movement of rod rated load and rated voltage	1.3 mm/revolutions ± 05%
Current necessary at a rated load for the rod in amps	maximum 0.15
Operation mode	Short-term, repeated

1.8.2. <u>Construction</u>

The MP-5 electrical mechanism has the following parts: Electric motor, direct current D-2S; reduction gear with conversion i = 94.6; actuator rod with a rise of 1.3 mm; two KV-1-20 cross-over switches; and small plug connection composed of SP-3 and VS-3.

01. The electric motor D-2A is a, direct current [motor] excited by a permanent magnet.

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Technical Specifications:

Voltage	27 V ± 10%
Required current (amps).	max. 0.15
Number of revolutions (rpm).	5,7000 ± 10%
Shaft torque (gcm)	20
Operation mode	sustained

02. The reduction gear (Fig. 119) consists of a four-stage conversion by spur gears. (1), fastened to the motor shaft by a pin meshes with idle double gear wheel (2) on shaft (3). Gear (2) meshes with double gear wheel (4), which in turn meshes with gear (5) which freely turns on shaft (3). Gear (5), engages a gear in a single unit with a nut (6), which has an internal trapezoidal thread for connection with actuator rod (7).

1.8.3. Principle of Action

The electric motor shaft turns the reduction gears and nut (6). Double nut (6) and actuator rod (7), convert rotary movement into linear. actuator rod (7) is moves to "pushed out" togehter with cams (12) and (19), in whose grooves the protrusion of the rod fits. On reaching the extreme extended position, the cam presses down on the tongue of the spring (20), which then depresses the button of the terminal switch (17) and breaks off the current to the electric motor. In switching over the two-pole commutator, the electric motor rotates in the opposite direction. The actuator rod begins to move in the direction of "pulled in" upon which the cam (19) disengages from the tongue of spring (20), releasing the terminal switch button (17). This way, the circuit "pushes out" is once again set for pushing out of guide bolt (7).

The movement of rod (7) to "pulled in" lasts until cam (12) moves the tongue of spring (21) which presses on the button of the second terminal switch "pulled in" (18), and breaks off the circuit upon which the actuator rod stops.

The electrical mechanism makes possible the setting of the movement of the rod by shifting cam (12), along actuator rod (7). The securing of the set position of cam (19) is effected by a guide, fastened by a screw to the body (14).

Nut (6) is placed on two special radial thrust bearings (11). Reduction gear housing (8), has cover (9), which has actuator rod sleeve (10) and four bolts for mounting the electrical mechanism.

Cam (12), on the end of rod (7), slides along the rod and prevents rotation. The rod fits into grooves in body forging (14) and is fastened to it by two screws.

The terminal switchs (17) and (18) for "pushing out the rods" that are aligned lengthwise in the grooves of the housing, are fastend by screws (16) to housing (14). 50X1

Cam (19) activates the terminal fastened to terminal changeover switches (17) and (18), switch for "pushing out the rods." Springs (20) and (21), relay the pressure of cam (12) to the button of the terminal switches. Electric motor D-2A (22) is fastened to the lower part of the housing, with four screws. Terminal switches (17), (18) and electric motor (22) are covered by case (23), fastened to the housing by four scres which are safety wired. A small plug connection is also fastened to the body.

1.9. SO-12AM (SO-4) Icing Indicator

The icing indicator shows the presence of ice on the outer parts of the engine.

1.9.1. Operating principle

The action of the indicator is based on the utilization of the flexible qualities of the corrugated metal diaphragms, opening and closing the electrical contacts during changes in the impact pressure of the air current flowing through the indicator air intake.

The SO-4 icing indicator is a differential pressure gauge with two sealed chamber, connected nozzle by (5) (Fig. 120).

One of the chambers (2) receives the pressure of the accumulating current of air in the engine inlet through intake (1). By "pressure" is understood the total ambient air impact pressure, that is, $p = P_H + P_C$.

The second chamber (4) receives static pressure through opening (3), placed on the side surface of the air intake head Chambers (2) and (4) are separated from each other by diaphragm (9).

The dynamic pressure intake has 20 openings with diameters of 0.7 millimeters. If the inpact pressure does not act, that is, when the engine is not in operation, the contacts are in a switched-on position. During operation when the indicator intake is charged with air, a varying pressure develops from the impact pressure, in the chambers of the differential pressure gauge, and bends the diaphragm. As a result, the contacts open and remain open [unless incing occurs].

Under icing conditions during flight, intake openings (1) are covered with a layer of ice, and the entrance of dynamic pressure to the chamber (2) of the differential pressure gauge is blocked. The pressure in chambers (2) and (4) is balanced through nozzle (5), and the diaphragm returns to the starting position and closes the contacts. This actuates the soleniod which energizes, in parallel, the "icing" warning light and the heating element.

Heat melts the ice on the intake, the [redacted] the difference in pressures in the chambers of the differential pressure gauge opens the contacts of the electric circuit; the solenoid opens disconnecting the warning light circuit and the heaters. The indicator assumes the initial position. 50X1

If in this period, the aircraft is not past the area of icing, the entire cycle is repeated. During passage of the aircraft through a zone of icing, in this way, the warning light will be periodically lit.

De-icing of the intake openings in the SO-4 lasts a maximum of 90 seconds from the moment of switching on the heating. The process of icing up the dynamic pressure openings lasts a maximum of 150 seconds, and the full cycle of icing and de-icing, a maximum of 240 seconds. On the first icing warning, the engine air intake heating system must be turned on manually. After the aircraft leaves the icing zone, that is, after the "icing" warning light turns off the system must be turned off manually. To protect the heating elements of the system against over-heating, it is necessary to switch them on when a dynamic pressure of a minimum of 250-mm of water is reached; by the passage of current to the coil of the heating soleniod from the starter generators STG-12TM (in accordance with the diagram, it is required that heating be switched on only during operation. When the engine reaches an rpm at starter STG-12TM provides sufficient voltage both for the supply of the cabin system and also for energizing the coil of soleniod TKE52PD. This [soleniod] relay, switches on a second relay, in which the winding of the coil is connected on the frame through the contacts of breaker (6), of the differential pressure gauge. These contacts are disconnected by the action of air impact, and for this reason, the relay works only when they are switched on; this happens during the icing of the front part of the intake, when it is necessary to switch on the heating. The "icing" light also does not light up because it is parallel to the relay.

1.9.2. Technical Specifications

Supply source	aircraft direct current, voltage 27V $\pm$ 10 percent
Range of temperatures at which the indicator operates without disturbing its characteristics	from +60 to - 60°C
Supply system	single-line
Maximum current carried to the contacts	at a voltage of 27v 0.6 amps
Maximum current of heaters at a temperature of 20 $\pm$ 5°C	7 amps
Weight	0.75 kilograms

1.9.2. Structure of the Indicator (Fi

The indicator is composed of two main parts: the dynamic and static pressure intake (1) and the electric differential pressure gauge (2), fastened to adapter (3).

The intake is cylindrical; on the front part it has a pressed-on and soldered cover (4), which has 20 openings with a diameter of 0.7 mm for catching the high-speed air which passes to the dynamic pressure chamber "p" by two tubes (5). In the lower part of cover (4) are three openings with diameters of 0.5 millimeters for drainage of water.

A heating device in the intake assures the periodical de-icing of the 0.7-mm diameter openings. On the back part of intake housing (7) is tube fitting (8), in which is placed the static pressure chamber, "connected" with the flowing current of air by 8 openings (10) with a diameter of 2.5 millimeters, located on the side surface of adapter pipe (3). At the same time, the heater static pressure chamber is connected with static pressure chamber (11) of the differential pressure gauge by rubber tube (12) and tube nipple (13).

The dynamic and static pressure chambers are interconnected by a calibrated opening, through which the pressure in the chambers is equalized when the intake openings in the cover are closed by ice.

On a ring in the intake is mounted the terminal of the feed to the heating element, which is made of nickel-chromium spiral.

The differential pressure gauge is composed of diaphragm (20), fastened to base (21) by nut (22). The diaphragm is made from berylium bronze and is the sensing element of the differential pressure gauge.

In the center of the diaphragm is soldered a silver movable contact point (23), that makes contact with silver contact point (24) of set screw (25), which pre-sets the tension of the diaphragm providing the necessary adjustment of the pressure drap required to open the contacts.

Set (25) is insulated from the housing by packing (26). The base of the differential pressure gauge is fastened to the adapter by four screws (27). The cylindrical heater (28) insulated with on both sides, is wound of nickel-chromium wire and is located in the elbow pipe. Insulator (29) is used to lead the through from the static pressure (29) chamber.

Rubber gasket (30), seals the dynamic pressure chamber. The steel outer case (31) is screwed to the base on threads and secured by two pins. Nut (33) seals the static pressure chamber with the aid of rubber gasket (34).

1.10. MZK-2 Electrical mechanism

The MZK-2 electrical mechanism is used to brake the propeller of the AI-20 engine.

1.10.1. Technical Specifications

Rated voltage 27
Range of operational voltage. . . . . 24.3 - 29.7

Note: The electrical mechanism may operate at 20 V.

Rated moment of force at the exit [output?] shaft kgm 2.5
Required current at rated voltage, amps . 3.6 maximum
Maximum angle of turn of the exit [output?] shaft, limited by the terminal switches degrees. . . . . 95, minimum
Time necessary to turn the exit [output] shaft from one extreme position to the other by 95°, seconds. . 3.6 - 5.6

Note: In order to switch on the contacts of the signal lights, it goes 5 to 10 degrees in front of the final position of the exit shaft. The angle to turn of the exit shaft must be set up with the aid of stopping devices within the range of 50 to 95 degrees. In this case, the terminal switches operate after the slipping of the friction clutch.

Operationing mode . . . . .repeated, short-term
Power to the electrical mechanism . . . . two-conductors

1.10.2. Structure

The electrical mechanism has the following parts: type D-12TF electric motor; reduction gear; friction clutch; panel of terminal switches; switch of signal lights; SR28P7NS7 plug connection.

01. Electric Motor

The D-12TF electric motor is 2-pole, reversible, direct current [motor] with series winding and a electromagnetic brake clutch. Reversing the electric motor is effected by changing the direction of the magnetic fux. For this, the electric motor has two separate exciter windings, switched on individually, depending upon the direction of rotation. The direction of the current in the armature does not change in the process. The switching-on is effected by a single-pole changeover switch.

Structurally, the electric motor (Fig. 122) is composed of a housing with exciter windings, an armature with winding, a commutator, an electromagnetic brake clutch, and a plate. 50X1

The electric motor housing (25) is a steel cylinder, within which there are two pole extensions fastened by screws, on which there are two separate exciter windings. The electric motor housing is covered on the drive end by plate (22) and on the commutator end by cover (36). Plate (22) is made of an aluminum alloy and has a seat for the roller bearing, which constitutes the front support of the armature shaft with openings for the end of the aramature shaft and for [oil?] supply lines.

Rotor (23) turns on two No 60024 ball bearings and consists of a shaft on which is pressed a laminated electrical steel armature.

The ends of every coil winding on the armature are soldered to commutator (28) tabs. The commutator is made of special shaped copper plates, each insulated from the other by micanite separater. The plates of the commutator are pressed from K6 plastic. The drive end of armature shaft has an extension for connection with the reduction gear of the electrical mechanism. Brake disc (51) is secured by nut (32) on the commutator end of the armature shaft, this braking disc of the electromagnetic clutch reduces the run out of the armature shaft after the electric motor is disengaged from the system.

The winding of electromagentic clutch (29) is enclosed in a steel housing. In the housing are pressed 3 guide pins, by which the braking washer with ring (34) can be moved. Clutch (29) and the braking washer create the magnetic circuit of the clutch.

The washer, through the action of cylindrical spring (33), is constantly pressed against the braking disc (31), which is fixed to the armature shaft. Between the disc and the braking washer, there arises, from the pressure of the spring, the constant braking moment of the armature. The winding of the clutch is conneced in parallel with the winding of the armature of the electric motor.

When the electric motor is not operating, there must be, between braking washer (30) [sic] of the terminal switch and clutch (29) of the clutch, a minimum space of 0.2 millimeters. In supplying voltage to the main magnetic flux, created by the coil, winding is stopped through this gap. The braking washer (30) [sic] restrains the force of spring (33), and by the action of the electromagnetic force moves along the pins clutch (29).

When the electric motor stops, the electromagnetic force ceases, the braking washer, through the action of the spring, moves along the guide pins, presses against the disc (31), and brakes the armature.

[redacted]

A support ring with 2 pressed brush hol[redacted] the body of clutch (29). In the electric motor, brushes (27) of the A-12 type with dimensions of 4 x 5 x 7 millimeters, are used. The brushes are pressed to the commutator by spiral springs. The pressure of the brushes is 110 to 150 grams.

50X1

For access to the commutator and the brushes, there are, in body D-12TF, access holes that are closed during operation covers (36). Plate (22) on the drive end, and the body of electromagnetic clutch (29) are fastened by clamp bolts.

Specifications of the electric motor

Moment on the shaft, (gram-centimeters)	125
Voltage	27
Current, amps (Maximum)	3.6
Number of revolutions of the exit shaft in rpm	12,500+10%
Output in Watts	16
Armature winding	lap-wound

02. Reduction gear

50X1

The reduction gear increases torque and decreases the rpm, transferred from the electric motor to the output shaft of the electrical mechanism.

The reduction gear is of the planetary type and is composed of 5 stages with a total transmission of 3275.91. The first 3 stages are located directly behind the electric motor, the fourth stage between panel (13) of the terminal switches and the friction coupling, and the fifth behind the friction coupling. Gears (15), (17), and (19) (of the first 3 stages) mesh with fixed [ring] gear (18), fastened by a pin to reduction gear housing (2)

Planet gears (19) of stage I of the reduction gear rotate on shafts in metalloceramic bearings, and gears (15) and (17) of stages II and III turn directly on the shafts. Drive gear (40) of stage I, fastened by a pin to the armature shaft of the electric motor, through the planet gear (19), drives gear (41) of stage II, which is made in a single piece sith a guide having 3 catches [balls?] located opposite each other at 120 degrees. On each one, is fastened planet gear shaft.

Drive gear (41) of stage II, drives gears (15) and (17), and drive gears (44) and (12) of stages III and IV.

Drive gear (12) of stage IV engages planet gear (9) which rotates within inner ring gear (10), secured to the case of the electric motor. It rotates the friction clutch sleeve (49). The movement from the sleeve is transferred through the friction clutch of drive gear (61), level V, which, through gear (64), rotates guide (63), by means of the output shaft (60) of the electric motor.

The friction clutch protects the electric motor during excessive, but short-term overloading.

Principle of operation:

The kinematic diagram of the electrical mechanism is shown in Figure 123. The electrical mechanism has two wires. Current from the aircraft circuit passes through terminal SR, and through the closed panel contacts for feeding the electric motor to one of the exciter windings, the armature winding, the winding of the electromagnetic clutch, and to "minus" (terminal 1). The coupling actuates the gears, and the electric motor shaft is turned through stage IV of the planetary reduction gear, the friction clutch, and stage V of the reduction gear on the output shaft of the electrical mechanism.

When the output shaft turns to the required angle, the signal light contact closes and when the output shaft stops, the friction clutch slips.

During this, the shaft of the mechanism does not move, and the electric motor armature continues to turn, which protects the motor from over-loading.

The friction clutch of the mechanism will turn until the front cam, located on the clutch sleeve disconnects the panel contacts, as a result of which it [the motor] is shut off, and the armature is stopped by the braking disc of the electromagnetic clutch. When the second excitater winding of the electric motor is energized, the output shaft of the electrical mechanism turns in the opposite direction.

1.11. Tachometer ITE-2

The magneto-induction tachometers continuously measure the number of revolutions per minute of the engine main shaft, which is expressed in percentages of its maximum revolutions.

The tachometer assembly is composed of the following: alternating current transmitter-generator (Fig. 124), whose frequency is proportional to the number of revolutions of the engine shaft and the magneto-induction indicator device, the read-out value is proportionate to the frequency of the supplied current.

The remote-control measurement of the revolutions per minute by the tachometer is based on the principle of the conversion of the engine shaft revolutions to electrical current with a frequency proportional to the speed of rotation. The conversion of the shaft rotation into [appropriate] movement of the needle by the magneto-induction instrument (ITE-1 or ITE-2) is based on the interaction of the magnetic field of the rotating magnets with the currents induced by this field in the metal disk. As a result of this interaction, the disc (connected with the needle), turns proportionately to the number of revolutions of the magnets (dependent on the frequency f), balanced by the counteraction spring.

The tachometer operates as follows: in stator winding (1) of transmitter (Fig. 125), during rotation of rotor (2), a three-phase current with a frequency proportionate to the speed of rotation of the engine shaft is generated and is conducted by three leads to the stator winding of the synchronous motor of the indicator (Fig. 125).

The rpm of the rotating magnetic field of the stator winding of the instrument if proportionate to the frequency of the current in the stator phase winding of transmitter DTE-2, and for that reason are proportionate to the rpm of the engine. The indicator rotor revolves at a speed synchronous with the rotation of the magnetic field.

Magnetic system (6) is fastened to the end of the rotor shaft of the motor. The system has six pairs of permanent magnets, among which is sensing element (a disc) (18). During rotation of the magnetic system, eddy currents are induced in the disc. As a result of the interaction of the eddy currents with the rotating magnetic field of the magnetic system, the sensitive element rotates proportionately to the rpm of the magnetic system. Spiral spring (8), fastened to the shaft of the sensing element, opposes the rotary movement of the sensing element. On the other end of the disc's shaft is needle (15), indicating on the evenly calibrated scale (17) of the indicator the appropriate value of engine rpm.

A shock absorber is used for the smooth operation of the indicating system. During the movement of the system, the magnetic current of the permanent magnets (6) generates eddy currents in the aluminum disk, and their reciprocal action, with the magnetic current of the magnetic system, activates a braking movement.

The instrument's rotor consists of two permanent magnets and three hysteresis discs. With the same revolutions of the rotor and field of the stator, the magnetic field of the stator winding interacts with that of the permanent magnets and the flux of the hysteresis discs, magnetized by the stator field. Because the magnetic flux of the discs, the synchronous movement of the rotor is mainly induced by permanent magnets, especially at slow rotation of the stator field, when its inductance is small and also when the flux of hysteresis discs is negligible.

In the asynchronous stage of operation, the rotating magnetic field lags both the permanent magnets and the hysteresis discs. During this, the rotary movement of the hysteretic discs, through the increasing rpm of the magnetic field of the stator, increases, and the rotation of the permanent magnets falls, because, at greater revolutions, the field of the permanent magnets is not sufficient to follow it without the aid of the hysteresis discs. For this reason, at low rpm of the magnetic pole, the rotation of the rotor stems mainly from the permanent magnets, and, during higher rpm, with the aid of hysteresis discs.

In the asynchronous stage of operation of the engine, with higher rpm of the magnetic field, the hysteresis disc of the rotor helps to bring to rpm where the permanent magnets are sufficient to adjust to the magnetic field of the stator. Then, the permanent magnets are synchronized with the hysteresis disc, exceeding considerably the braking load of the rotor.

In order to facilitate the interaction of the permanent magnets with the rotating magnetic field, the magnets are placed on the shaft in such a way that they can start rotating freely behind the rotating field without loading the shaft until the spring winds up. After spring winds, the magnets are loaded by the braking action of the rotor. As a result of this, the magnets interact with the moving magnetic fields follow it, and then synchronously pass into the assigned load of the shaft and exceed the load of the shaft, already in the synchronous stage, when they control with a considerable force the mutual action with the magnetic field of the current of the stator winding.

The principle of action of the hysteresis discs is as follows: it is located in the rotating magnetic field; during the entire period it is magnetized in such a way that the magnetizing poles move along the circuit of the discs behind the poles of the rotating field. The mutual interaction of the magnetic flux of the discs and the rotating magnetic field causes the rotation of the disc in the direction of rotation of the field. During the rotation of the hysteresis discs, the direction of magnetization changes, but it is constantly lagging the magnetic field, and when the discs reach synchronous speed, the torque begins to act upon it.

After the attainment of synchronization, the hysteresis discs act upon the winding as permanent magnets, but the force of their action is considerably lower (that is, the magnetization of the synchronous discs is less than for the permanent magnets).

1.11.1 Construction

01. Transmitter

The construction of the transmitter is shown in Figure 124. The transmitter is a 3-phase, alternating current generator with a permanent 4-pole magnet, comprising rotor (1). The rotor is cast from an alloy having a high inductance and a considerable coercive force. The transmitter rotor, type DTE, operating with one motor of the instrument (ITE-1 or ITE-2) is cast from alloy ANK; the rotor of the type DTE-2 transmitter, operating with 2 motors of the instrument (ITE-1 or ITE-2) is cast from alloy ANKO-2, which has a greater residual inductance than alloy ANK.

The construction of transmitters DTE-1 and DTE-2 is the same. The rotary movement of the drive-shaft of the aircraft engine is transmitted by drive (2), set in bushing (3) and connected with it by a 4-side drive [coupling] and a flexible ring (4). The shaft is sufficiently flexible; it bears twisting well and compensates for the slight bending which may arise during the assembly of the transmitter.

Between the rotor bushing and the drive a packing is inserted, which prevents the penetration of the oil to the transmitter. The bushing rotates in two ball bearings (6); one in cover (8) and the other in seat (19), inserted in cover (23). The covers (8), (23), cast from an aluminum alloy, are bolted (9) together and position the stator and the rotor. The stator (10), in order to lower the eddy currents, is made from transformer sheet with a thickness of 0.5 millimeters, and has 12 grooves, in which are placed double-layer winding.

The stator plates are insulated from each other. The winding of the stator is 4-pole, 3-phase, and is made from copper wire brand PEV-2, with a diameter of 0.27 millimeters. Each phase of the winding has 4 coils. The phases are star-connected.

50X1

02. Indicator [Fig. 125]

The indicator consists of two basic parts, mounted in one body: the synchronous motor; the mechanism of the instrument.

The synchronous motor consists of stator (1) with a 3-phase winding (2) located in the plate assembly of stator (3); and rotor (4), made in the shape of two cross-shaped magnets (5); and starter element (6), composed of 3 hysteresis discs [rings] placed on bushing (7). The permanent magnets seat freely on the shaft and are connected with it by spring (8), through which it transfers the torque to the motor shaft. The spring causes the magnet to rotate in relation to the shaft and bringing it to synchronization, as the magnets reach full torque.

[One end of] the shaft (9) seats in ball bearing (10), fixed to a cover (11). The other end of the rotor shaft protrudes beyond the front face of cover [38], and magnetic system (12) is fastened to it; this system consists of two round plates with affixed permanent magnets (13).

The roung plates are aligned so that the opposite poles of the magnets are opposed to each other and concentrate the magnetic flux around the outer edges of sensing disc (14), in order to attain the maximum rotary torque.

The mechanism of the device has a sensing element (14), placed in the air gap of the magnetic bundle between the fronts of the cylindrical magnets.

The needle (15) on the other end of the shaft (16) of the sensing element indicates on scale (17) of the instrument the shaft rpm of the aircraft engine. The material of the sensing element is aluminum-magnesium alloy, having a small thermal coefficient of electrical resistance, so that temperature changes cause no significant diviations.

The heat compensation is executed in the device as follows: On magnets (13) is placed a shunt prepared from a special alloy, whose magnetic permeability falls with a rise in temperature and rises with a fall in temperature.

With unchanged ambient temperature, the shunt takes upon itself part of the operational magnetic flux, and with this, decreases the operational flux in the gap between the front parts of the magnets.

With a rise in the temperature, the magnets operational flux in the gap increases, just as the intake by the shunt decreases, and, conversely, with a fall in the temperature, the magnetic flow in the gap decreases, just as the intake of the flux by the shunt increases.

With a rise in temperature, the electric resistance of the sensing element increases, and with a fall in temperature, it decreases. In this way, the change in the magnetic operational flux in the gap, as a result of the change in the magnetic permeability of the shunt, conforms to the

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change in the electrical resistance of the sensitive element, preserves an almost unvarying rotation created by the magnetic bundle. The sensing element is fastened to three supports, on which there are adjusting nuts (20) for balancing the entire element and setting the gap between the sensing element and the magnet of the magnetic bundle.

Spring (21) is fastened by its inner end to the bushing pressed to the shaft and by its outer end to the adjusting lever (22). The damper is basically a magnetic system, analogous to magnetic system (12). Between the fronts of the six pairs of magnets is placed a disc (25) fastened to the movable system of device (24).

During the movement of the magnetic system of the instrument, a magnetic flux of the magnets of the damper induces eddy currents, by whose mutual interaction with the magnetic flux of the system movable magnets, a braking torque, increasing the stability of the needle, is produced.

The two-part instrument consists of two identical systems mounted in one frame. Each of these systems consists of a synchronous motor and an indicator mechanism.

Technical Data

The scale of the instrument has divisions from 0 to 105% and is numbered from 0 to 100%.

The instrument measures accurately from 10 percent. The scale is even, divided into one-percents. The operational range of the scale is 60 ≠ 100 percent.

The maximum allowable error in measuring at a temperature of 60 ± 5^{0} Centigrade is 2.5 percent.

1.12. Control lever position indicator of fuel control unit KTA-5F (UPRT-2)

The electrical indicator UPRT-2 consists of an indicator device (Fig. 127) and [sensor] transmitters (Fig. 126). It indicates the position of the control lever for fuel control unit KTA-5F.

1.12.1 Principle of Operation

The operation of the lever position-indicator is based on utilization of a potentiometric system, composed of a round potentiometer and a three-coil magneto-electric ratiometer with a movable magnet.

The transmitter shaft is connected by a collar to the shaft of the unit. It changes the position of the cursor on the round potentiometer, depending on the position of the control lever of the unit.

With a change in position of the c
is a change in the distribution of current in the coils and the value of the magnetic flux in each of the coils of the ratiometer is change

The indicator rotor forms a permanent magnet, which is set when the current is on, in the direction of the resulting magnetic flux created by currents flowing in the winding of all the coils.

When the transmitter shaft turns, the position of the potentiometer and the supply points is changed in relation to the cursor. The change in the distribution of the current causes the magnet of the indicator rotor to turn. In this way, a specific position of the magneto-rotor in relation to the coils of the ratiometer corresponds to each position of the cursor and on the potentiometer.

On the shaft of the movable magnet of the rotor is fastened a needle, rotating with the magnet, and indicating the position of the control lever. Appropriate markings have been placed on the dial of the instrument.

1.12.2. Construction

01. Transmitter UPRT-2

The construction of transmitter UPRT-2 is shown in Figure 126. The transmitter is composed of a potentiometer (14) and cursor (2), firmly fixed to plate (13), mounted on the transmitter case.

When the control lever changes position, shaft (19) turns, and this movement is transferred at a 1:2 ratio to shaft (4) through gears (18) and (11). Gear (18) consists of gears (21) and (22) connected by spring (20) which sets the meshing clearance with gears (11).

Potentiometer (14) is fixed on shaft (14) and turns with it. When the position of the lever is changed, current is fed to the potentiometer through spiral spring (9), fastened to the contact plates (24), electrically connected with posts (5) and mounted on bed (7). In order to prevent the coils of the spiral springs from touching, insulating washers (8) are inserted between them. A pin (17) moves to the stopping device (15) in the case (3), prevents continued rotation of shaft (19), and in this way protects the spring conducting the current from breaking.

For the initial setting of the potentiometer in relation to the pin (17), socket [?] (10) is placed on the gear (11), making it possible to rotate the potentiometer shaft in relation to the gear [22].

All the parts of the transmitter are mounted on case (3) and covered by covers (1) and (6). For fastening to the motor, the body has four openings for mount bolts. The transmitter is wired to the electrical system through plug (12).

02. Indicator UPRT-2

The structure of indicator UPRT-2 is shown in Figure 127. In the device are mounted two identical magneto-electric ratiometers, each of which is electrically connected with its own transmitter. A ratiometer is a system consisting of a stator with a 3-phase winding and a permanent magnet-rotor (1), rotating within the stator on ball bearings (2). One magnet turns on a hollow shaft (3) and a second on shaft (4), into which a thin shaft (5) is pressed.

Shaft (5), on which pointer (6) is fastened, with the designation "1" or "3" phases through hollow shaft (3) of the first ratiometer. Pointer (20), with the designation "2" or "4", is fastened to shaft (3) by nut (7).

The axial spacing of the rotor is regulated by washers. The winding of stator (9) is in the form of a toroid, divided into six sections. The ends of the winding are connected in such a way that two diametrically opposite sections form one phase. All six sections comprise three phases, spaced 120° apart. In carbolite frame (10) are placed permalloy discs (11) of the magnetic line, and the stator winding is on the outer part of the frame. Six wires leading from the plug connection (12) pins connect to the stator. The ratiometers are fastened to the body (13) by three screws (14). The steel cover (15) protects the device from mechanical damage and from dust, and also forms a shield for the ratiometer.

The scales (16) are fastened to the column of the first ratiometer. Rubber seal (17) and glass (18), which is held by a flexible ring (19), are on the front end of the body (13). The indicator is wired to plug (12). For fastening the indicator to the aircraft, the body of the indicator has four eyes with self-locking nuts.

Technical Data

1. The UPRT-2 operates on a DC voltage of 27 - 2.7 V;

2. The UPRT-2 operates reliably at ambient temperature of from 50 degrees C to - 60 degrees C.

3. The distance transmission error on the device, when the voltage varies according to point 1, and in the temperature range cited in point 2, does not exceed - one degree according to the scale of the device, in the range of 60 to 105 degrees and 1.5 percent in the other parts of the scale.

4. Maximum current for the assembly's two instruments and four transmitters is 0.6a.

5. The transmitter is designed for an overload by the vibrations [which occur] at an acceleration of [6g] and the instrument [is designed for an overload of ?] up to 1.5 "g" within a frequency range of 20 to 80.

1.13. Generator SGO-8.

The SGO-8 generator is basically a 12-pole synchronous unit genera 50X1 three-phase alternating current, with excitation from the direct-current aircraft system in emergency cases from the batteries. On the rotor, there is a three-phase alternating-current winding, which is delta connected. The ends of the three phases of the winding lead to the collector rings.

In the terminal box are three terminals (from the three phases of the synchronous generator) with designations C_1, C_2, C_3, for the current output, and two terminals with the designations I_1, I_2, for feeding the exciter winding.

The generator may be used as a single-phase generator by attaching the AC current collector to any two of the three terminals of the winding. If the generator is connected as a three-phase generator, its output is 15 kilovolt-amperes.

The generator is driven by the engine through a flexible shaft, which is splined on the end.

The cooling of the generator is cooled by a current of air with a pressure of a minimum of 300-mm of water column at the intake duct, at a maximum temperature of ≯ 60° Centigrade.

The generator operates at a single-phase network, together with one of the following assemblies: Voltage regulator RN-600, resistor VS-33, voltage precision regulator box KRT-1, switch box KVP-1A, program mechanism box PMK-14, contactor KM-100 D; regulator box KRL-31, voltage regulator RN-400 B, regulation resistance VS-30 B, contactor KM-100 D.

Technical Specifications:

Voltage	115 V
Sustained output	8 KVA
Rated current	69.5 A
Frequency range	400 to 900 cps
RPM range	4,000 to 9,000 rpm
Exciter voltage	26 to 30 V
Maximum exciter current	28 A

1.13.1. Structure

The generator is partially encased: the cover and the body have openings on the drive end for the intake and discharge of cooling air.

The air reaches the generator through a hose fastened to a connecting pipe on the back end of the generator.

Part of the air passes along the surface of the slip rings and channels of the armature sleeve, and the other part along the body between the exciter coils. Both currents of air come out through openings in the body.

01. Body.

The body of the generator (7) (Fig. 128) is a monoblock and is cast from steel. The outer surface is covered with a black protective paint. Twelve terminal bars (9), with excitation coils, are fastened to the body by screws (6). The coils (11) are interconnected in series; two outlets are fastened to the terminals an the panel. The coils are treated with insulation lacquer.

The terminal bars are wound from copper leads with a diameter of 2.44 millimeters, and closed on the front end by connecting copper plates.

In the body (7) there are, on the drive end openings for exit of cooling air from the generator. To prevent the access of foreign objects into the body, the [main] openings are protected inside by perforated cover (10).

02. Rotor with slip rings.

The rotor is made with electrotechnical steel plates and is fixed to the bushing by a support ring. In the rotor grooves is a 3-phase winding, which is delta connected. The ends of the winding are soldered to the slip rings. The bushing, with the rotor, is pressed on hollow shaft (19), made of type 30CHGSA steel.

Within the hollow shaft is fastened flexible shaft (18). The flexible shaft has a splined end for connecting the generator with the drive. The winding of rotor (8) is double-layer, impregnated with insulating lacquer. On the front end, the winding of the rotor has a protective wire binding.

The rotor is dynamically balanced by an application of lead to the binding. The slip rings (21) are made of copper and embedded in plastic. The rotor turns on ball bearings. On the drive end, there is fastened, in the body, near the laboring by means of a support ring, an external collar. The bearing is secured on the shaft by a nut (12).

At the opposite end, the ball bearin

03. Front.

50X1

The front part (5) is made of aluminum alloy and is fastened to the body by screws (14). A double brush-holder (13) is fastened to the front part with screws (15) and bushings (16). On every slip ring there are two brushes (17). The brushes are pressed in by springs.

The wires from the brush-holders are clipped to terminals C_1, C_2, and C_3, located on the panel. The terminal panel (3) is in case (2) whose lower part is fastened to the front by screws (4), and the upper part is removable. For access to the brushes, there are openings in the front part covered with band (20).

The air intake pipe (23) is made of aluminum alloy and is fastened to front (5) by screws (22). A hose, through which cooling air passes is fastened to the air intake pipe.

1.14. RN-180 Voltage regulator.

The RN-180 carbon voltage regulator automatically maintains the voltage of the DC starter generators at a designated range, upon the change of its load in the generator stage and upon changes in rpm in the operational range. At the same time, the regulator assures the uniform distribution of the load during the parallel operation of the generators.

Technical Data.

Nominal regulated voltage 28.5

Maximum loss of carbon column W 180

Stage of operation .... Uninterrupted

The regulator operates safely under the following conditions: 95 to 98 percent humidity and at temperatures of 25 - 5° Centigrade; at a change in the ambient temperature from 50° to 60° Centigrade.

The RN-180 voltage regulator is an electro-magnetic rheostat type regulator with a continuous change in the resistance of the carbon column. The main parts of the voltage regulator are: the regulator itself, the support with the shock absorber, the base, and the plug connection SR28PK7NG-9.

The regulator assembly includes the carbon column, the coil with the core and contact, serving for the regulation of resistance of the carbon column.

Heat compensation resistors are located on the base together with the stabilization resistor and the tuning rheostat. The regulator operates as follows:

Higher armature rpm, increases the voltage and at the same time increases the current in the operational winding of the regulator; as a result of this, the magneto-motive force, which overcomes the action of the spring, begins to draw the armature to the coil core with three windings (in this case, if regulation resistor RN-180 is in a position corresponding to the setting).

The changed position of the armature decreases the pressure on the carbon column, and its resistance then increases, which causes a reduction of current in the exciter circuit of the generator. As the exciter voltage falls, the voltage at the terminals of the generator falls, proportionate to the exciter current $u_2 = f$ (ib). With a decrease in the generator voltage, the voltage in the operational winding decreases proportionately. When the armature, by means of the flexible diaphragm increases the pressure in the carbon column, the resistance of the column decreases, the generator voltage increases.

The characteristics of the electromagnet and of the diaphragm of the armature are selected in such a way that a slight change in the voltage of the operational winding of the regulator causes a comparable change in the resistance of the carbon column, which is necessary for keeping the generator voltage in the desired range.

In the calculation of the ampere turns and the resistance of the operational winding, it is necessary to give attention to the attainment of a specific stability of regulation during transient periods.

In order that temperature changes should not influence the operation of regulator RN-180, it has a heat compensation: 1. heat compensation resistors R_1 and R_3, made of "constantan" are wired in series with the operational winding; 2. parallel to the operational winding and the R_1 heat compensation resistor, is fastened a heat compensation winding whose magneto-motive force acts in opposition and is subtracted from the magneto-motive force of the operational winding, and the difference between these magneto-motive forces acts upon the regulator.

The parameters of the resistors and the winding are selected in such a way that with a change in temperature, the magnetic flux is not changed, and the resulting magneto-motive force remains constant, with an unchanged number of generator revolutions and load.

In this way, the "constantan" resistors switched into the regulator circuit (having a high specific resistance and a small change in resistance during changes in temperature) and the winding of the heat compensation [device] considerably lower the changes in regulated voltage, caused by the changes in the resistance of the operational winding at various temperatures. In addition to this, stabl[redacted] achieved by switching over the reverse power connection to circuit RN-180, with the aid of stabilization resistor R_2. As a result of this, the regulator operates without a stabilizing transformer. The balancing winding "So" is used when the generators are switched in parallel to aircraft system in order to equalize the excitor currents of the generator of the same type. 50X1

The adjustment of RN-180 during operation is carried out only with adjustment resistor VS-20 switched into the operational winding of the regulator.

1.15. Electro-magnetic feathering control valve

The electro-magnetic valve (Fig. 36) for feathering directs oil from the feathering channel to the piston for control of feathering during negative torque.

Technical Data

Current	Direct
No of leads	Single-line
Voltage	27 ± 10% V
Current at a voltage of 27 V	3 Amps
Operational pressure of oil	45 kg/cm^2
The valve is tight at a pressure of	up to 70 kg/cm^2
Operational regime	repeated, short-term

The valve (Fig. 36) is fastened to a flange on the reduction gear housing. The oil is fed to channel (1) and passes to the valve cavity.

The valve is controlled from the pilot area by throwing the feathering switch under negative torque conditions. The voltage passes to the coil (14), and the resultant electro-magnteic force moves core (12). The core pulls pin (11) and needle (10), which opens the channel in insert (6). The oil passes through the insert and the hole (2) to the feathering piston.

Note: The valve may be operated three times, each time lasting 30 seconds. The time interval between the individual switchings is three minutes, and then follows cooling, for a minimum of 30 seconds.

1.16. Transmitter for feathering when allowable revolutions are exceeded

The transmitter for feathering when the allowable revolutions (Fig. 37) are exceeded, transmits a signal (switching of contacts) in the electrical system for automatic feathering when engine rotor exceeds allowable rpm.

Technical Data

Type of transmitter	Electro-hydraulic
Current	Direct
Voltage	27 10% V
No of wires	two
Load current contacts	1.5A
The valve begins operation at	13.6 kg/cm^2
Error during ambient temperature range from -60° to + 120°C	5%
Overload pressure	30 kg/cm^2
Tightness [tolerance?]	to 88 kg/cm^2

A schematic of the transmitter is shown in Figure 38. When the engine rotor reaches 140,000 + 500 - 250 revolutions per minute the control pressure in KTA reaches a value of 13.6 kg/cm^2, point (2) contacts point (3), fastened into the upper spring (4), and transmits voltage to the electrical system for automatic feathering.

Structurally, the transmitter is composed of the following main parts: housing with parts; mechanism with sensing element, and cover.

On the housing (5) [Fig. 37] are mounted the following: insert (18) with a filter, threaded fitting (19), plug connection (7), and plug (34). Cover (8) screws on threads in the housing. A sensing element is fastened inside the housing by means of collar (2). The collar is secured to the body by two screws (20). The transmitter sensor is a spring "VID" box (16), composed of two welded parts.

2. STARTING SYSTEM.

2.1. General

The electrical starting system assures: starting the engines on the ground; cranking the cold engine; interruption of starting (switching off the starters); restarting the engine in flight.

The starting system consists of assemblies mounted on the motors of controlling components and instruments located in the crew cabin, and assemblies located in the electrical section under the wing roots.

On the engine are mounted the following: STG-12 TM starter generator-two; KPN-4 ignition coil [illegible] with SPN-4 spark igniter plug - two set 50X1 VE-2S pressure switch - one; starter fuel valve - one; MZK electric mechanism - one; propeller brake - one.

The following control parts and control instruments are in the crew cabin:

1. On the left board on the starter panel: main starter switch; engine selection switch; starting button; signal light for operation of automatic starting device; button for disconnecting starters; switch for cold engine cranking; button for fuel transfer changeover switches for propeller brakes; signal lights of propeller brakes; relay and button for control of signal lights.

2. On the central pilot panel: air restart button.

3. On the lower part of the instrument panel on the side of the central panel: voltmeters of starter power sources.

In the electrical section under the wing roots located between ribs nos. 24 and 26: APD-75 automatic starting device PSG-2A starter case; case of starter circuit relay no. 63.

The blocking relay which prevents starting when the propellers are braked is located in the box of the fire prevention system No. 65 of the electrical section.

The contractors for feeding the starter-generators are located in the distribution boxes of the appropriate engine nacelles.

2.2. Starting engines.

The starting of the engines is conducted basically by means of a single ground source and aircraft batteries, or, in case of need, only by means of the batteries.

To prepare for starting, it is necessary to set switch 16-196, on the distribution panel, into the position of "switched-on", and to set change-over switch 026-195, on the control panel of the directcurrent sources, into the position "airfield source," which actuates the relay and contactors 63-0177, 63-0178, 63-181, 63-183, 63-184, 63-182, 63-0181, 63-0182, 63-5647; these connect the ground power source to the aircraft circuit; shut off the generators; and energize the starter circuit. Together with these relays and contactors, contactors 43-0169, 43-100A, and 43-0170 are also put into operation. The voltage of power sources is checked by two voltmeters 10-185 and 10-186, located on the instrument panel.

From main starter switch 11-5505, through contacts of relay P7 of automatic device APD-75 and contacts of blocking relay 63-5647, current is supplied to starter button 11-5509 from the main starter switch 11-5505, and also contactor 63-0187a, which switches on the supply for the starter circuit, is switched on.

The engine selector switch 11-5510 is set in position for the engine to be started (in Figure 143, it is set for starting motor No 1).

Changeover switch 11-5515 of the propeller brake is set into the position "brake released." The MZK-2 electrical mechanism releases the propeller brake and blocks the "minus" circuit of starter relay 65-5529. On the left pilot panel, the red warning light 11-5519 goes out.

Starter relay 65-5529 goes into operation and switches on starter button 11-5529 and button 11-5525 for the starting fuel supply to the engine selected for starting. The system now is ready for starting.

On pressing button 11-5509 "plus" is fed to relay 62-5627 and contactors 62-5639 and 62-5643. Relay 62-5627 is switched on through contacts of intermediate relay P3 of automatic device APD-75 and through contacts 18-17, and yields a "plus" on control relay P1 of automatic device APD-75.

Control relay P1 goes into operation and through its contacts is blocked, because it attains a "plus" at the main starter switch 11-5505 through the button for switching off starters 11-5508, and its contacts 17-18, and the terminal switch "B" of the program mechanism.

Pressure switch 5553 is switched on to the "minus" circuit of control relay P-1. Through the contacts of control relay P-1, is fed the relay of the electric motor of program mechanism P2, intermediate relay P3 of the automatic device APD-75, and the signal light "starting is in progress" 11-5506.

Relay P-2 of the electric motor goes into operation and feeds electric motor D-2 from the program mechanism.

Intermediate relay P3, through its contacts 5-6, switches on the blocking relay, which disconnects the contacts and breaks off the supply to the starter button 11-5509.

Relay 62-5627 attains the "plus" necessary for blocking from the main starting switch 11-5505 through contacts 3-2 of intermediate relay P3 and its contacts 17-18.

Contactors 62-5639 and 62-5643 are fed by relay 62-5627, closing the circuit for supply of voltage to the exciter winding of starter-generators 101 and 103.

Through contacts 8 - 9 of control re[redacted] cranking relay P6, which goes into operation and feeds, through the term[redacted] switch and contacts 11-12 of relay 62-5627 on contactor 62-5635.

The contactor 62-5635 switches on the ignition system on the engine preparing the spark igniter plugs for firing. Contacts 11-12, of relay 62-5627, and relay 62-5631, go into operation and set the delivery range of the electromagnetic valve for starter fuel 5561.

Through contacts 6-5 and 2-3 of relay 62-5627, "plus" switches on contactors 81-5611 and 81-5613 and blocking relay 63-181a.

Contactors 81-5611 and 81-5613 close the supply circuit for the starter-generator, and blocking relay 63-181a disconnects the starter-generators from the aircraft circuit.

From the terminal switch "V" of the program mechanism, "plus" is conveyed to contactors K_1 and K_2 in case PSG-2A, which switch on, to the circuit for feeding the starter generator armatures, starting resistors R_{p1} and R_{p2}.

The full voltage of the aircraft network, equivalent to 24V goes to the exciter winding of the starter-generator because the carbon columns of the output regulators RUT-600D are short-circuited by contactors K_5 and K_6.

The switching valve 5-185 in KTA-5F is fed from the terminal switch "G".

In the first stage, the following were assured: 1. Supply of voltage to starter case PSG-2A; 2. Switchover of the exciter winding from the generators stage to the starter stage (relay 62-5639 and 62-5643); 3. Switching on the armature circuit of the starter generators through the starter resistors (contactors K_1 and K_2); 4. Switching on electromagnetic valve 5-185 in KTA-5F; 5. Switching on the ignition system for "conditioning" the spark plug (contactors 62-5635); 6. Switching on blocking relay 63-181a, disconnecting the circuit for switching on relay DMR-400 AM.

As a result of this, the starter-generators begin to turn at low rpm and no torque is generated in the mechanical transmission.

Operation then continues in according to the schedule of the program mechanism of automatic device APD-75. In the first 3.5 seconds, the starter-generators are fed through the starter resistors. This assures their running without generating torque.

In 3.5 seconds, terminal switch "A" feeds the intermediate relay P_1 of case PSG-2A. Intermediate relay R_1 turns on contactor K_3 which briefly connects resistors R_{p1} and $R_{p}2$ and supplies 24 volts from the aircraft system to starter-generator armatures.

In nine seconds, terminal switch "B" disconnects from contactors K_1 and K_2 of case PSG-2A, which disconnect starting resistors R_{P1} and R_{P2} 50X1

Terminal switch "v" disconnects the supply of relay R_5 for switching on the output regulator of the APD-75 automatic device.

The relay for switching on the output regulator P_5 closes the supply circuit on intermediate relay P_4 of case PSG-2A. Intermediate relay P_4 passes current from the terminal switch through contacts 6-5 of the relay for switching on the output regulator P_5 and contacts 6-5 of relay P_6 for cold turning of automatic device APD-75.

Intermediate relay P_4 of case PSG-2A switches on its contacts and feeds the coils of contactors K_5 and K_6, which switch on the output regulators RUT-600D. Through contacts 2-3 of relay P_5 for switching on the regulator and through contacts of relay 62-5681, the coil of the electro-magnetic valve for starter fuel 5561 is energized, and the valve opens, but the fuel still does not pass into the system.

In 15 seconds, the terminal switch "V" feeds the coil of intermediate relay P_2 of case PSG-2A; relay P_2 conducts "plus" to contactors 63-0183 and 63-0184, which switches over the supply source from parellel to series connection. In this way, a 48-V voltage supply is attained on the winding of the starter-generators.

In switching over, terminal switch "V" breaks off the supply of intermediate relay P_4 of case PSG-2A. Relay P_4 disconnects contactors K_5 and K_6, which short-circuit the carbon columns of output regulator RUT-600D. The full voltage of the aircraft system will be supplied to the exciter winding of the starter-generators, which develop a greater torque, and the rpm of the motor increases.

In twenty seconds, terminal switch "D" switches on the electro-magnetic stop valve 5-185 in KTA 5F. In switching on the coil of this valve, the supply of fuel begins to flow to the starter system and the fuel nozzles. The starter fuel is ignited and the flame is transferred to the combustion chamber. The turbine begins to develop torque.

In 20 seconds, terminal switch "D" switches on intermediate relay R8 of automatic device APD-75. Intermediate relay P-8 feeds, through its own contacts and the contact of the relay for cold cranking P_6, the winding of intermediate relay P_4 of the PSG-2A, which switches on contactors K_5 and K_6. During the action of contactors K_5 and K_6 output regulators RUT-600D operate at a voltage of 48 V.

If the engine reaches N = 4,500 to 6,000 rpm (35-50%), pressure switch 5553 disconnects the "minus" circuit of control relay P_1 of a50X1atic device APD-75.

Control relay P_1 feeds through its contacts 2-1, contacts 5-6 of the relay of electric motor P_2 on electro-magnetic coupling 53 for accelerated operation of the automatic starting device after disconnecting the starter-generator. Contactor 62-5635 disconnects the supply to the ignition system and to relay 62-5631 on the electro-magnetic starter fuel valve 5561. If a command does not come from pressure switch 5563 for switching off the starter-generators, they obtain this command from the program mechanism, in accordance with the operational schedule of the automatic device APD-75 after 69 seconds.

In 25 seconds, terminal switch (D) stops the supply of contactor 62-5635 and relay 62-5631; this switches on the ignition system and the electro-magnetic valve for starter fuel 5561.

In 68 seconds, terminal switch "V" switches into initial position. Intermediate relay P_2 is disconnected in the PSG-2A, which switches off contactors 63-0183 and 63-0184, and these change the starting circuit from 48 to 24 V.

In 69 seconds, terminal switch "A" is switched over to initial position and switches off intermediate relay P_1 of the PSG-2A, which ceases to supply contactor K_3, which switches off the supply circuit of the starter-generator armatures. In 70 seconds, the terminal switch "E" disconnects the circuit for blocking control relay P_1 of the APD-75 automatic device. The control relay switches over to the initial position, switches on coupling 53 to accelerated schedule of the program mechanism. The relay of the electric motor of program mechanism P2 of intermediate relay P3 and blocking relay P7 of automatic device APD-75 remain switched on, because their supply is assured through terminal switch "O", which switched on its contacts for 2.5 seconds after the starter button was depressed.

During the cut off of the relay for switching on output regulator P_5, the relay for cold cranking P_6 and intermediate relay P_8 of automatic device APD-75, contactors K_5 and K_6 of the PSG-2A are switched off and short-circuit the carbon columns of output regulators RUT-600D, and there occurs a supplementary magnetization of the magnetic circuit of the starter generators for assuring their operation in the generator stage.

In 73 seconds, terminal switches "V", "D", and "E" are switched over to their initial positions.

In 74 seconds, terminal commutator "Kh" is switched over to initial position.

In 75 seconds, terminal commutator "O" is switched over to initial position.

50X1

Automatic device APD-75 is switched off. Intermediate relay P_3 disconnects the circuit of relay 62-5627. During this, contactors 62-5639 and 62-5643 switch the exciter windings of the starter-generators to the generator stage from output regulators RUT-600D to regulators RN-180 (Figs 117 and 119).

With the deactivation of relay 62-5627, blockage the switches of generators DMR-400 AM is stopped (blocking relay 63-181A is switched off), the circuit is switched off for feeding the starter-generator armatures from the PSG-2A (relays 81-5611 and 81-5613 are switched off).

Upon transition of the starter-generators to the generator stage, relays 62-5607 and 62-5619, which prevent the operation of the starter-generators on the running engine, are switched on.

The conversion of the starter generators to the function of generators for the aircraft system is effected by the switches of generators DMR-400 AM at the moment the voltage of the starter generators exceeds by 0.3 to 0.7 the voltage of the aircraft system (during the switching on of switches 026-141 and 026-143.

2.3 Switching off engines

To break off the starting process, it is necessary to press the button for switching off starters 11-5508. During this, the control relay P1 of automatic device APD-75 is switched off. The program mechanism is switched over to accelerated operation and is set in the initial position. The accelerated setting is affected by switching on the clutch for accelerated operation through contacts 1-2 of control relay P1 and contacts 5-6 of the relay of the electric motor of program mechanism P2 of automatic device APD-75. In order to switch off the operating motor, the switch "switching off of motors" on the central board in the crew cabin is closed. During this, the "plus" passes from the aircrft system through the switch "switching off motors" to the electro magnetic switching-off valve 5-185 in KTA-5F. The fuel supply is stopped. The fuel transfer turns on the electro magnetic fuel transfer valve, button KTA-5F. In this way, the supply of fuel to the nozzles is decreased, and the temperature of the gases in the exhaust nozzle and in front of the turbine is decreased.

2.4 Cold cranking

Cold engine cranking is effected when the position of the switch of the electro-magnetiv valve for stopping the engine is at "seitched off," and the switches for cold cranking 11-5507 are in the position "cold cranking."

[redacted]

After the pressing of starter button 11-5509, the automatic system works in the same way as during starting, except that contactor 62-56 [redacted] 50X1 does not switch power to the ignition system and relay 62-5631 for feeding the electro-magnetic valve of starter fuel 5561 in KTA-5F, and they are not switched on after the second output regulator RUT-600D, at a voltage of 48V.

The starter generators are cut off in this case by terminal switch "kh," which, in 25 seconds, switches on clutch 53 to accelerated operation of the program mechanism. Power to the clutch for accelerated operation passes, in this case, from main starting switch, 11-5505, through the terminal switch "kh," contacts 2-1 of relay P6 for cold cranking and contacts 14 to 15 of control relay P1.

2.5 Air restarting

In order to restart, button 15-5523, on the central board in the crew cabin, is pressed. Current passes directly to the ignition coil and the electro-magnetic valve for starter fuel 5561.

CHAPTER VII

AIRCRAFT POWER PLANTS

1. GENERAL REMARKS

Four power plants: two outboard engines, Nos 1 and 4, and two inboard, Nos 2 and 3, are located on the center section.

The engines and accessories are enclosed in the nacelles. The inboard engine nacelles also contain the main landing gear structs, and units [accessories or aggregates] of the hydraulic, fuel, fire protection, and electrical systems of the aircraft. Therefore, the inboard engine nacelles are larger at the bottom than the outboard. The outboard engines differ from the inboard in that the oil coolers are located in the nacelle, instead of in the engine cowling.

The axes of the outboard engine nacelles are aligned with the axis of rib (20) of the center section, while the inboard nacelles are on the axis of rib (10) [Figure apparently missing].

The nacelles are divided into two parts: into the cowling and the nacelle itself.

The cowling is attached to the engine and not to the nacelle. The rear edge of the cowling cover rests on shaped rubber seals. The nacelle itself is a continuation of the cowling, and makes up the enclosure for the main landing gear strut and exhaust pipe. The nacelle transmits stress from the engine to the center section. In addition, it contains attached tubing, and cables for controlling the engines and landing gear.

The engine bay is separated from the exhaust pipe by firewalls, which are formed by the bottom part of bulkhead (1), a horizontal partition, and the upper part of bulkhead (3). The firewalls have a titanium metal covering.

The places where the tubes and linkages pass through are sealed. Engine bulkhead (3) is sealed by removable pressed shapes, fixed by a rim to the turbine housing shield.

The inside of the nacelle and cowling is colled by air through an [air] scoop located on the cowling and nacelle.

The wing covering is shielded by protective walls from overheating by the exhaust pipe: by a lower wall and two side walls. The walls are made of titanium metal. The end parts of the nacelles and the upper access panels can be removed.

1.1 Cowlings

50X1

The cowlings of the inboard and outboard nacelles differ in shape and construction in that the cowlings of the inboard nacelles have a lower panel not on the outboard nacelles.

1.1.1 Inboard nacelle cowling

The cowling consists of the front part with the [air] inlet duct for the oil cooler, of the streamlined cover of the reduction gears, of the top support bracket, two side panels, and a bottom panel with an outlet duct for the oil cooler.

The side panels can be opened upwards (131). This provides access to the parts of the engines and accessories located in the engine bay. In the opened position, the side panels are held by supports located in the front part of the enclosure.

The front section of the cowling and the streamlined enclosure for the reduction gears forms an air intake, and a duct for supplying air to the engine. The bottom of the front section contains an oil cooler.

The front section of the cowling is attached to the flange of the front engine housing by 12 fittings mounted in the place of contact of the partition with the covering of the air supply duct and bulkhead 2.

A "textolit" strip is attached to the corner on which the side panels and upper load bearing section rest. The front section of the cowling contains two openings: the upper -- for access to the electrical mechanism of the propeller brake and the lower -- for access to the oil drain plug of the coller, and also for heating the engine.

The streamlined cover of the reduction gear is box reinforced by four longitudinal partitions, by one transverse partition, and two circular molded shapes.

The molded shape has eight "textolit" nuts equally spaced around the circumference, which serve to center the cover on the box.

The streamlined cover and also the front section of the cowling are attached to the engine. The front flange of the reduction gear box has bolts for this purpose, while the rear flange has outside faces on which the "textolit" lock nuts are located.

The upper support part of the cowling i [redacted] and to the special fastening plates located on the rear flange of the compressor housing. The support member is fastened on rubber [shock] absorbers tightened by screws. 50X1

The sides contain metal fittings on which the side panels of the cowling turn.

In front, the support member has a cut-out section for the centrifugal air vent valve. The cut-out section is covered. Shaped rubber sealing, covered with linen, is at the contact point of the support member with the side panels.

The forward mounting points of the support member are attached to the metal fittings on the front section of the cowling, while the rear mounting points are attached by three shafts and metal fittings to the plates on the rear flange of the compressor housing.

The side panels of the cowling consist of a stamped frame and covering.

The upper part of the panel has metal mountings, which are joined by 6 millimeter diameter bolts with the metal fittings of the upper support members. The panels hinge on these fittings when being opened.

The side panels are secured in the closed position by locks located on the lower part.

Each panel has a countersunk air vent to ventilate the engine area. The left panel has an access hole for adding oil to the tank and the cover for the oil gauge transmitter, while the access cover has an air vent for cooling the oil gauge transmitter.

The panels are held in the open position by a support fitted with an end piece. The end piece is set on a stop which is on a partition of the front section of the cowling.

The lower panel consists of transverse and longitudinal reinforcing elements and covering. The cover is attached by four hinges. By means of the front hinges, the cover is attached to the metal fittings of the front section of the cowling, while the rear hinges on four supports, attach the panel to the special plates and metal fittings located on the rear flange of the compressor housing. The panels are attached by means of rubber sleeves.

Both sides of the panel have metal fittings on the upper molded pieces for engaging the locks. The outlet duct of the oil cooler is attach to the partitions of the panel. A flap, controlled by the MVR-2V electrical mechanism, is at the end of the duct.

The front edge of the outlet duct adjacent to the oil cooler has a molded rubber seal. The outlet duct is riveted on the panel.

The rod of the electrical mechanism which passes through the cut out section in the duct covering has a seal. The lower panel contains four openings: two circular shaped openings for access to the flap attachment, a left opening for access to the fuel outlet, and a right opening for draining the oil and fuel and for access to the propeller pump.

The entire cowling is sealed by shaped pieces at the contact of the cowling side panels.

1.1.2 Outboard cowling (engine)

The cowling for the outboard engines consists of the front section, the upper support section, and two side panels. The side panels, just as on the inboard engines, open toward (131). This position provides access to all parts of the engine and accessories located in the engine bay.

The front section of the cowling is circular, and together with the streamlined cover forms the air intake and air supply duct to the engines.

The upper support section and the attachment of the side panels to it is similar to that of the inboard engines. Below, the side panels are jointly connected by tightening locks. In the closed position, they rest on two side stops which are attached to special attachment plates located on the rear flange of the compressor housing. The opening for preheating of the engines is on the right panel.

1.2 Propeller hub fairing

The propeller fairing consists of a cover for the propeller hub, four covers for the blade roots, and two rings. The cover of the propeller hub is streamlined and has three rings. The cover rests on the front ring on the front part of the propeller hub and also is attached by the two other rings to disks attached to the propeller hub.

The rings are riveted to the covering, the flanges are riveted to the cover plate.

The rings are attached to the propeller hub on rubber damper sleeves. The cover can be easily removed from the rings by special pins located in the two rings of the cover. The pins fit into the ring openings into which steel casings are pressed, and they are held in this position by a circular safety catch located on the front ring. The safety catch secures all 16 pins of a ring at the same time, which makes it possible to remove the connection easily. The safety catch is a steel ring (30 CHGSA) [30KhGSA] with shaped cut out sections. The safety catches are closed and opened by a special key turning the ring to the right or left. To prevent the circular safety catch from opening, it is secured by a special safety device which shows whether the circular safety catch is in the open or closed position.

The inside of the panel has a heating element for electric heating. The heating element is connected to the front end of the propeller hup. The connection consists of two pins, which when the cover is mounted onto the propeller, fall into the openings in the propeller head.

2. ENGINE MOUNTING

The engines in the outboard and inboard nacelles are mounted the same with differences in the size of girders and struts. (132).

The engine mounting is flexible and done by rubber disks with [vibration] absorber. The combination of disc and absorber sleeves enables good flexibility both vertically and horizontally.

The flexible mounting of the engine reduces transmission of vibrations which develop when the engine is running, and prevent their being transmitted to the airplane frame.

The engine is mounted on four pivots. The front pivots [trunnions] (1) (Fig 132) are set in the front absorbers (2) of two girders (5). The girders are joined to two upper [rigid] struts (4), and two [tubular] struts (6) are attached to the mounting brackets on bulkhead No 1 of the engine nacelle. The rear pivots are attached to the upper mounting brackets on bulkhead No 1 and two shock struts are attached.

Struts (6) on the inboard nacelle, and the left struts of the outboard nacelle are steel tubes. The right internal strut of the nacelle is a girder forged from AK-6 material.

To facilitate assembly and balancing out possible stresses in the couplings of the girders and struts on bulkhead No 1 and in the couplings of the rear shock struts, ball bearings are inserted.

The position of the engine can be changed by adjusting the length of the tubular struts and the rear absorbers. Adjusting the length of the struts moves the engine horizontally, while adjusting the rear shock struts moves the engine vertically.

When installing or removing an engine, the girders and shock structs are not disassembled, but only turn in the attached mounting brackets on bulkhead No 1. The tubular struts are disconnected from the girders [during adjustment procedure?].

All screws, pivots, and sleeves are lubricated with CIATIM-201 grease when the engines are installed.

3. EXHAUST SYSTEM

The exhaust system (Fig 133) consists of: adapter flange (1) attached by bolts to the rear flange of the engine; cones (2), connected telescopically with the adaptor flange and pipe; and exhaust pipe (4), attached by its front end to the nacelle [engine ?]. (The rear end of the pipe rests on rollers (29) in guides mounted in nacelle (28), which allows the pipe to change its position freely during temperature changes); and contact collars (8) and (14) for connecting the cone between the adaptor flange and pipe.

The cone is essentially a pipe extension whose wall is made of heat resistant steel 1.2 millimeters thick. Welded onto the front end of the cone is a ring with a lug (7), while the rear end has flange (11) welded to it for the telescopic connection of the cone with the engine and the exhaust pipe. The telescopic connection makes it possible for it [the cone ?] to shift from the axis or along the axis.

To restrict the spontaneous shifting and vibration of the cone, it is attached to the adaptor flange by eight springs (10). Adaptor flange (1) is attached to the engine flange by 48 bolts (5), 8 millimeters in diameter. All four cones are identical.

A ring with lug (12) for connection with the cone is welded on to the front end of the pipe. Two metal fittings (22) into which pivots (21) are engaged, are attached to the hoops of the front part of the pipe, and seated snugly into metal fitting (19) with rubber sleeves (20) located on the sides of the nacelle. The mounting of the pipe can be adjusted, making possible to properly adjust the front end of the pipe. Metal guide (26), with rollers (29) is attached to the rear end of the pipe, and the pipe is supported by the rollers on the guides of the nacelle. Rollers are also located on the front end of the pipe to ease installing the pipe when it is being mounted on the airplane.

The exhaust pipes of the inboard engines are 1.5 meters longer than the pipes of the outboard engines. The contact sleeve consists of two halves joined together by four screws.

The points where the pipe is connected with the cone and the cone is connected with the engine flange by contact sleeves are telescopic connections which make it possible to align out any possible displacement off axis during installation of the pipe, "and in flight it makes possible relocation of the back of the engine in regard to pressing out the shock absorbers of the engine suspension mounts [?]."

4. DRAIN TUBING SYSTEM ON THE ENGINE AND NACELLE

The drainage system (Figs 134, 135) includes; drains for fuel leaking from the tescopic connection of the cone and exhaust pipe; and drains for fuel accumulations in the combustion chamber of the engine. The system consists of a collector tank and jackets.

The front and rear jackets are attached to the sleeves of the cone of the exhaust pipe.

The collecting tank of the inboard engine is set on the bottom part of bulkhead No 1, while the collecting tank of the outboard engine is on the lower part of the nacelle between bulkheads Nos. 5 and 6.

Tubes with a 12 x 10 millimeter cross section are welded to the bottom of the jackets. These tubes, with the help of the hoses of the pipe extention adaptor, increase the opening cross section from 10 to 16 millimeters, and the tubing of AMGM [material] cross section 18 x 16 millimeters (for the inboard nacelles) is attached to the collector tank. Hoses with an internal diameter of 16 millimeters lead to the outboard nacelle from the pipe extension adaptor to the collector tank.

Drainage of fuel from the combustion chamber is done by AMGM tubes of 12 by 10 millimeter cross section.

To prevent fuel from leaking to the wheels and landing gear struts, the trainage tubes from the combustion chamber of the inboard engine are led outboard the nacelle behind bulkhead 13.

To prevent the fuel from leaking to the bus of the central distribution box of the outboard power plant, the drainage tube from the combustion chamber is led outboard the nacelle behind bulkhead No 6, and here a cover on the opening provides access to the fuel accessories and bus of the central distribution box. The drain tube from the oil tanks also leads out here.

Fuel drains from the recessed [?] control opening of the horizontal brace of the nacelle through a tube 8 x 6 millimeters in cross sectio 50X1 which is led out behind bulkhead No 4 from the right side of the nacelle.

Water draingage openings are at the bottom of the cowling panels, the propeller fairings, the landing gear doors, and the lower surfaces of the nacelles.

5. COOLING AND FIRE-WALLS

To increase the fire safety, the engine nacelles are divided by fire walls into three bays (Figs 136, 137). The engine bay, the exhaust pipe bay, and the bay for the main landing gear shrut of the center nacelle (in the outboard nacelle the area of the oil cooler). The fire wall is formed by the lower part of bulkhead No 1, the horizontal brace, and the upper part of bulkhead No 3. The bulkheads are made of VPI-DI titanium steel 0.6 millimeter thick.

The fire walls are sealed. All guides passing through the bulkheads have flange connections or seals.

The engine mounting bay in bulkhead No 3 is sealed by removable pressed shapes, secured by a band to the turbine housing shield.

The three generators mounted on the engine are cooled by the upper air scoop (2) on the nacelle. The engine bay is cooled by two inverted air scoops (8) on the side panels of the cowling, scoop (1) on the cover of the centrifugal de-aerator and by the air coming from the generators. The air in the engine bay is removed by louvres (3) on two side panels of the control openings of the nacelle.

Through the upper scoop (2) air proceeds to the turbine shield of the engine, cooling it, and comes out through the circular space at the level of bulkheads No 3 to the exhaust pipe section. In addition, the exhaust pipe section is cooled by air from two scoops located on the sides of the nacelles.

Air comes out from the [exhaust] section through a circular space 6 between the exhaust pipe and the inside coating of the rear of the nacelle. A compensator, assuring free movement of the engine, is inserted in the frame of the pipe connection cooling the turbine housing.

Two side air scoops (9) on the nacelle cool and ventilate the main landing gear bay. After passing through the nacelle, the air passes out through rear louvres (10).

50X1

The oil cooler area is ventilated by six openings (9) (Figure 136) found above the air intake for the oil cooler duct. The air exits through louvres on the lower part of the nacelle.

The oil gauge transmitter is cooler by air from the scoop on the cover of the oil filler hole to the tank.

The right side of the nacelle contains an intake for cooling the booster gear for the emergancy brakes and the brake accelerator. Shield protect the wing skin from overheating by the exhaust pipe: the horizontal ? shield (5) with air gap between wing covering and the shield plate and two side walls. The shields are made from titanium (VTI-DI alloy), 0.6 millimeter thick.

The horizontal shields are removable and are mounted by bolts and self-locking nuts to shaped sections on the wing.

In addition, the nacelle contains shields preventing the overheating of the booster gears of the mergency brakes and the brake accelerator. The KTA-5F thermal cartridges, cartidges are cooled by intake (7) located to the right in the front part of the cowling air intake.

The antiicing devices on the front part of the cowling are protected at the same time by the air intake cooling the "thermal cartridges". The outboard nacelles have shields to ensure high [air] velocity in the tubing which fans the "thermal cartidges." Tubing for air cooling is made of AMGM material of 34 x 32 millimeters cross section, which at the pipe connection for the thermal cartridges is reduced to a 27 x 25 millimeter cross section. The pipe connections use "durit" [duraluminum ?]

The tubing for air cooling is thermally insulated by two ASIM-9 layers; a LAS strip, and outer ANZM layer, since the degree of heat of the air by the air cooling under the engine cowling seriously affects fuel control [?].

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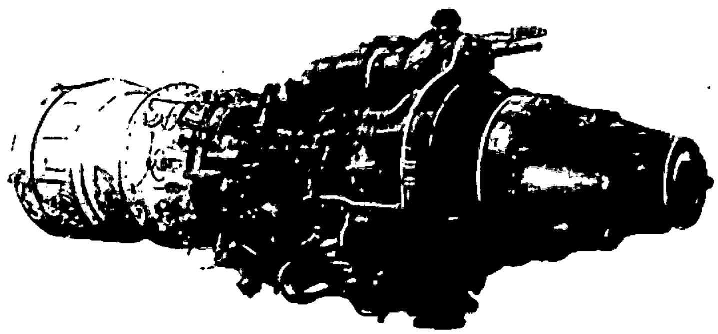

Fig. 1. AI-20 Engine (view from right)

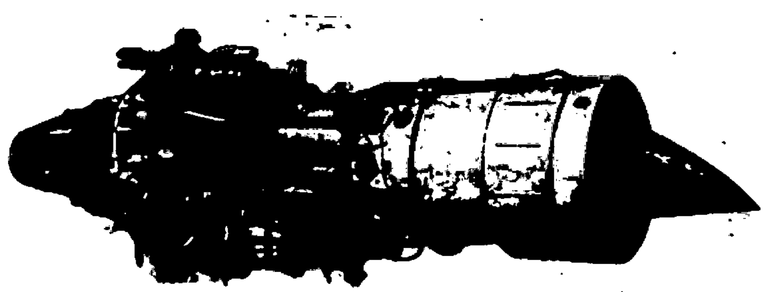

Fig. 2. AI-20 Engine (view from left)

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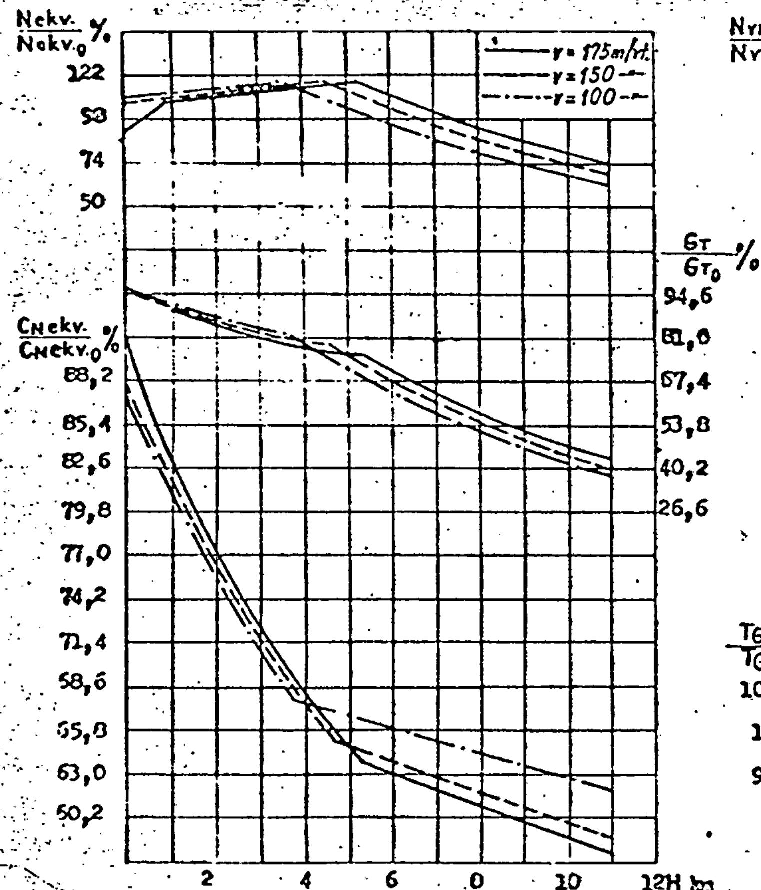

Fig. 5. Altitude and speed characteristics of AI-20 engine. Mode, 0.6 nominal [n = 12,300rpm]. Parameters $N_{ekv.}$ 0 $C_{Nekv.}$ 0, correspond to engine ground operation on 0.6 nominal mode H = 0 m, v = 0 meters per second].

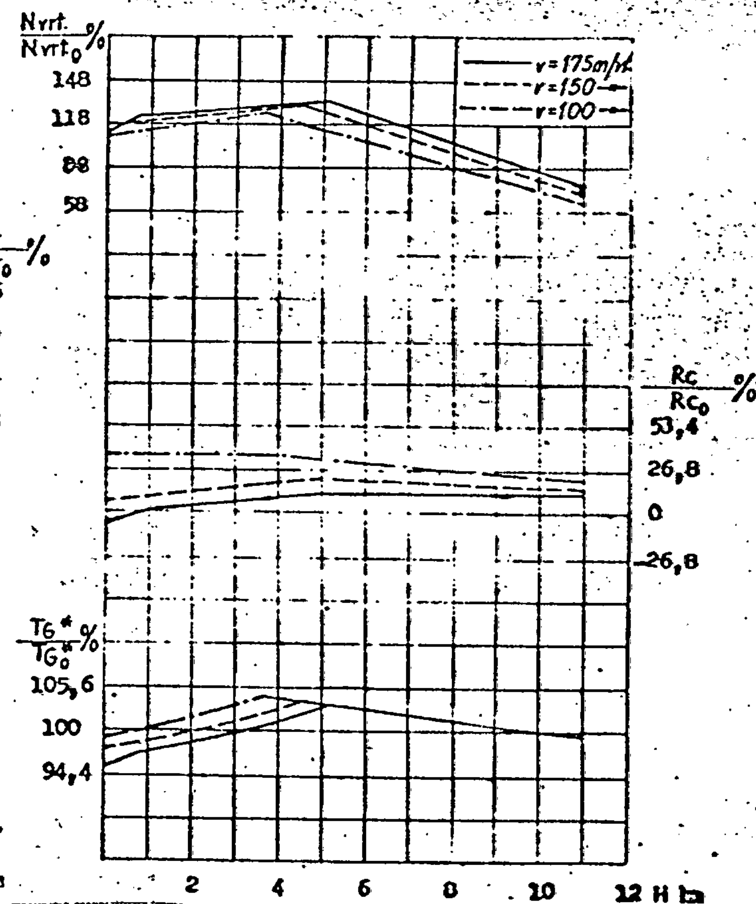

Fig. 6. Altitude and speed characteristics of AI-20 engine. Mode, 0.6 nominal [n = 12,300 rpm]. Parameters N_{BO}, T_{Go} and R_{Co} corresponds to engine ground operation on 0.6 nominal mode [H = 0 m, v = 0 meters per second].

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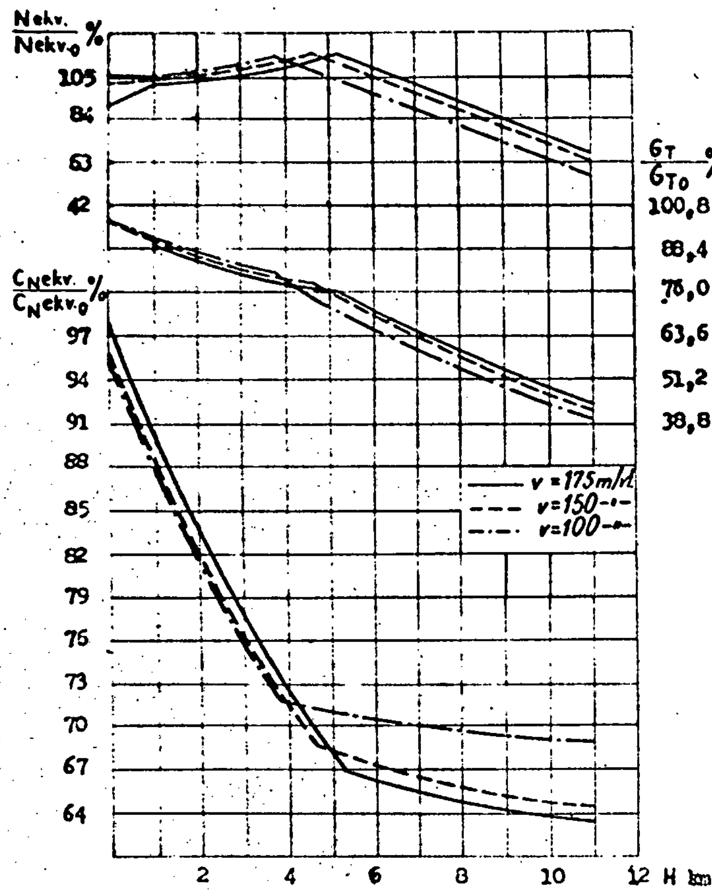

Fig. 7. Altitude and speed characteristics of AI-20 engine. Mode, 0.7 nominal [n = 12,300 rpm]. Parameters $N_{ekv.\ 0}$, $C_{Nekv.\ 0}$ and G_{To} correspond to engine ground operation on 0.7 nominal mode [n = 0 m, v - 0 meters per second].

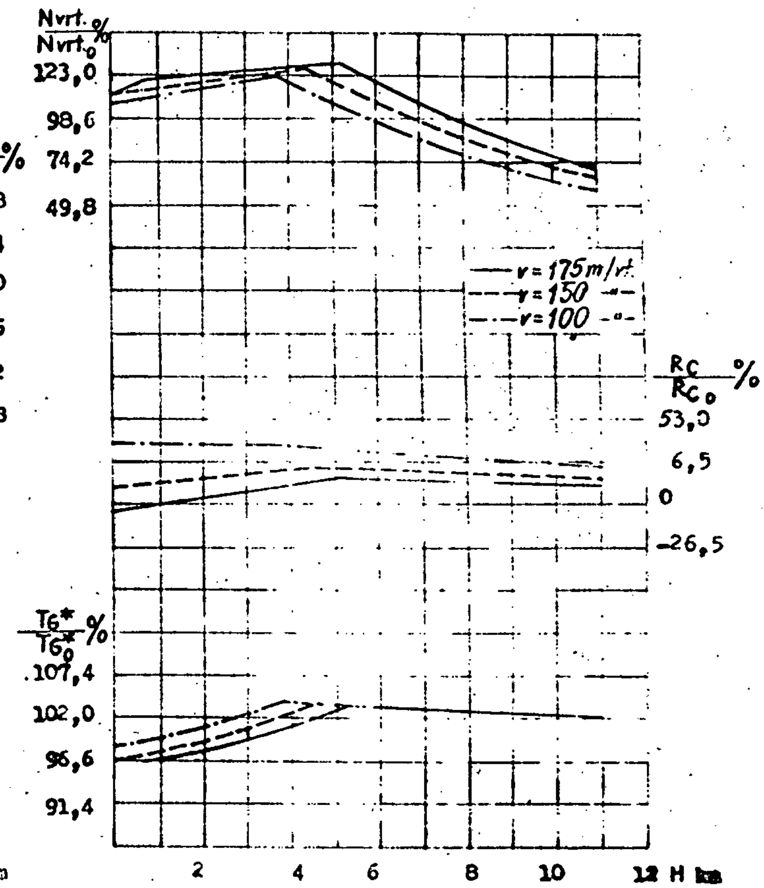

Fig. 8. Altitude and speed characteristics of AI-20 engine. Mode, 0.7 nominal [n = 12,300 rpm]. Paramters N_{Bo}, T_{Go} and R_{Co} correspond to engine ground operation on 0.7 nominal mode [H = 0 m, v = 0 meters per second].

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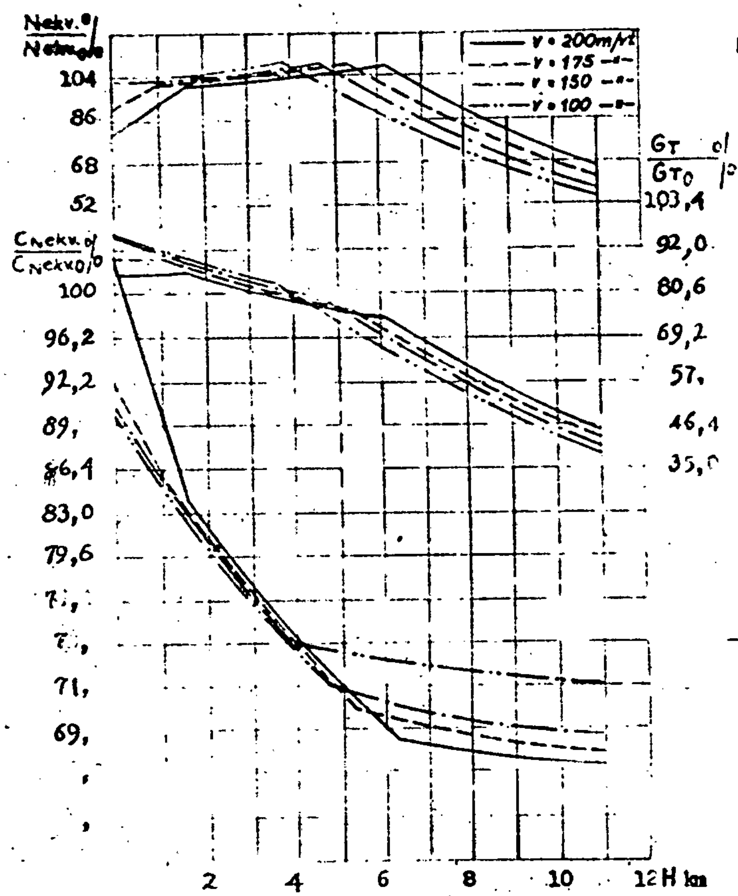

Fig. 9. Altitude and speed characteristics of AI-20 engine. Mode, 0.85 nominal [n = 12,300 rpm]. Paramters $N_{ekv.\ 0}$, $C_{Nekv.\ 0}$ and G_{To} correspond to engine ground operation on 0.85 nominal mode [H = 0 m, v = 0 meters per second].

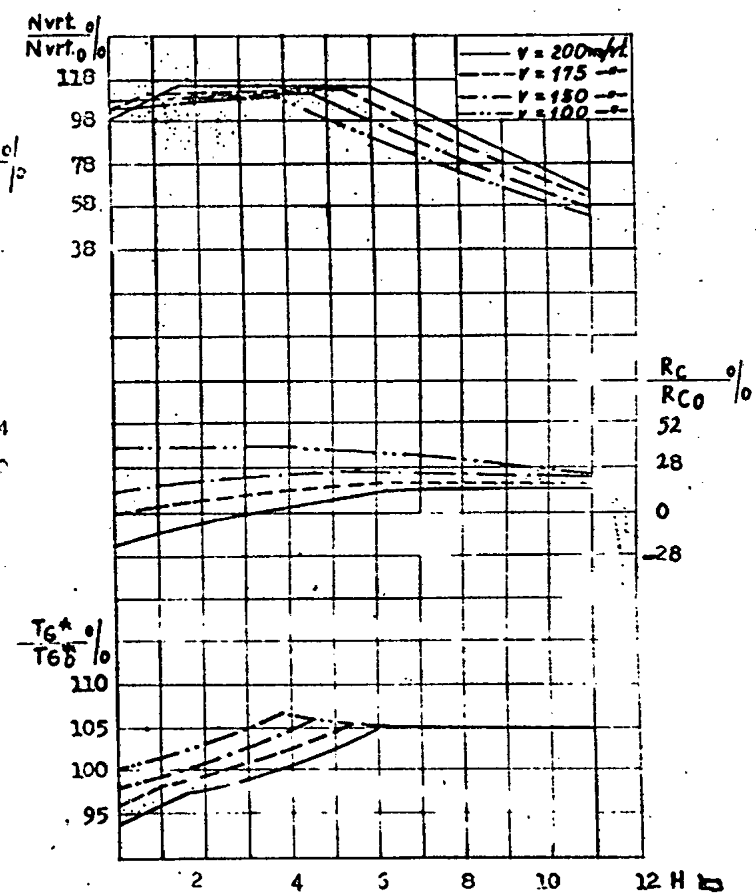

Fig. 10. Altitude and speed characteristics of AI-20 engine. Mode, 0.85 nominal [n = 12,300 rpm]. Parameters N_{Bo}, T_{Go} and R_{Co} correspond to engine ground operation on 0.85 nominal mode [H = 0 m, v = 0 meters per second].

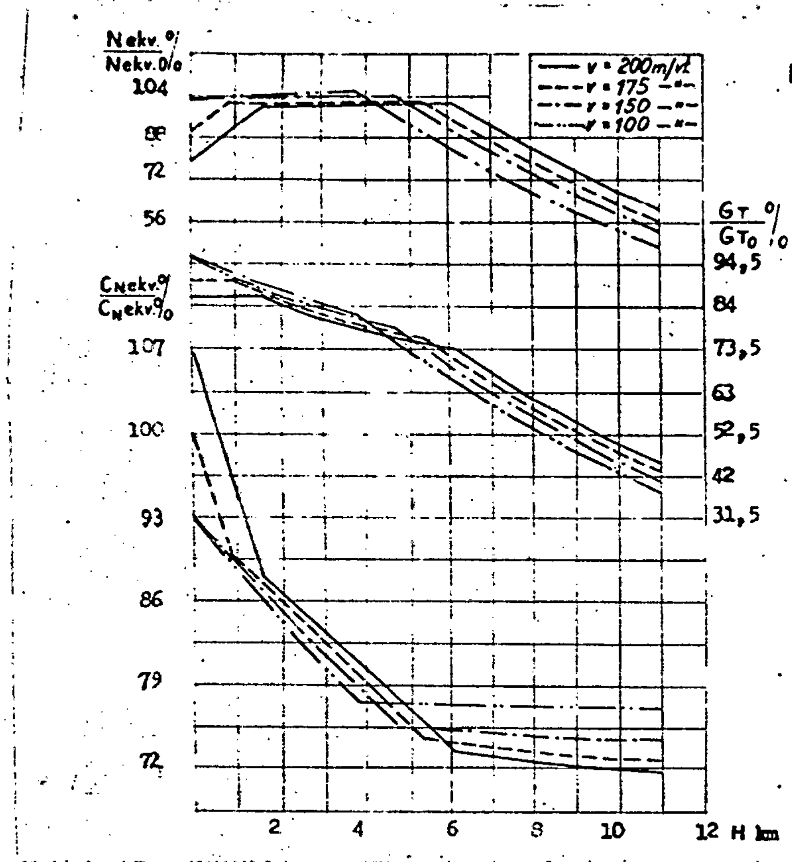

Fig. 11. Altitude and speed characteristics of AI-20 engine. Mode, nominal [n = 12,300 rpm]. Paramters $N_{ekv.\ 0}$, $C_{Nekv.\ 0}$ and G_{To} correspond to engine ground operation on nominal mode [H = 0 m, v = 0 meters per second].

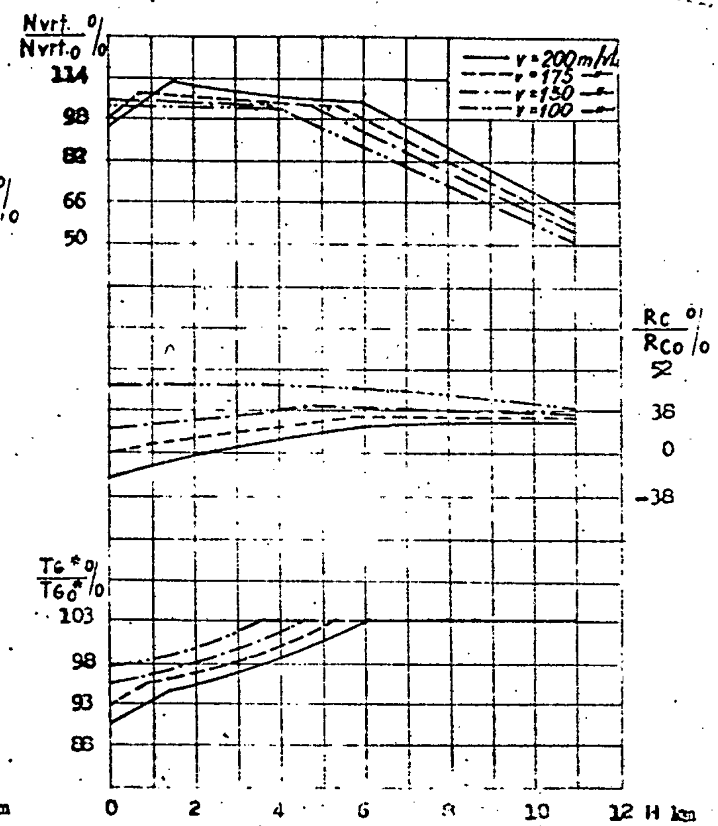

Fig. 12. Altitude and speed characteristics of AI-20 engine. Mode, nominal [n = 12,300 rpm]. Paramters N_{Bo}, T_{Go} and B_{Co} correspond to engine ground operation on nominal mode [H = 0 m, v = 0 meters per second].

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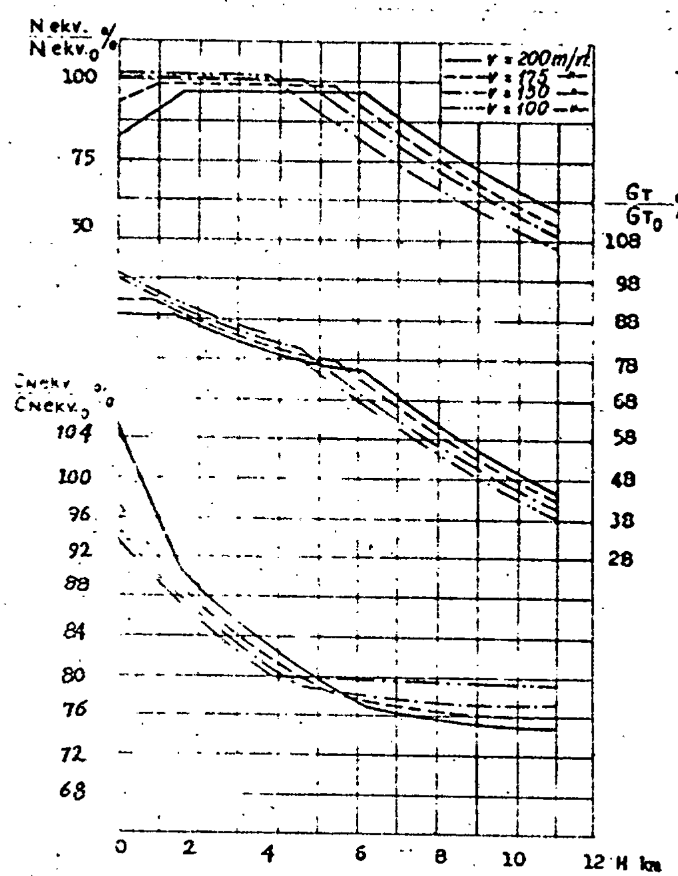

Fig. 13. Altitude and speed characteristics of AI-20 engine. Starting mode [n = 12,300 rpm]. Paramters $N_{ekv.\,0}$, $C_{Nekv.0}$ and G_{To} correspond to engine ground operation on starting mode [H = 0 m, v = 0 meters per second].

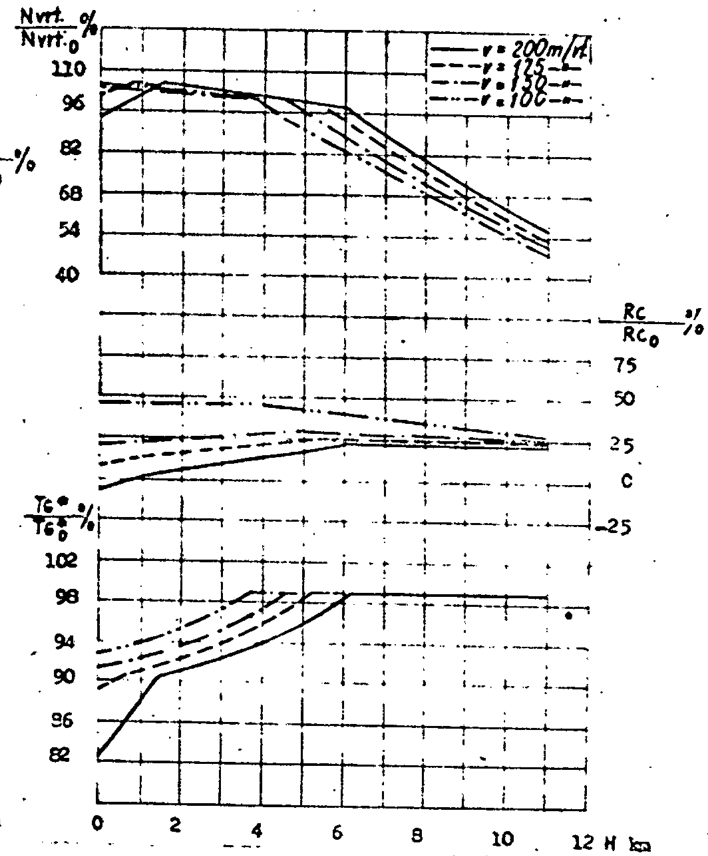

Fig. 14. Altitude and speed characteristics of AI-20 engine. Starting mode [n = 12,300 rpm]. Paramters N_{Bo}, T_{Go} and B_{Co} correspond to engine ground operation on starting mode [H = 0 m, v = 0 meters per second].

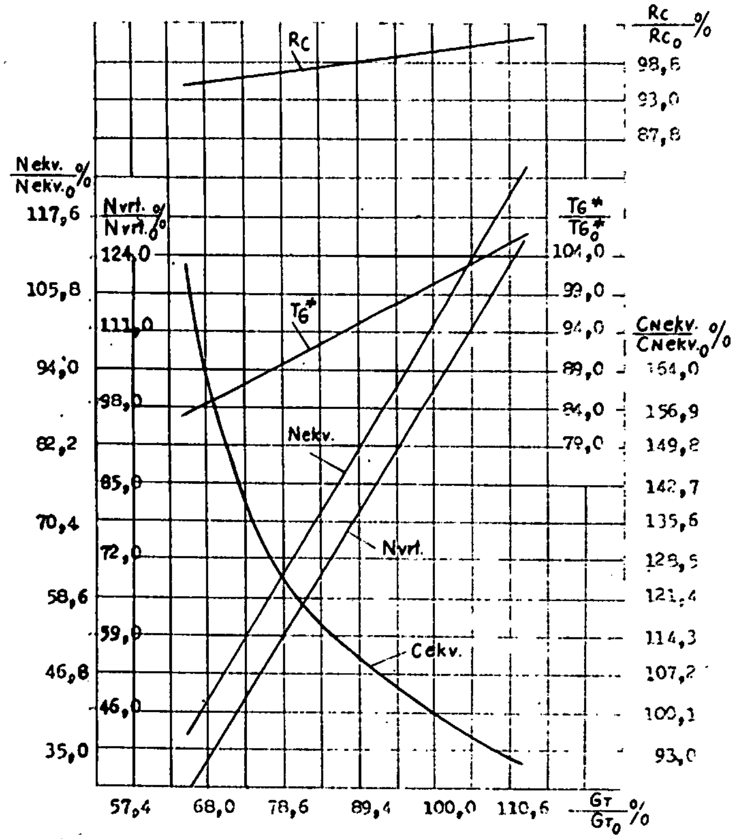

Fig. 15. Throttle characteristics compiled during engine operation in test chamber. [H = 0 m, v = 0 meters per second, n = 12,300 rpm]. Paramters $N_{ekv.\ 0}$, N_{Bo}, G_{To}, $C_{Nekv.0}$ and R_{Co}.

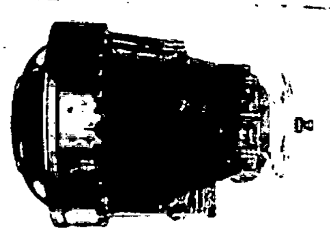

Fig. 16. Reduction Gear Unit (complete)

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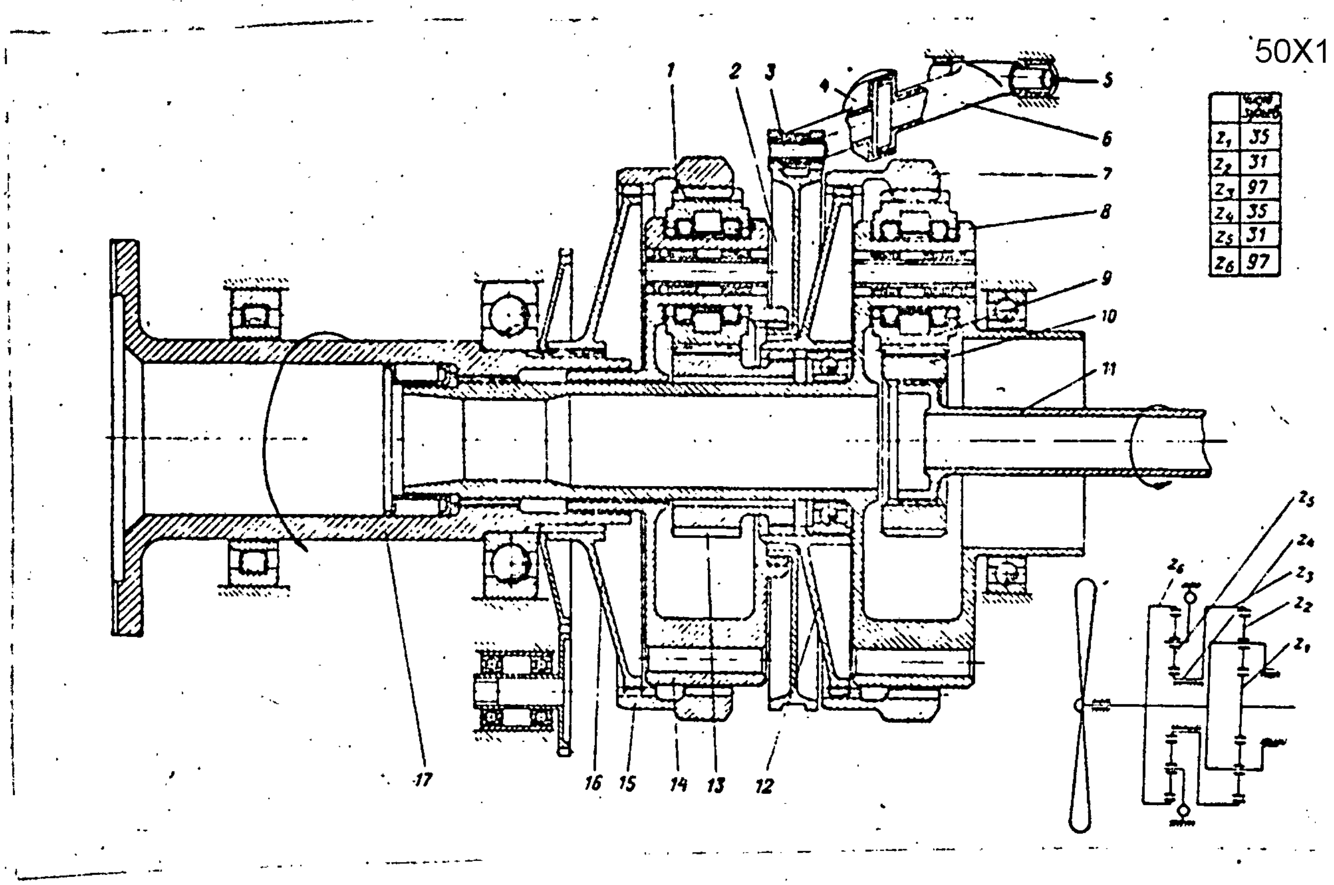


Fig. 17. Schematic of Reduction Gear - 1. Planet gear; 2. Ring gear; 3. Pin; 4. Cylinder; 5. Pin; 6. Piston; 7. Inner ring gear [1st stage]; 8. Planet gear carrier; 9. Planet gear; 10. Sun gear [1st stage]; 11. Shaft; 12. Inner ring gear hub; 13. Sun gear [2nd stage]; 14. Countershaft housing; 15. Inner ring gear [2nd stage]; 16. Countershaft hub; 17. Propeller shaft

50X1

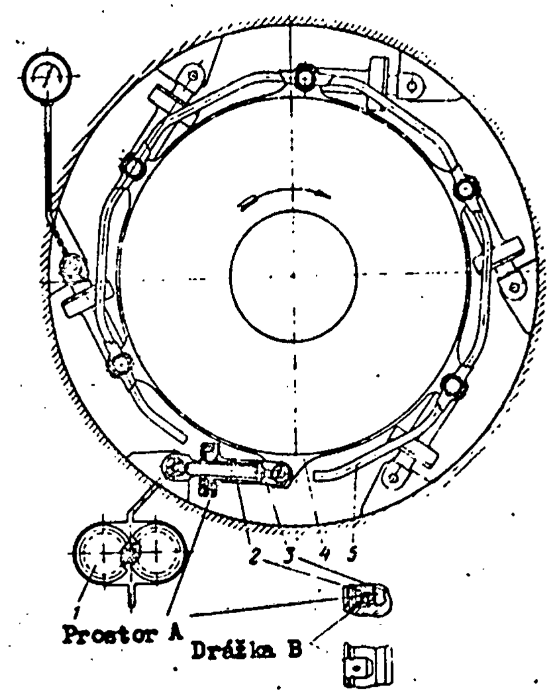


Fig. 18. Schematic of the Torque meter mechanism
Space A
Groove B
1. High-pressure pump
2. Piston
3. Cylinder
4. Rim
5. Oil line

50X1

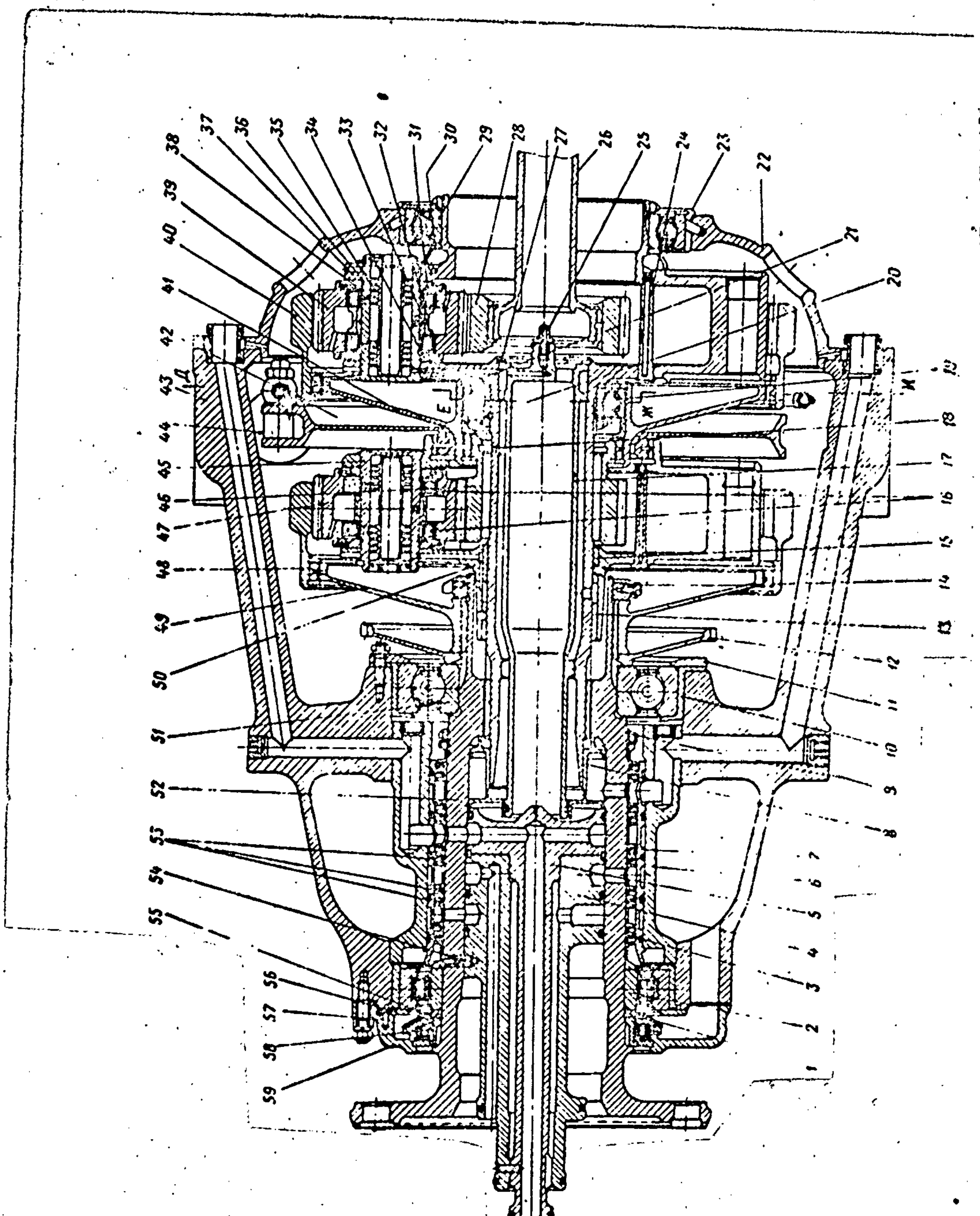


Fig. 19. Reduction gear housing (lateral section)

Fig. 19. Reduction gear housing (lateral section)

1. Oil slinger ring
2. Roller bearing
3. Liner
4, 5. Oil passage inserts
6. Liner casing
7. Sleeve
8. Planetary mechanism seat
9. Nut
10. Bearing seat ring
11. Bearing flange
12. IKM drive gear
13. Sleeve
14. Nut
15. Sleeve
16. Roller bearing
17. Tubular shaft
18. Nozzle
19. Ball bearing
20. Spacer ring
21. Retainer ring
22. Housing cover
23. Ball bearing retainer ring
24, 25. Nozzles
26. Drive shaft
27. Thrust ring
28. Sun gear [1st stage]
29. Ball bearing
30. Bearing retainer ring
31. Roller [bearing?]
32. Bearing cage
33. Spacer ring
34. Front retainer ring
35. Blind flange
36. Planet gear shaft
37. Planet gear carrier
38. Rear retainer ring
39. Planet gear
40. Inner ring gear [1st stage]
41. Ring gear hub
42. Torquemeter ring
43. Reduction gear housing
44. Pin
45. Planet gear shaft [2nd stage]
46. Sun gear [2nd stage]
47. Planet gear
48. Inner ring gear [2nd stage]
49. Countershaft ring gear hub
50. Countershaft housing
51. Radial shaft bearing
52. Propeller shaft
53. Packing rings
54. [lock] pin
55. Bushing
56. Ring
57. Pin
58. Packing
59. Cover

50X1

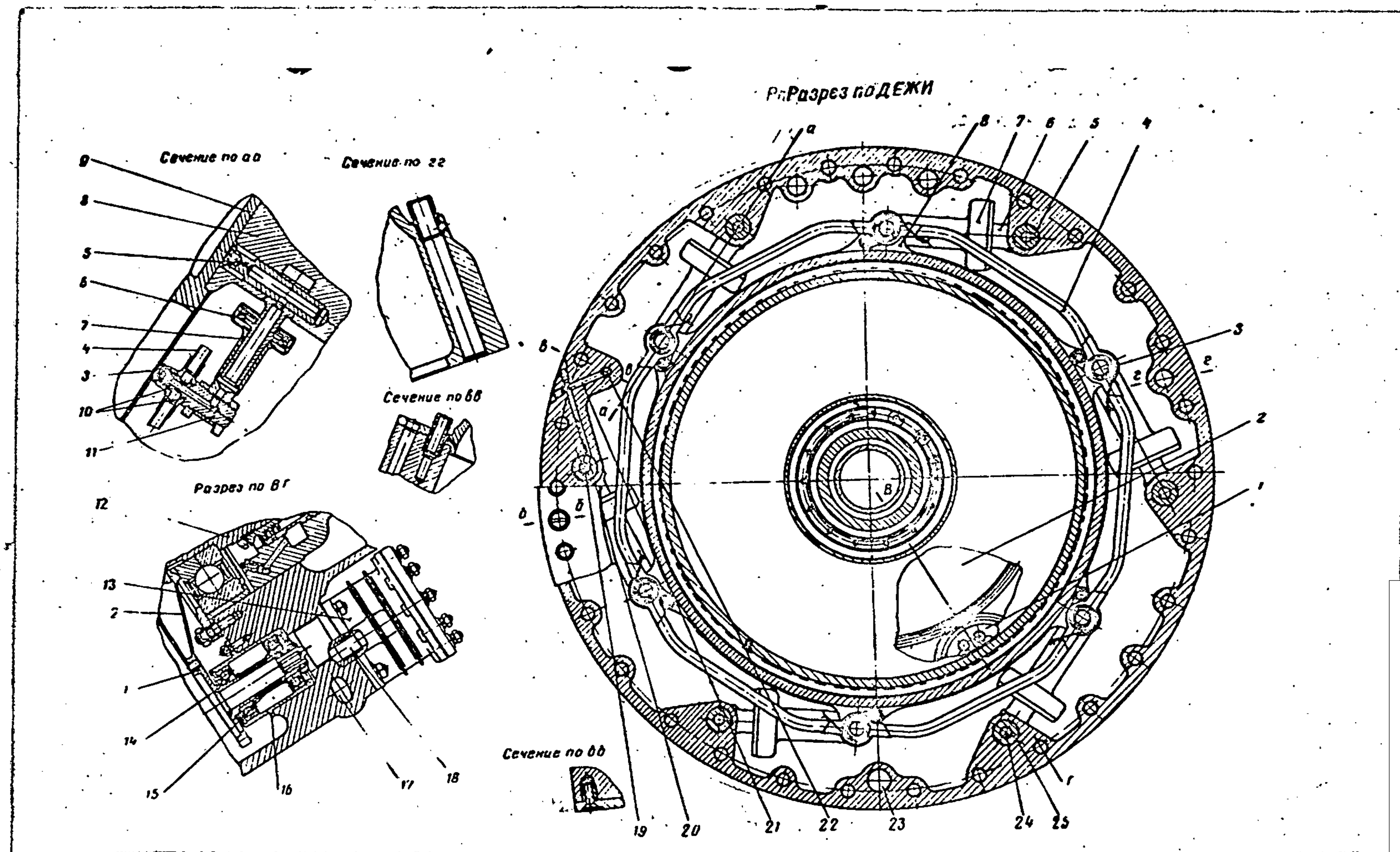


Fig. 20. Torque meter - 1. IKM pump driven gear; 2. IKM pump driven gear; 3. Nut; 4. Oil supply line; 5. Pivot [pin]; 6. Piston; 7. Cylinder; 8. Rim [torque meter plate?]; 9. Reduction gear box partition; 10. Rubber seal rings; 11. Cylinder pivot pin; 12. Propeller shaft; 13. MIKM-20 oil pump; 14. Ball bearing; 15. Spacer sleeve; 16. Bearing housing; 17, 18. Oil supply channels for MIKM-20 pump; 19, 20, 21, 22. Supply channels for oil pressure gauge in the operating spaces of the cylinder; 23, 24. Holes

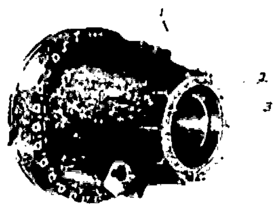


Fig. 21. Reduction gear housing
1. Centering lug
2. Sleeve
3. Oil drain hole

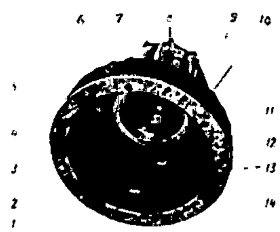


Fig. 22. Reduction gear housing (rear view) - 1. Oil drain hole for the reduction gear cavity; 2. Oil passage sleeve; 3. Roller bearing housing; 4. Oil feed hole from the operational cavity of the IKM cylinder to the pressure meter; 5. Holes for mounting bolts; 6. Tap hole for mounting reduction gear bulkhead; 7. Outer cylindrical surface; 8. Oil channels; 9. Flange for mounting bearing housing; 10. Flange of mounting roller bearing seat; 11. Oil supply channel for lubrication of reduction gear components; 12. Inner cylindrical surface; 13. Hole for electrical cable; 14. Opening under the IKM piston journal

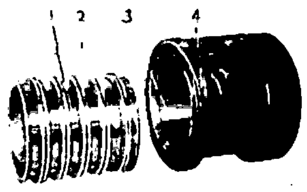


Fig. 23. Oil passage sleeve
1. Oil distribution sleeve; 2. Ring; 3. Oil distribution sleeve; 4. Oil passage sleeve housing

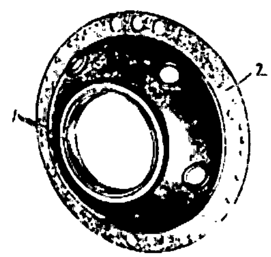


Fig. 24. Housing cover
1. Ball bearing seat ring
2. Housing cover

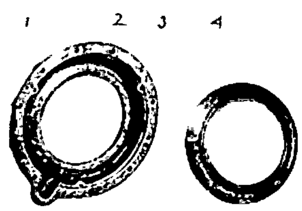


Fig. 25. Cover for front portion of reduction gear housing
1. Rubber cap
2. Body of cover
3. Pin
4. Oil seal ring

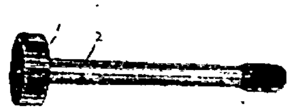


Fig. 26. Drive Shaft
1. Sun gear [1st stage]
2. Shaft

50X1

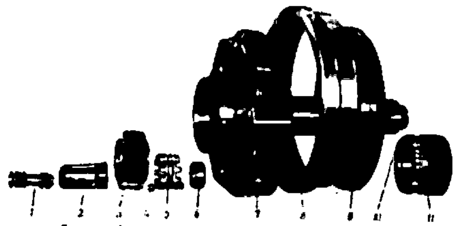


Fig. 27. Planetary system components
1. Journal insert; 2. Journal; 3. Planet gear; 4. Roller bearing; 5. Bearing cage; 6. Spacer ring; 7. Planet gear carrier; 8. Inner ring gear; 9. Ring gear hub; 10. Plug; 11. Sun gear

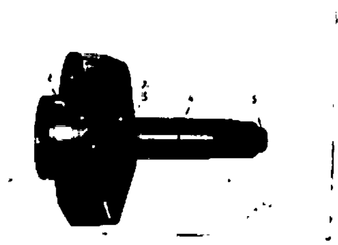


Fig. 28. Planet gear carrier
1. Planet gear carrier
2. Nozzle
3. Spline coupling lubrication nozzle
4. Centering boss
5. Bushing

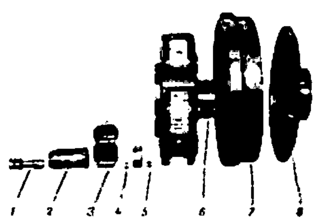


Fig. 29. Countershaft [2nd stage] components - 1. Journal insert; 2. Journal; 3. Planet gear; 4. Roller bearing; 5. Spacer sleeve; 6. Countershaft tube; 7. Inner ring gear; 8. Countershaft hub

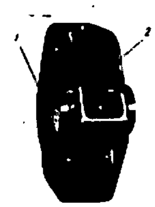


Fig. 30. Countershaft [2nd stage] planet gear carrier
1. Countershaft [2nd stage] planet gear carrier;
2. Nozzle

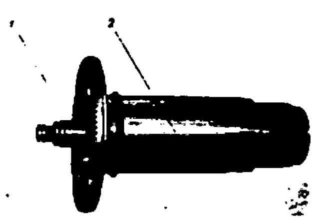


Fig. 31. Propeller shaft
1. Propeller shaft insert
2. Propeller shaft

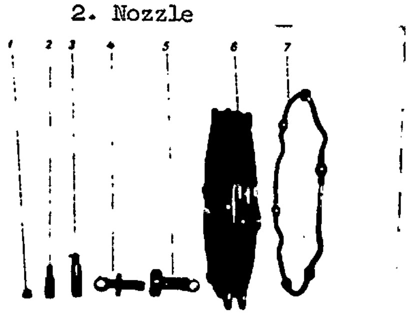
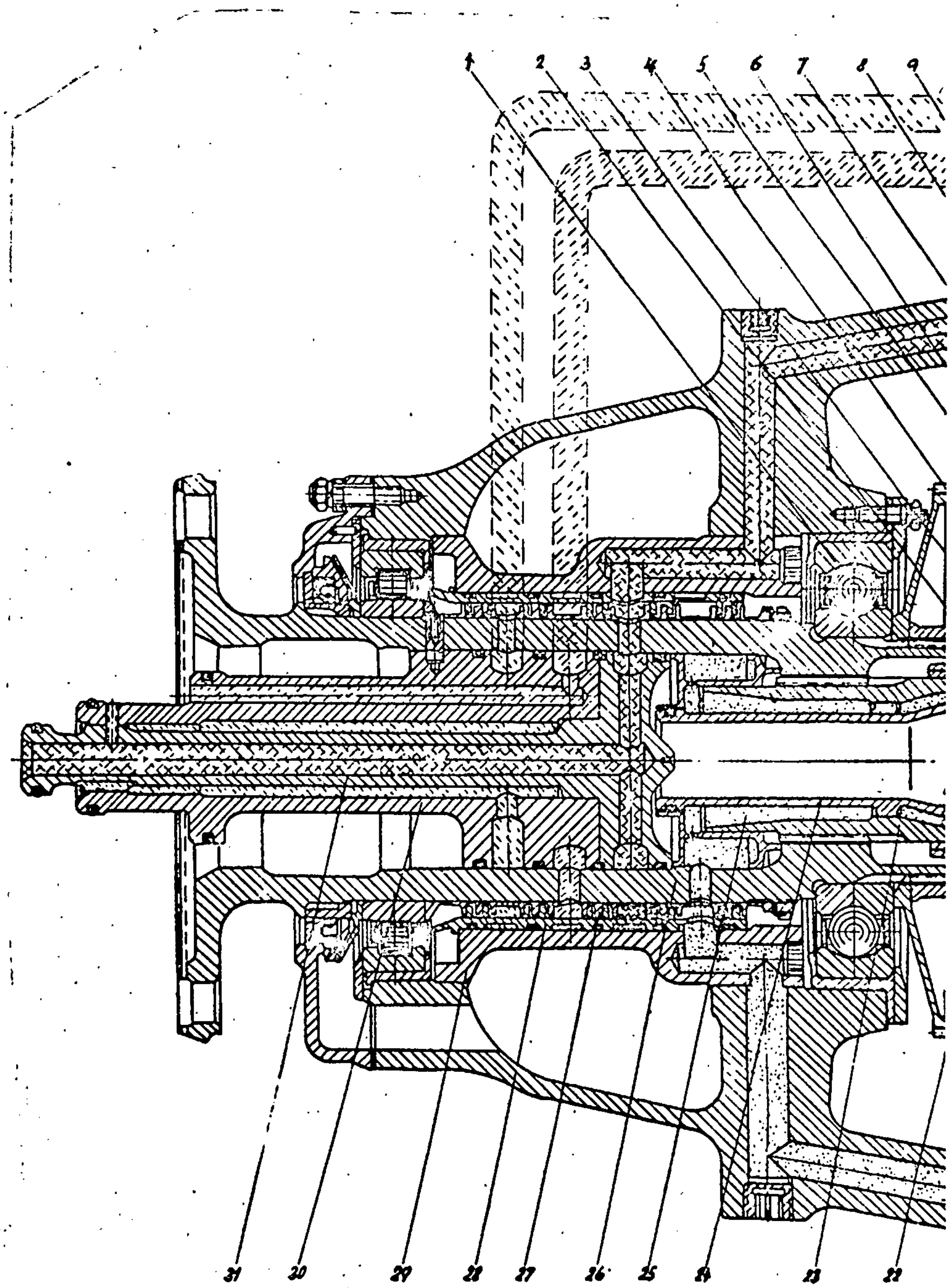


Fig. 32. IKM components
1. Nut; 2. Cylinder pin;
3. Piston pin; 4. Piston;
5. Torque meter cylinder;
6. Rim [torque meter plate?];
7. Oil line

50X1



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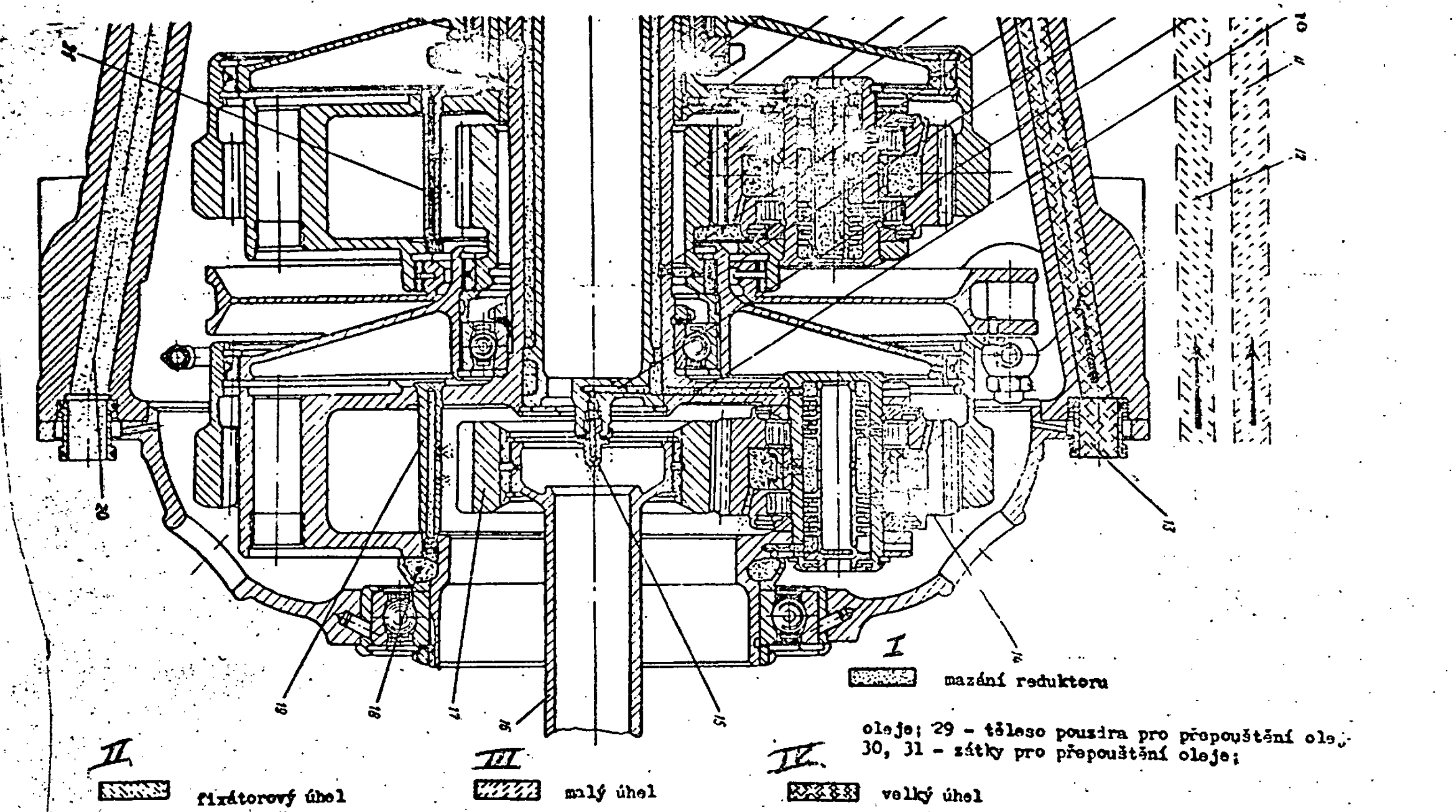


Fig. 33. Reduction gear lubrication system - I. Reduction gear lubrication system; II. Feathered [pitch]; III. Low pitch; IV. High pitch; 1. Ball bearing; 2. Annular groove; 3. Recess; 4. Hole; 5. Countershaft sun gear; 6. Planet gear; 7. Nozzle; 8. Ring gear hub; 9. Oil supply channel; 10. Bore; 11, 12, 13. Channel system; 14. Planet gear; 15. Nozzle; 16. Drive shaft; 17. Sun gear; 18. Cavity; 19. Nozzle; 20. Oil supply channel for lubrication of reduction gear; 21. Nozzle; 22. Hole; 23. Planet gear carrier; 24. Oil passage sleeve; 25. Annular cavity; 26. Propeller shaft; 27. Oil distribution liner; 28. Oil passage sleeve; 29. Oil passage sleeve housing; 30, 31. Oil passage inserts

50X1

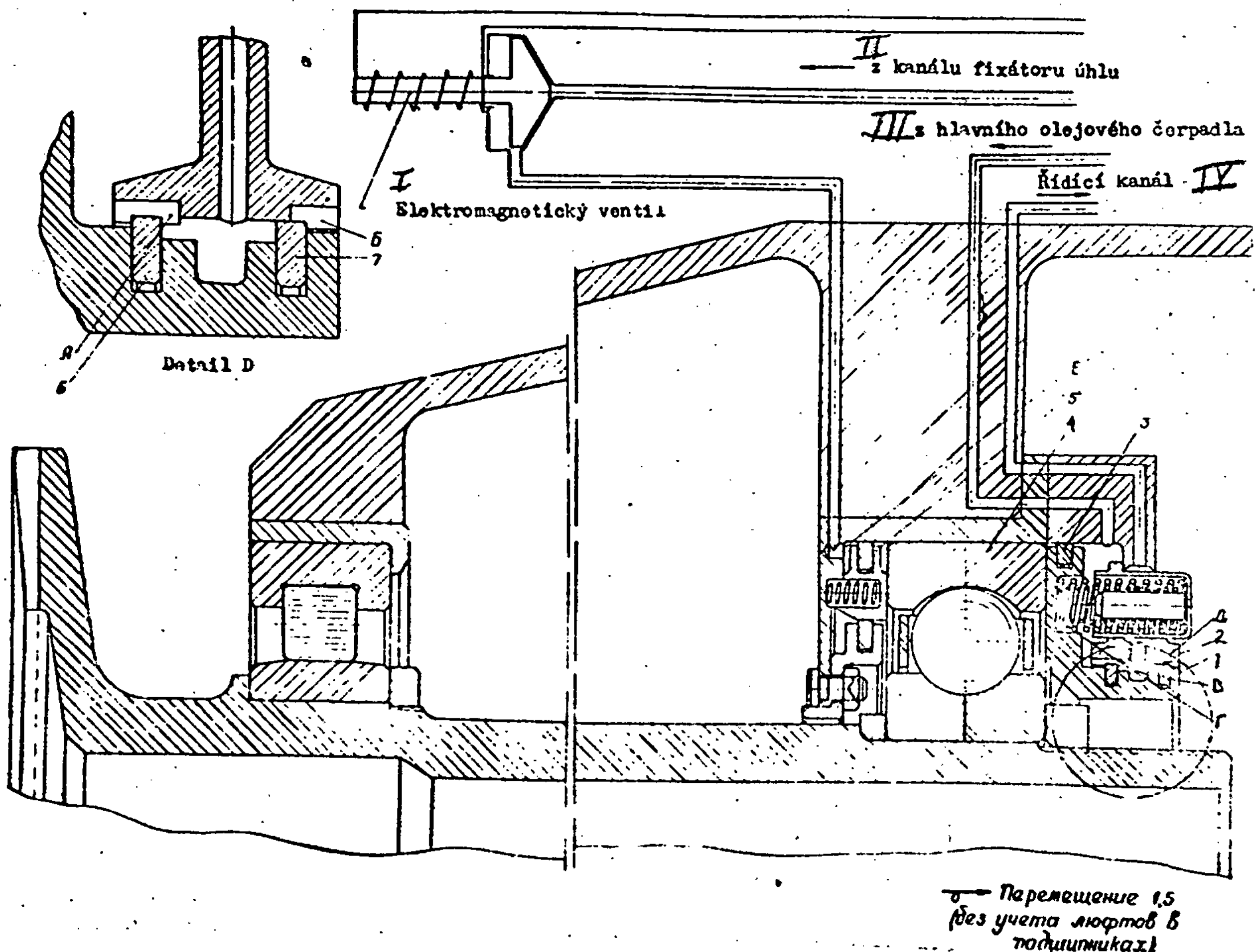


Fig. 34. Schematic of the negative torque automatic feathering
I. Electromagnetic valve; II. From the "fixator" [feathering?] channel; III. From main oil pump; IV. Control channel; 1. Piston; 2. Cylinder; 3. Packing ring; 4. Ball bearing; 5. Piston; 6. Packing ring; 7. Packing ring

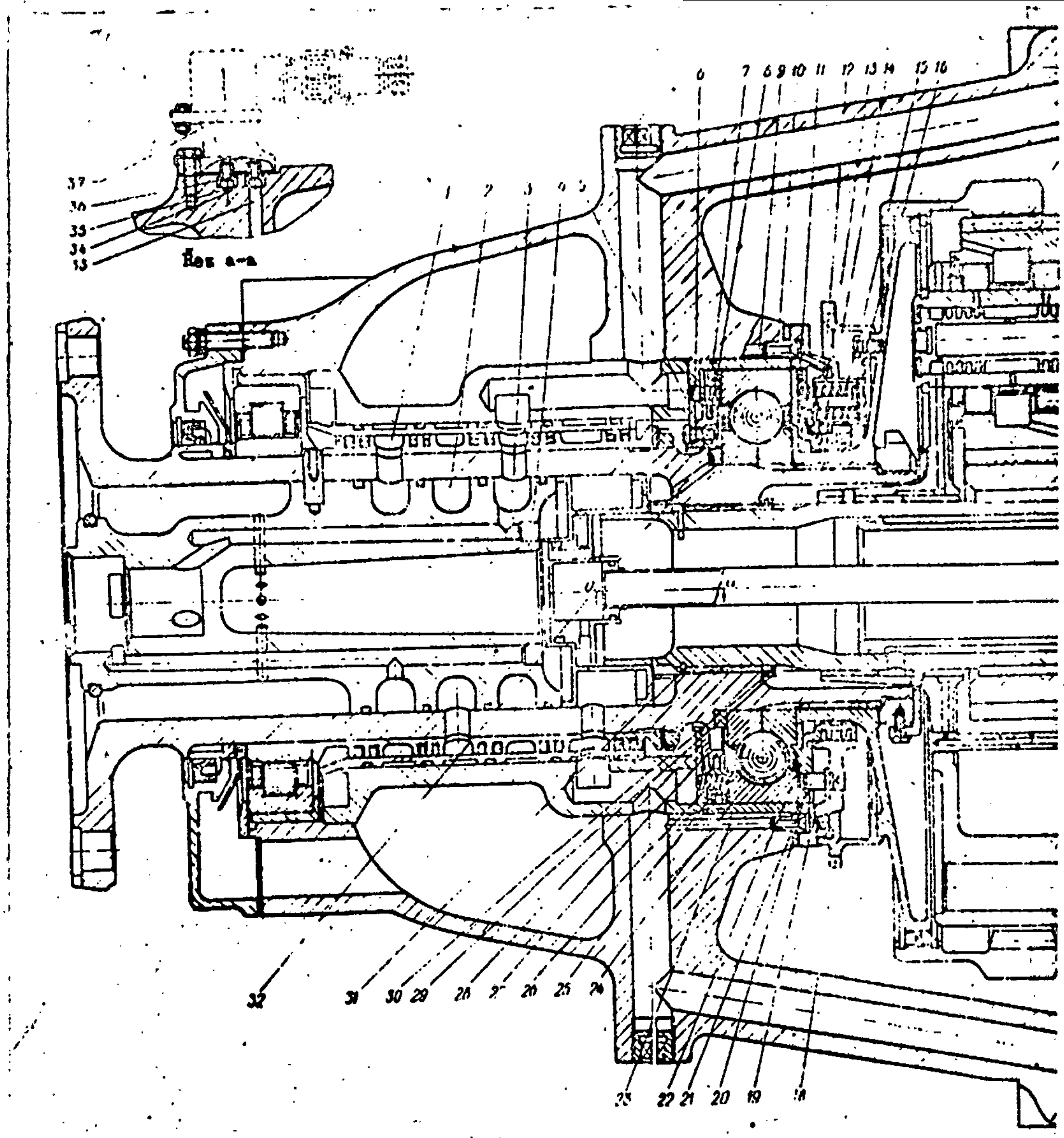


Fig. 35. Lateral section of reduction gear
1. Propeller feathering [?] channel; 2. Low pitch channel; 3. High pitch channel; 4. Oil passage insert; 5. Spacer washer; 6. Coupling pins; 7. Packing ring; 8. Packing ring; 9. Oil scavenge channel from feathering transmitter; 10. Bearing insert; 11. Packing ring; 12. Packing ring; 13. Insert retaining spring; 14. Inner spring; 15. Outer spring; 16. Spring guide; 17. Planet gear ball bearing carrier; 18 IKM pump drive wheel; 19. Roller;

50X1

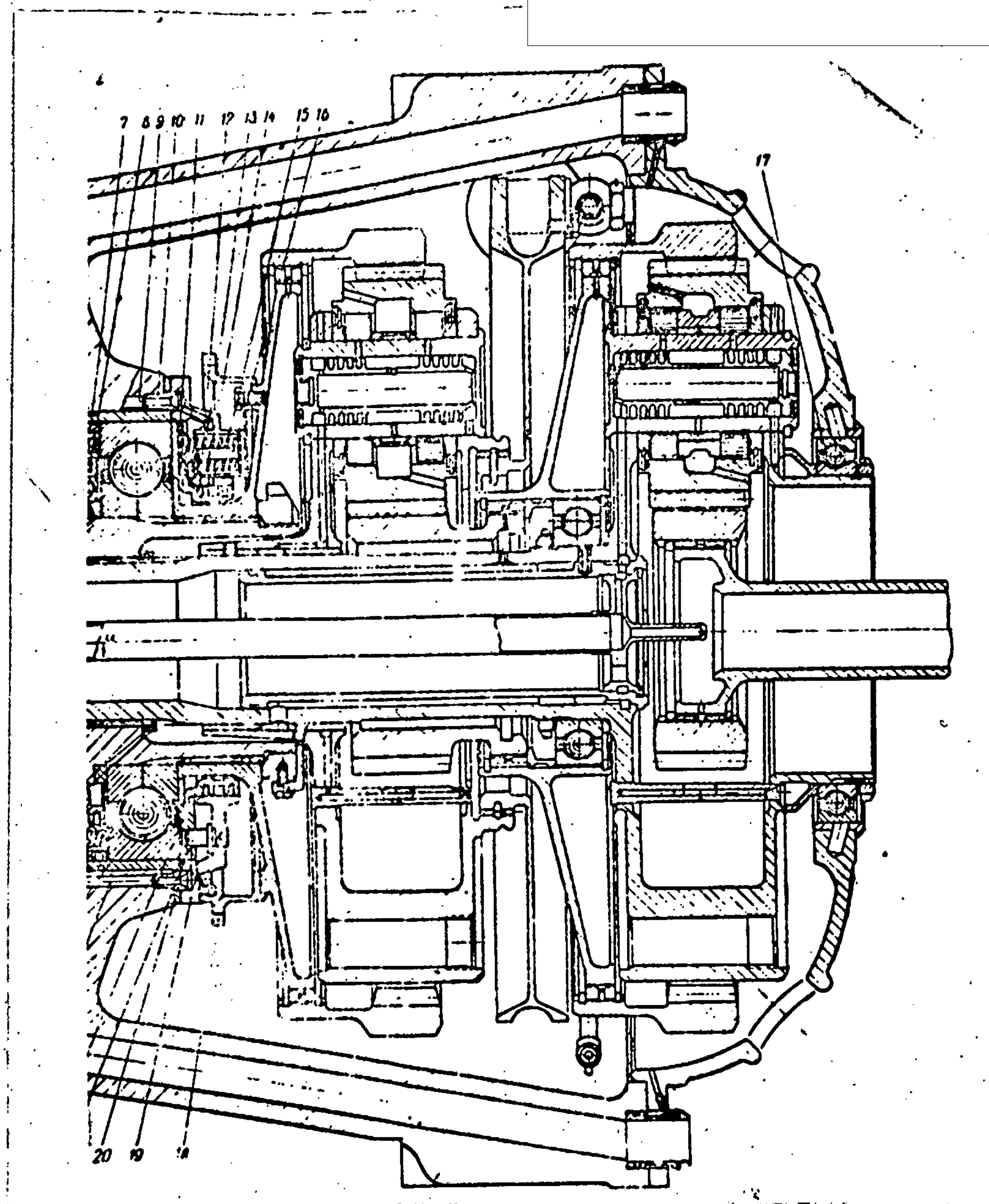


Fig. 35. (Cont'd)

20. [Bearing] insert; 21. Coupling pin; 22. Piston; 23. Oil supply channel to the automatic feathering transmitter; 24. Ball bearing; 25. Piston; 26. Spring; 27. Insert; 28. Bearing insert; 29. Space washer; 30. Lock ring; 31. Lock ring; 32. Oil supply hole to ball bearing; 33. Oil scavenge channel from the electromagnetic valve under the control mechanism piston; 34. Insert; 35. Oil supply channel to the electromagnetic valve; 36. Insert; 37. Electromagnetic valve

50X1

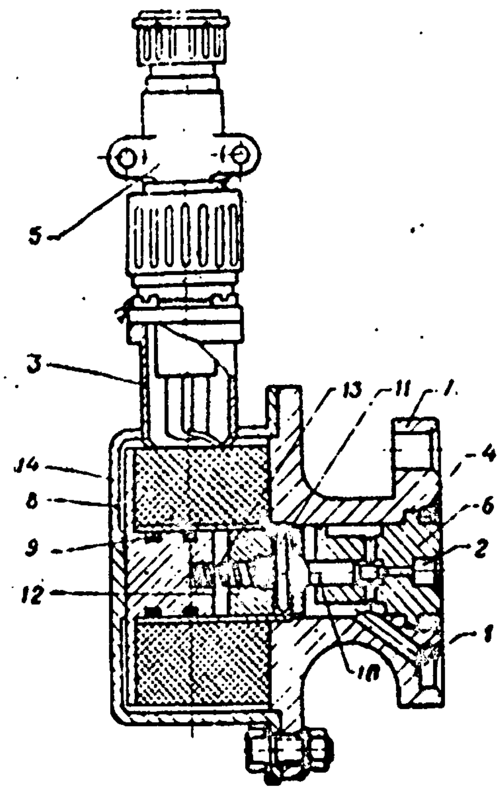
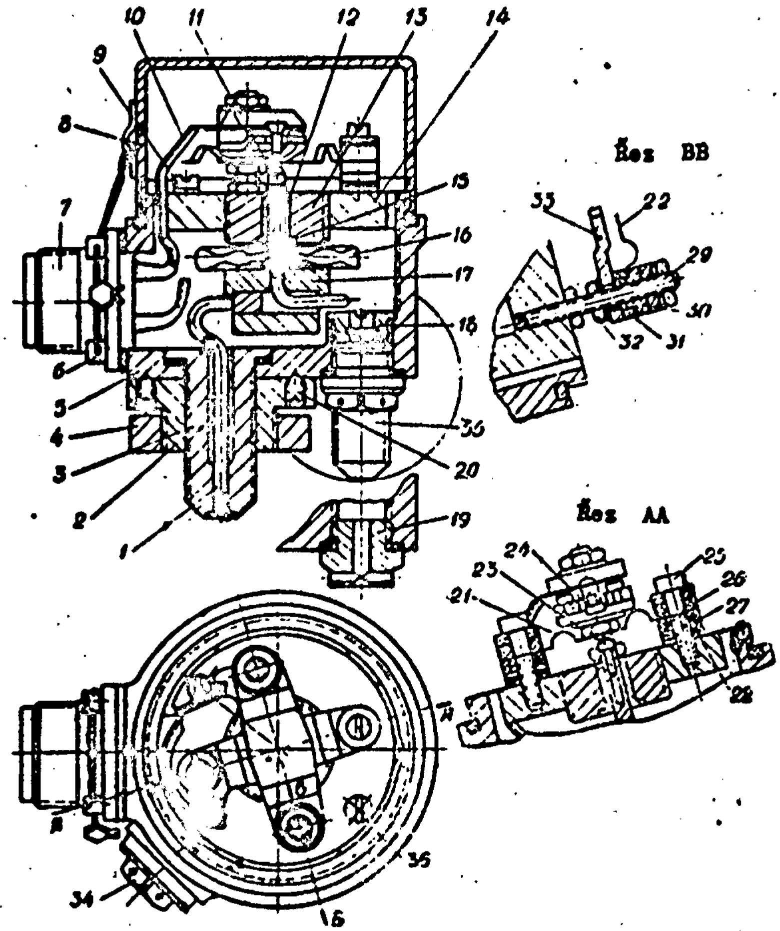


Fig. 36. Electromagnetic valve for feathering the propeller

1. Oil supply channel to valve chamber
2. Oil supply hole to the propeller pitch control piston for negative torque
3. Electrical coupling base
4. Thrust ring
5. Plug coupling
6. Insert
7. Housing
8. Cover
9. Ring seal
10. Needle
11. Pin
12. [Solenoid] core
13. Spring
14. Coil



Pohled shora (bez víčka)

Fig. 37. Feathering Transmitter when permissible revolutions are exceeded (view from above without cover)

1. Tube
2. Collar
3. Threaded coupling
4. Nut
5. Housing
6. Bolt
7. Male plug
8. Cover
9. Bolt
10. Electrical lead
11. Insulated contact point
12. Sleeve
13. Stop
14. Threaded casting
15. Plunger
16. Sensing element
17. Center portion
18. Filter insert
19. [oil] fitting
20. Screw
21. Lower spring
22. Upper spring
23. Contact point
24. Contact point
25. Bolt
26. Insulating bushing
27. Washer
28. Washer
29. Pin
30. Sleeve
31. Washer
32. Nut
33. Plate
34. Plug
35. Bolt
36. [oil] fitting

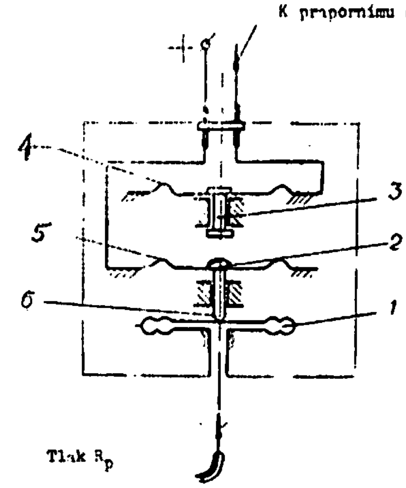
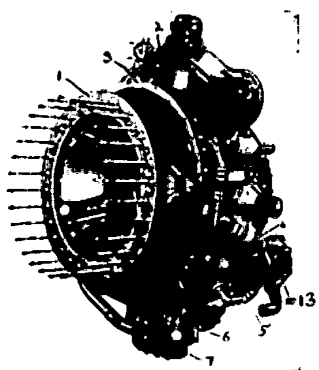


Fig. 38. Schematic of the propeller feathering transmitter
1. Sensing element; 2, 3. Contact points; 4. Upper spring; 5. Lower spring; 6. Plunger



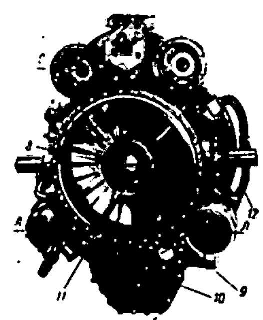


Fig. 39. Front housing (view from right front)
1. Front housing
2. Propeller brake
3. Oil pressure measuring nozzle for high pitch setting
4. Oil return line from the [cooling] fins to the air separator
5. Oil supply pump
6. Drain cock
7. Main oil pump
13. Air separator

Fig. 40. Front housing (rear view)
8. Sun gear [1st stage]
9. Oil filter
10. Drive housing
11. Bearing scavenge pump
12. Oil return line from the main pump to the [cooling] fins

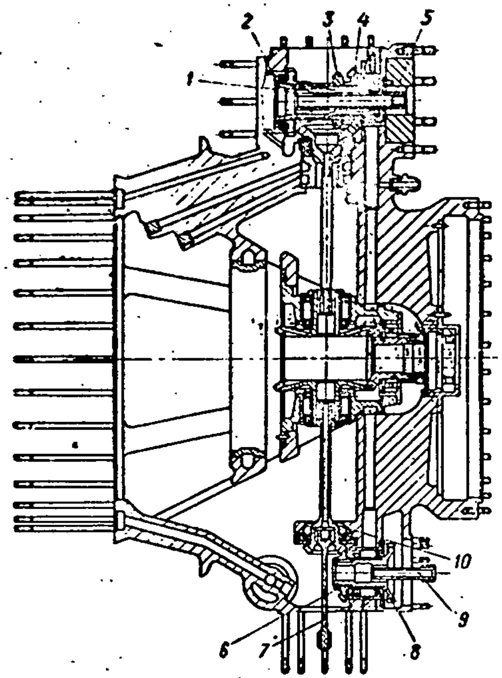


Fig. 41. Lateral section of front housing
1. Splines of the propeller brake drive
2. Upper horizontal shaft
3. Centrifugal de-aerator drive gear
4. Bevel gear
5. Spline shaft of the propeller governor
6. Bevel gear
7. Main oil pump drive shaft
8. Gear and shaft
9. Shaft into drive box
10. Gear and shaft

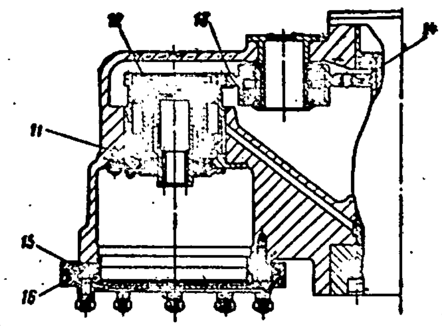


Fig. 42. Starter-generator drive (Section S-T-U, see Fig. 35)
11. Starter-generator drive shaft
12. Gear and shaft of the starter generator drive
13. Intermediate gear
14. Starter-generator drive gear
15. Adapter flange of the starter-generator drive
16. Starter-generator adapter flange

50X1

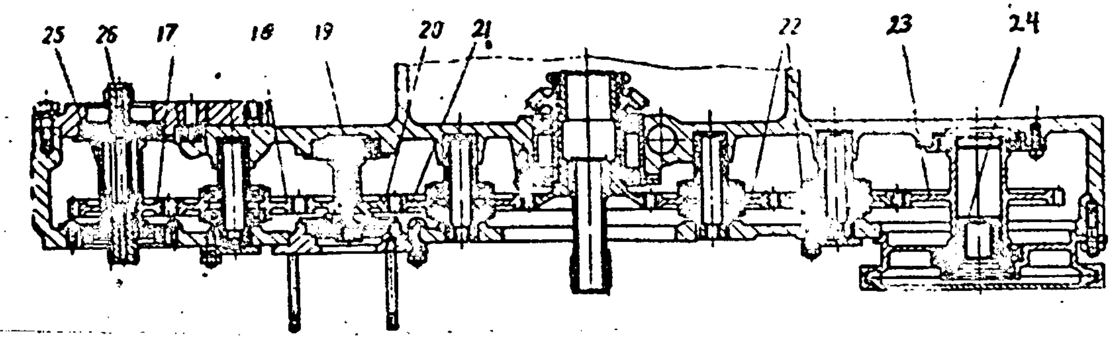


Fig. 43. Drives, located in the lower portion of the front housing (Section A-B-V-G-D-Z-I-K-L, see Fig. 35)

17. Air separator and oil pressure pump drive gear
18. Intermediate gear
19. Oil scavenge pump drive shaft
20. Oil scavenge pump drive gear
21, 22. Intermediate gears
23. Generator drive gear
24. Generator drive coupling
25. Air separator drive shaft
26. Oil pressure pump drive shaft

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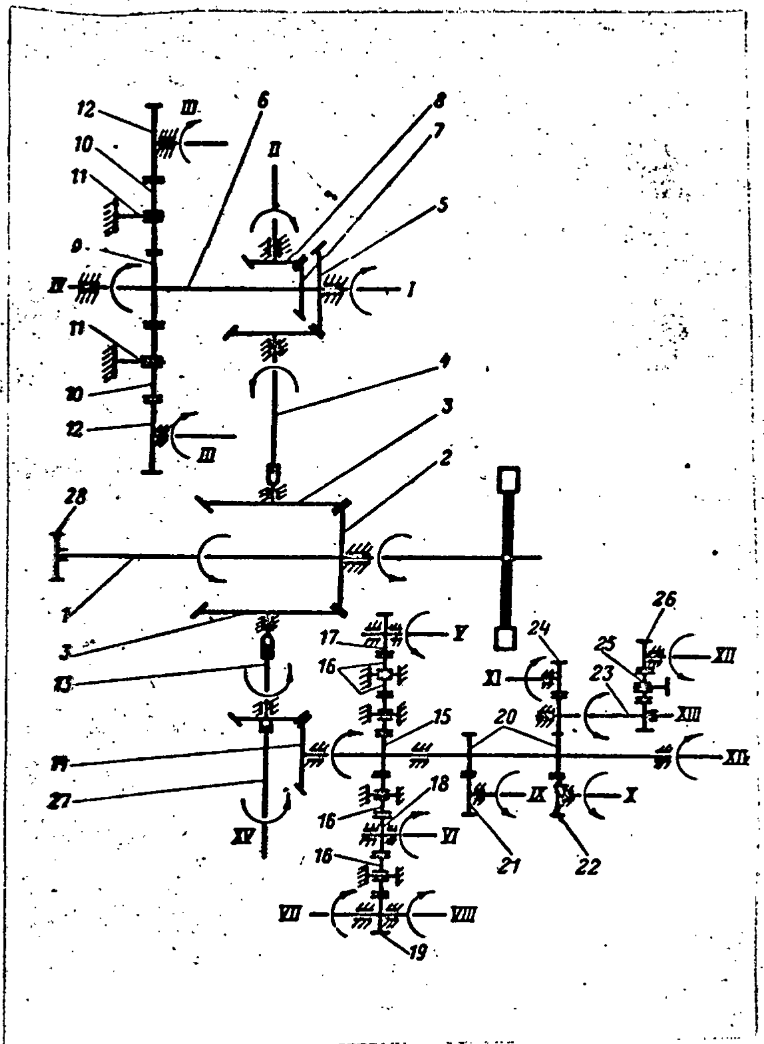


Fig. 44. Kinematic diagram of the front housing and associated drives

1. Drive shaft
2. Main drive gear
3. Driven gear of the main drive
4. Upper vertical gear and shaft
5. Upper bevel gear
6. Upper horizontal shaft
7. Centrifugal de-aerator drive gear
8. Centrifugal de-aerator driven gear
9. Starter-generator drive gear
10. Intermediate starter-generator
11. Intermediate gear shaft
12. Starter-generator drive shaft and gear
13. Lower vertical gear and shaft
14. Lower bevel gear
15. Lower horizontal shaft and gear
16. Intermediate gear of the lower drive
17. Generator drive gear
18. Oil scavenge pump drive gear
19. Separator drive gear
20. Main gear
21. Main fuel pump drive gear
22. Fuel delivery pump drive gear
23. Hydraulic pump drive gear
24. Housing of oil scavenge pump drive gear
25. Intermediate gear
26. Tachometer transmitter drive
27. Main oil pressure pump drive shaft
28. Drive gear

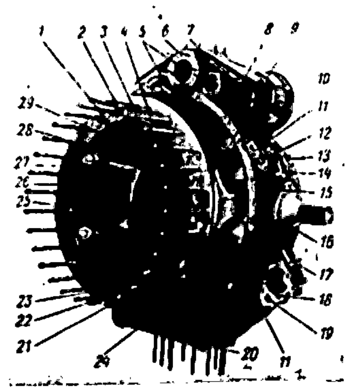


Fig. 45. Front houding (right front view)

1. Reduction gear mounting flange
2, 3, 4. Oil supply holes for propeller
5. Flanges for mounting drive shafts to the starter-generator
6. Centrifugal de-aerator mounting flange
7. [no caption]
8. Aircraft [cabin] air filter mounting flange
9. Reinforced rib
10. Engine air passage space [air intake duct?]
11. Mounting flange for oil line to separator
12. Hydroelectric switch mounting flange
13. Mounting flange for air supply line for heating the inlet guide vanes
14. Technological openings
15. Ice warning device mounting flange
16. Engine forward mounting trunion
17. Mounting flange for oil line to separator
18. Mounting flange for MNP-20 oil pressure pump
19. Channel connecting MNP-20 pump to main oil pump
20. Drain cock mounting flange
21. Oil drain hole from reduction gear to front housing
22. Opening for oil from the main pump for reduction gear lubrication
23. Oil drain hole to the reduction gear
24. Outer cone of front housing
25. Main drive mounting bolts
26. Oil passage ring
27. Sleeve of the channel for electrical lead for de-icing propeller blades
28. Inner cone of front housing
29. Oil passage from the IKM torque meter cylinder to the automatic propeller pitch transmitter

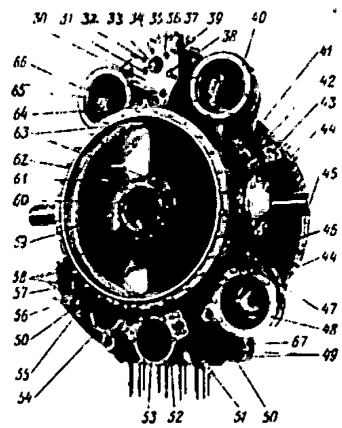


Fig. 46. Front housing (right rear view)

30. Governor mounting flange
31. Oil supply hole to governor
32. Regulator oil return hole
33. Centering hole under governor
34. Oil passage hole to the low pitch setting channel
35. Groove
36. Oil passage hole to the feathering channel
37. Oil passage hole for the feathering [control?]
38. Oil passage hole to the high pitch setting channel
39. Threaded oil fitting from feathering pump to propeller governor
40. Starter-generator mounting flange
41. Technological openings
42. Fire-extinguishing valve mounting flange
43. Adapter for mounting male socket of electrical lead
44. Mounting flange for oil lines from scavenging stage of main pump to the centrifugal separator
45. Engine mounting trunion
46. Threaded oil fitting from the oil passage channel from compressor
47. Mounting flange for air supply line for heating compressor inlet guide vanes
48. Generator mounting flange
49. Oil filter chamber
50. Mounting flanges for intermediate gear
51. Threaded oil fitting to the KTA
52. Main oil pump mounting flange
53. Drive housing mounting flange
54. Mounting flange for scavenge pump adapter unit
55. Threaded oil fitting from de-aerator tank to forward housing
56. Oil passage holes for lubricating air separator components
57. Air separator mounting flange
58. Technological openings
59. Compressor roller bearing seating recess
60. Bolts for mounting compressor inlet guide vanes
61. Mounting bolts for roller bearing seating recess
62. Compressor housing mounting flange
63. Retaining pin
64. Oil nozzle for lubricating turbine and compressor bearings
65. Oil pressure measuring nozzle in low pitch channel
66. Oil pressure measuring nozzle in the pitch control channel
67. Drainage nozzle

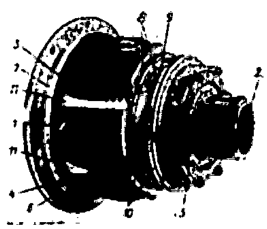
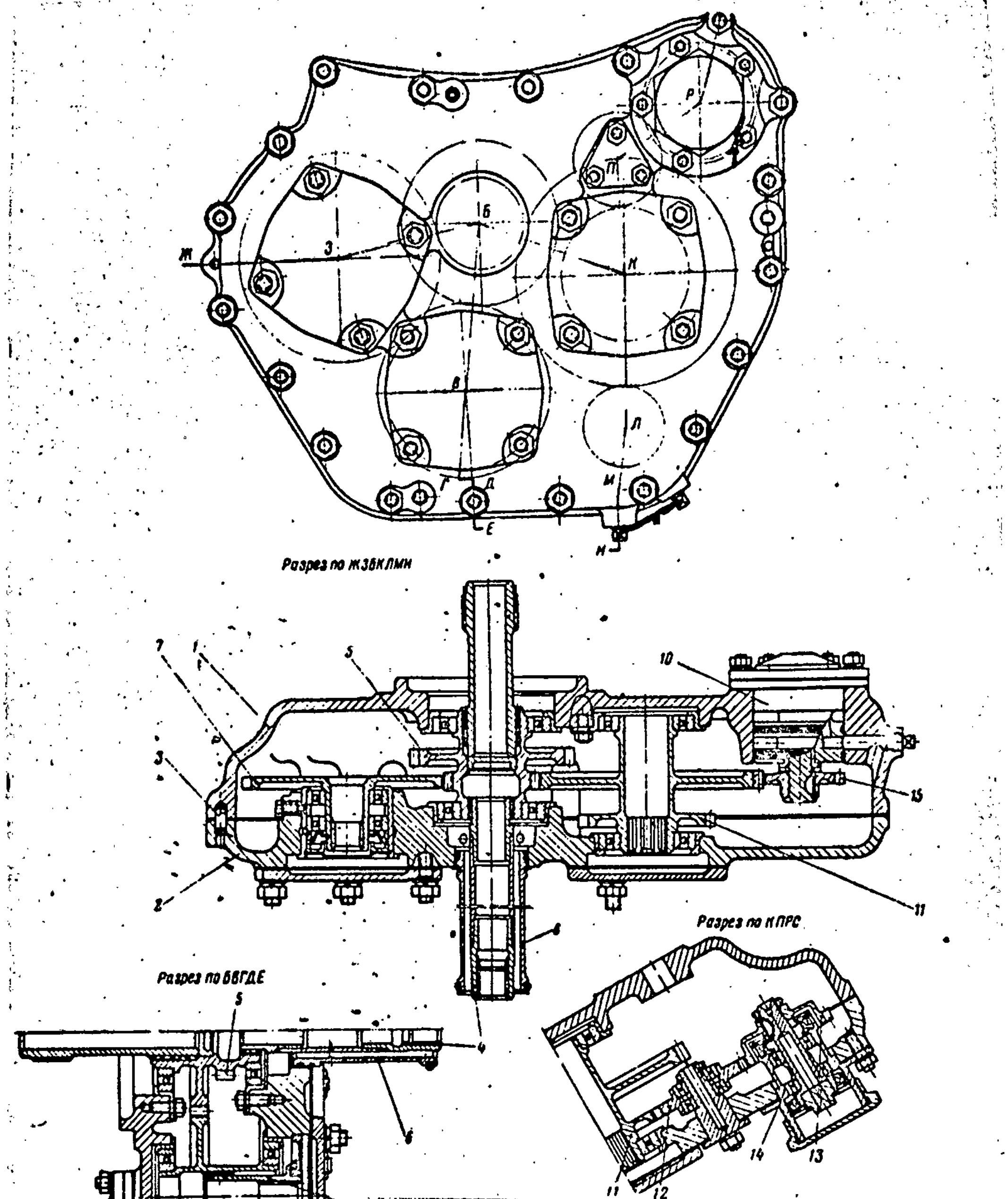


Fig. 47. Central drive

1. Central drive housing
2. Bevel drive gear
3. Upper driven bevel gear
4. Lower driven bevel gear
5. Mounting flange of the drive gear
6. Mounting flange of the central drive housing to the forward [reduction gear] box
7, 8. Cylindrical surfaces
9. Oil supply groove from the main pump to the propeller governor and for drive lubrication
10. Rubber seal ring
11. Cut-outs for mounting bevel drive gear



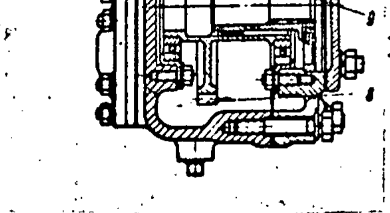
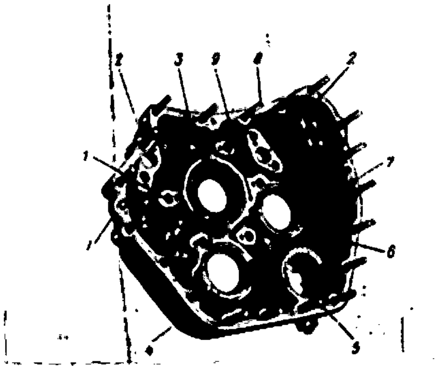


Fig. 48. Drive housing - 1. Housing; 2. Cover; 3. Pin; 4. Splined drive shaft for control of fuel assembly; 5. Main gear; 6. Tubular shield for the fuel assembly control shaft; 7. Fuel pump drive gear; 8. Main fuel pump drive gear; 9. Main fuel pump splined drive shaft; 10. Hydraulic pump drive gear; 11. Tachometer transmitter drive gear; 12. Intermediate gear; 13. Driven gear; 14. Transmission housing; 15. Scavenge pump drive gear



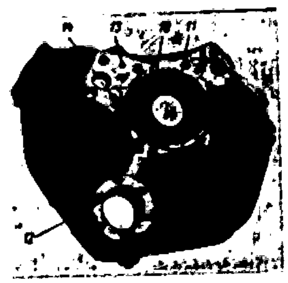


Fig. 49. Drive housing (inside view)

1. Holes for fastening housing to front [reduction gear] box
2. Holes for axle stops [retainers?] of intermediate gear
3. Central gear bearing insert
4. Main fuel pump drive gear bearing insert
5. Mounting hole for pump draining oil to the housing cavity
6. Hydraulic pump drive gear bearing insert
7. Pins
8. Cover fastening bolt
9. Nozzle

Fig. 50. Drive housing (outer view)

10. Centering lug
11. De-aeration opening
12. Return oil channel
13. Hole
14. Oil supply channel nozzle

50X1

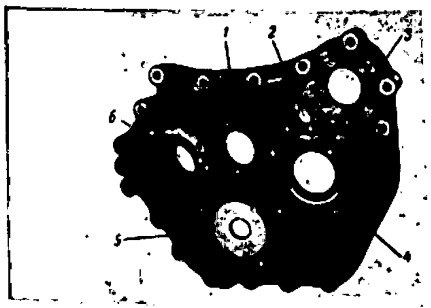


Fig. 51. Drive housing cover (outer view)

1. Thrust bearing flange of the KTA drive shaft shield
2. Hole for intermediate gear shaft
3. Tachometer transmitter drive mounting flange
4. Hydraulic pump mounting flange
5. Main fuel pump mounting flange
6. Fuel supply pump mounting hole

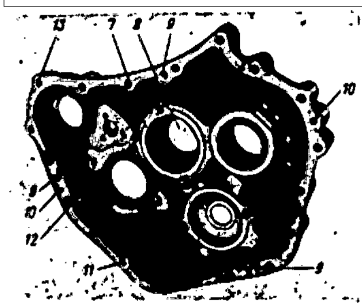


Fig. 52. Drive housing cover (inside view)

7. Central gear bearing insert
8. Central gear seat
9. Tapped drills for cover-pulling bolts
10. Holes for centering pins
11. Main fuel pump drive bearing insert
12. Hydraulic pump drive bearing insert
13. Holes for drive housing cover mounting bolts

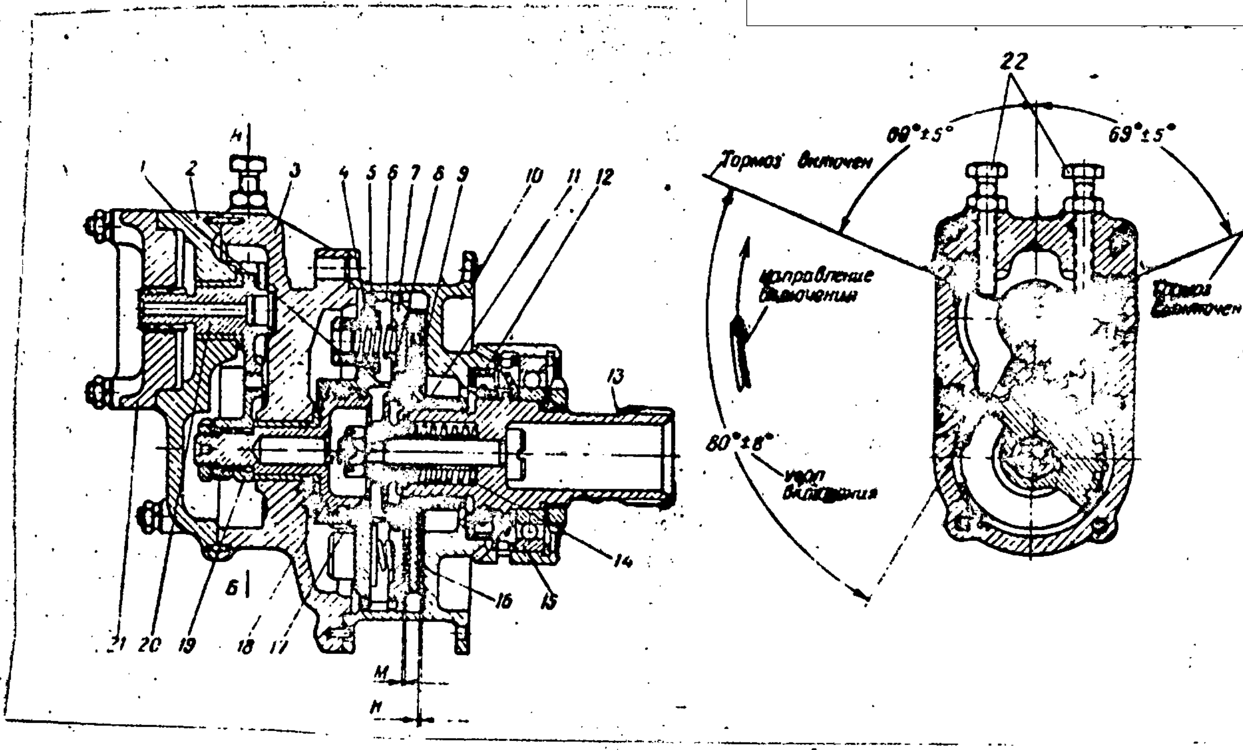


Fig. 53. Propeller brake

1. Spacer
2. Transmisstion cover
3. Housing cover
4. Spring assembly
5. Plate
6. Housing grooves
7. [fixed?] disc
8. Flange
9. Thrust ring
10. Steel housing
11. Regulating sleeve
12. Rubber cup
13. Brake shaft
14. Spring
15. Brake shaft bearing
16. Movable disc
17. Stop sleeve
18. Brake engagement shaft
19. Driven gear sector
20. Drive [gear] sector
21. Mounting cover
22. Set screws

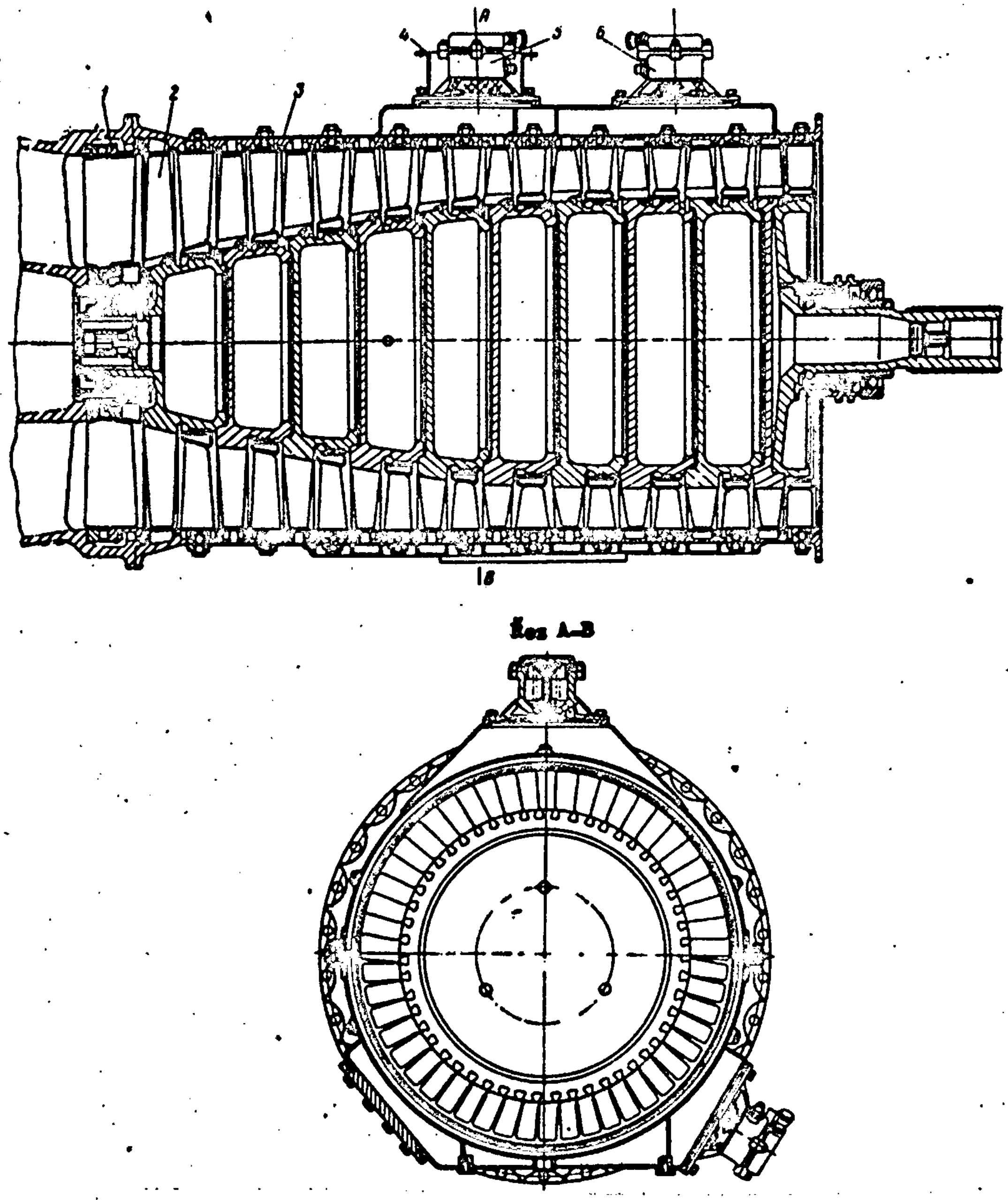


Fig. 54. Compressor

1. Inlet guide vanes
2. Compressor rotor
3. Compressor housing
4. Cover for air bleed valve behind compressor Stage V
5. Air bleed valve behind compressor Stage V
6. Air bleed valve behind compressor Stage VIII

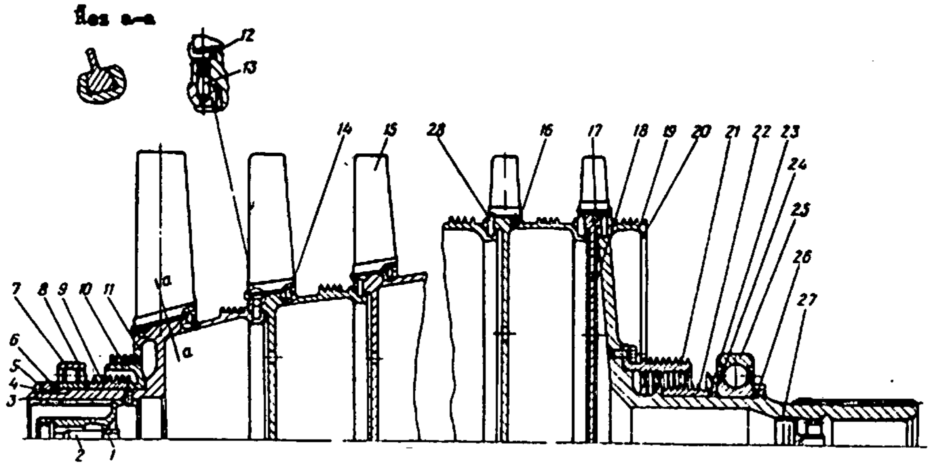


Fig. 55. Compressor rotor

1. Lock housing
2. Journal
3. Stage I disc
4. Nut
5. Retainer
6. Thrust ring
7. Roller Bearing
8. Spacer ring
9. Baffle [labyrinth] seal sleeve
10. Baffle seal
11. Trim and balance point
12. Lock
13, 14. Pins
15. Rotor blade
16, 17. Locks
18. Intermediate disc
19. Rear shaft [mounting plate and shaft]
20. Trim and balance point
21, 22. Baffle seal sleeves
23. Spacer ring
24. Oil slinger disc
25. Ball bearing
26. Nut
27. Guide journal
28. Pin

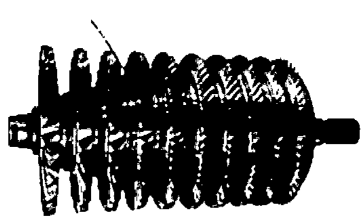


Fig. 56. Compressor rotor

50X1

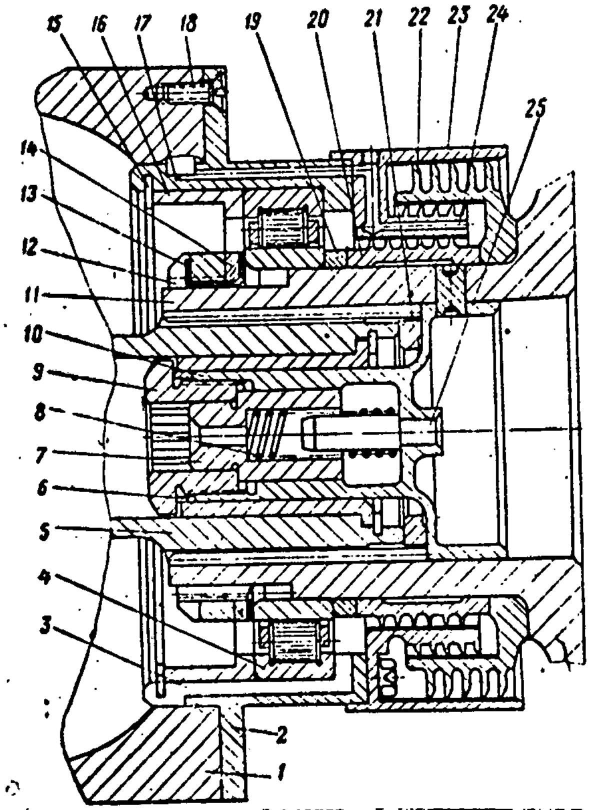


Fig. 57. Front compressor roller bearing

1. Front housing
2. Front roller bearing insert seat
3. Oil return groove from the baffle seal space
4. Front roller bearing
5. Reduction gear drive shaft
6. Retaining ring
7. Retaining sleeve
8. Spring
9. Plug
10. Lock housing
11. Stage I. disc
12. Nut
13. Lock
14. Thrust ring
15. Flexible ring
16. Spacer sleeve
17. Air supply channel to front roller bearing seal
18. Screw
19. Spacer ring
20. Baffle seal sleeve
21. Spacer sleeve
22. Baffle seal ring
23. Baffle seal sleeve
24. Air supply channel
25. Pin

50X1

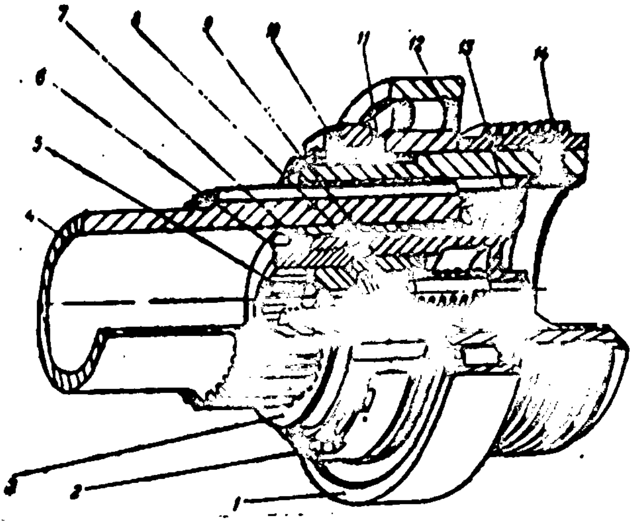


Fig. 58. Coupling between compressor rotor and reduction gear
1. Front compressor roller bearing
2. Nut
3. Splined shaft from compressor Stage I
4. Reduction gear drive shaft
5. Plug
6. Retaining sleeve
7. Spacer ring
8. Spring
9. Lock housing
10. Lock
11. Thrust ring
12, 13. Spacer ring
14. Baffle seal sleeve

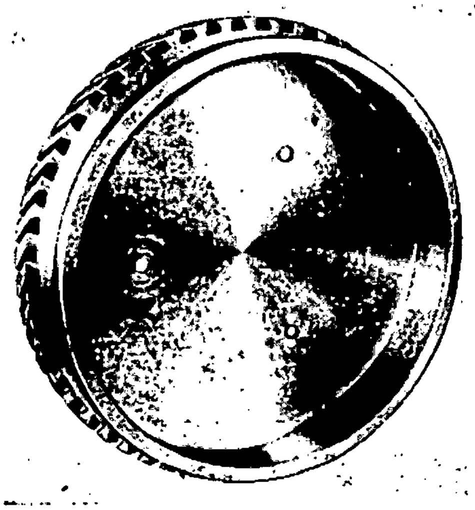


Fig. 59. Fig. 59. Disk

Fig. 60. Rotor blade

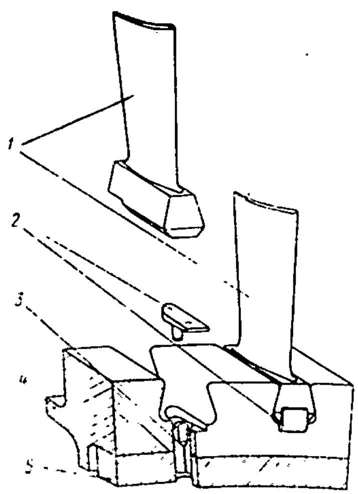


Fig. 61. Mounting the blade in disc of the compressor rotor
1. Blade
2. Locking pin
3. Pin
4, 5. Compressor rotor discs

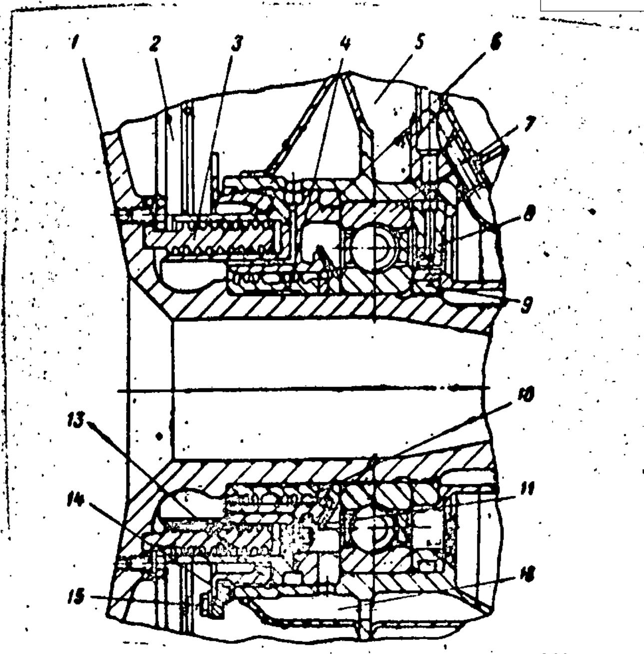


Fig. 62. Rear compressor bearing

1. Rear shaft
2. High pressure area
3, 4. Baffle seal sleeve
5. Deaeration area
6. Baffle seal sleeve
7. Ball bearing
8. Lubricating ring
9. Nut
10. Regulator ring
11. Oil slinger
12. Oil sump, combustion chamber casing
13. Nut
14. Safety lock
15. Bolt

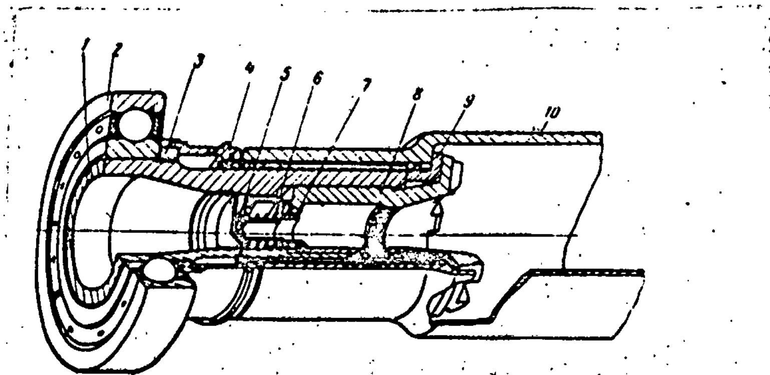


Fig. 63. Compressor shaft coupling with the turbine shaft

1. Rear shaft, compressor
2. Ball bearing, compressor
3. Nut
4. Spacer sleeve
5. Guide pin
6. Spring
7. Locking sleeve
8. Threaded coupling member
9. Thrust bushing
10. Turbine shaft

50X1

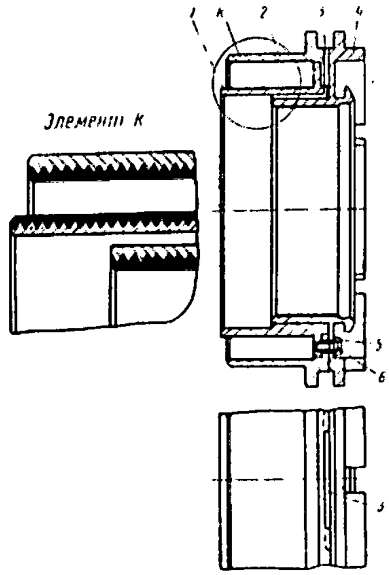


Fig. 64. Baffle seal [assembly]
1, 2, 4. Seal rings
3. Air passage aperture
5. Screw
6. Lock washer

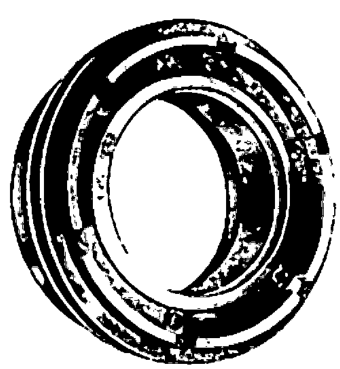


Fig. 65. Baffle seal

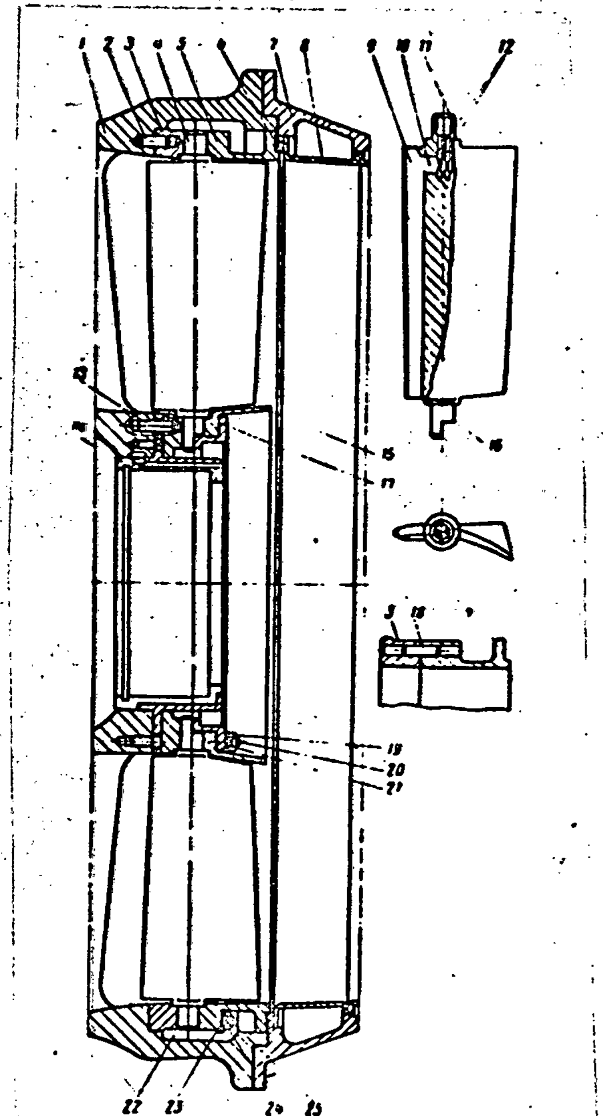


Fig. 66. Inlet guide vane assembly

1. Front casing
2. Pin
3. Front outer ring
4. Guide vane
5. Rear outer ring
6. Regulator ring
7. Compressor casing
8. Working ring
9. Heated air channel
10. Groove
11. Vane top[mounting]pin
12. Hot air openings
13. Pin
14. Front bearing cup
15. Inner ring
16. Vane bottom [mount] pin
17. Spacer plate [ring]
18. Centering pin
19. Nut securing the inner ring and lock washer for forward casing
20. Bolt securing inner ring and lock washer for forward casing
21, 23. Spring lock
22. Annular cavity
24. Nut securing the outer rings
25. Bolt securing the outer ring

50X1

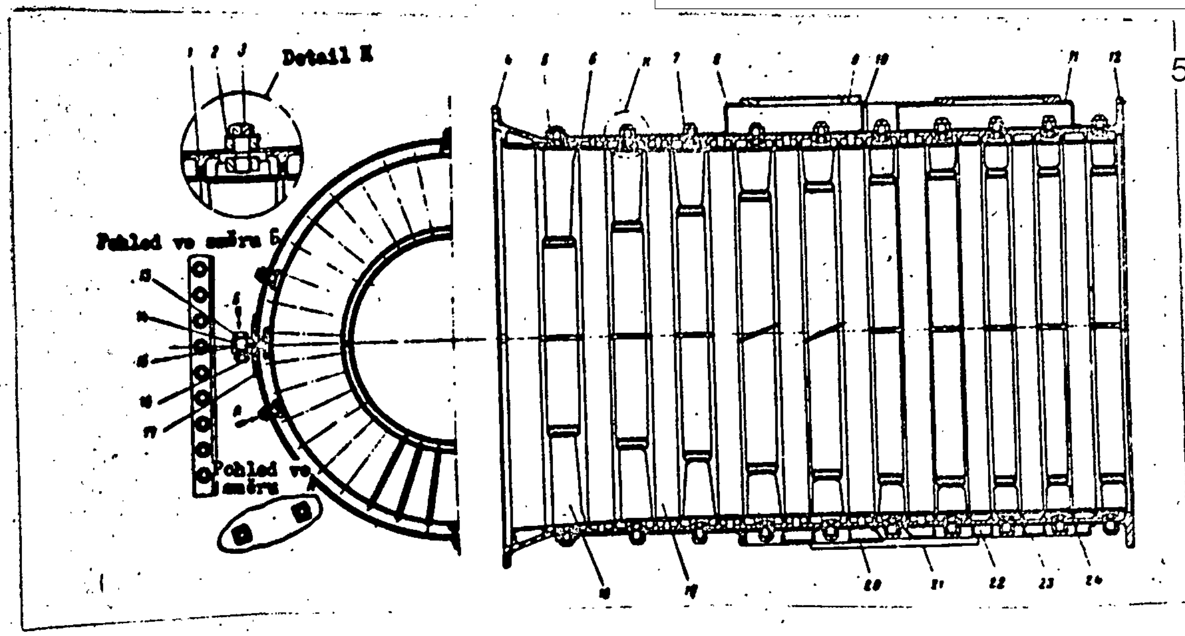


Fig. 67. Compressor housing

1. Reinforcement
2. Lock washer
3. Stator vane bolt
4. Front flange
5. Support under stator vane bolt, stage I
6. Compressor housing
7. Support under stator bolt, stages II - X
8. Upper forward [collector] pocket
9. Flange
10. Upper [collector] pocket cup
11. Upper rear [collector] pocket
12. Rear flange
13. Flexible shim
14. Upper longitudinal flange
15. Gaskets
16. Bolt
17. Lower longitudinal flange
18. Stator vane, stage I
19. Rotor, stage III
20. Lower forward [collector] pocket
21. Flange for mounting KTA
22. Lower collector cup
23. Lower rear covering
24. Reinforcement

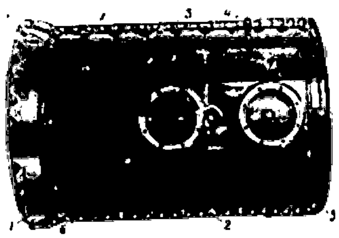


Fig. 68. Compressor housing (upper half)

1. Clamps for fastening wires to the MP - 5 electro-mechanism
2. Mounting bosses for the two KPN-4 starter coils
3. Mounting plate for clamp of the line carrying off the air from the oil area of the turbine shaft channel to the centrifugal deaerator
4. Bosses for mounting the hot air bleed valve to the inlet guide vanes
5. Bosses for mounting the clamps of the wiring leading from the KPN-4 starter coils to the igniters
6. Coupling for air supply to the baffle seal of the roller bearing

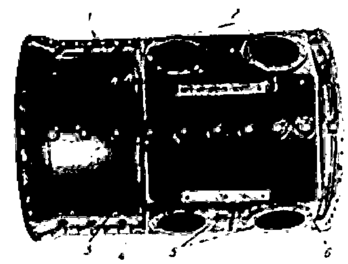


Fig. 69. Compressor housing (lower half)

1. Bosses for mounting the hydraulic VE-2S switch
2. Flanges
3. Bosses for mounting the clamp holding the wires to the fuel control assembly
4. Bosses for mounting air line clamps
5. Flanges for mounting the air bleed valves behind stages V and VIII
6. Mounting bars for fuel control assembly

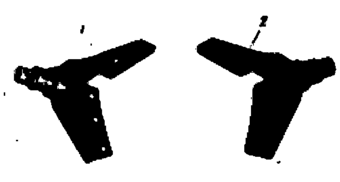


Fig. 70. Rear engine mounts

1. Right rear mount
2. Left rear mount

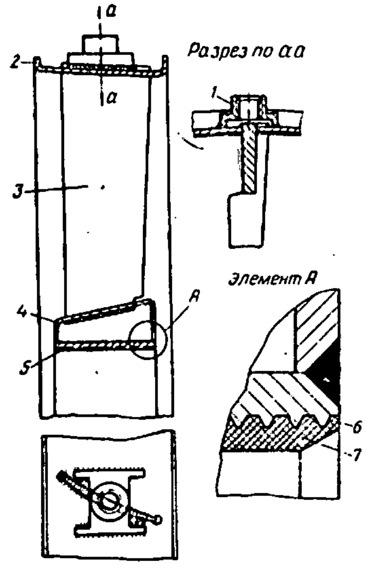


Fig. 71. Compressor stator ring

1. Pin
2. Outer rim
3. Blade
4. Inner rim
5. Labyrinth ring
6. Ridging
7. Aluminum layer with graphite

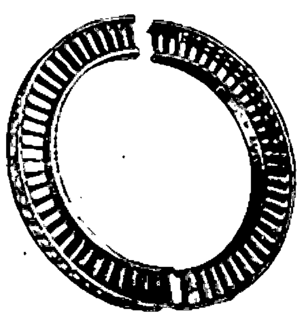


Fig. 72. Stator ring, stage V compressor

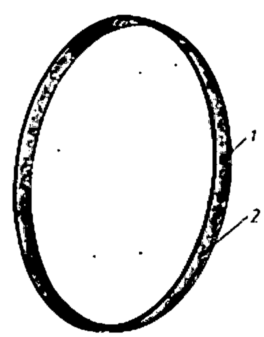


Fig. 73. Rotor ring

1. Stop
2. Ring

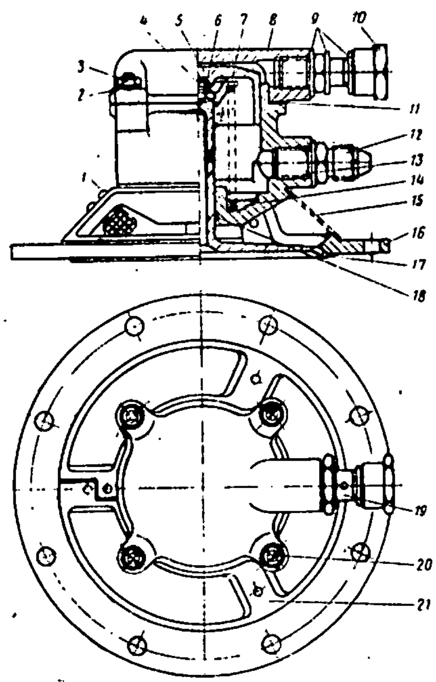


Fig. 74. Air bleed valve - 1. Rivet; 2. Lock washer; 3. Nut for fastening cover; 4. Heel; 5. Piston; 6. Safety lock; 7. Plate; 8. Cover; 9. Aluminum gasket; 10. Nut; 11. Packing; 12. Tube fitting; 13. Aluminum packing; 14. Spring; 15. Screen; 16. Body; 17. Valve; 18. Ring; 19. Tube fitting; 20. Bolt for securing the cover; 21. Support

Fig. 75. Air bleed valve - 1. Valve; 2. Valve housing; 3. Cover; 4. Nut; 5. Spring washer; 6. Gasket; 7. Piston; 8. Lock washer; 9. Plate; 10. Spring;

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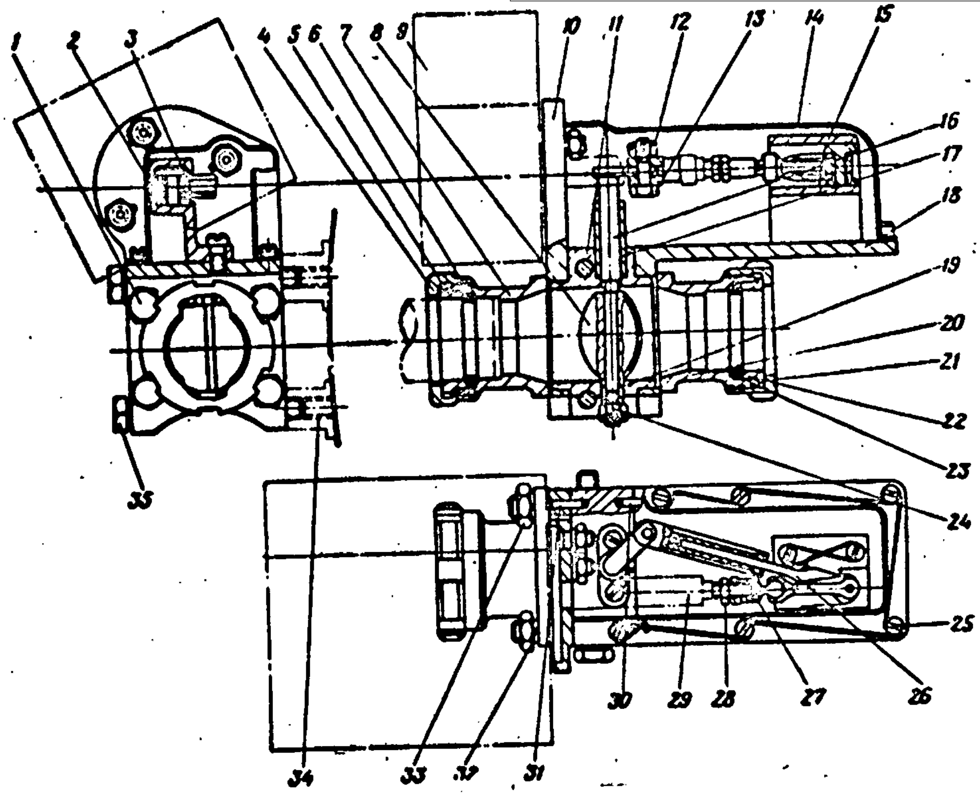

Fig. 76. Hot air bleed valve for heating inlet guide vanes

1. Bolt
2, 3. Rollers
4. Securing nut
5. Seal ring
6. Asbestos cord
7. Flange
8. Butterfly valve
9. MP-5 electromechanism
10. Flange
11. Casing
12. Nut
13. Bolt
14. Cover
15. Forging
16. Butterfly valve shaft
17. Bushing
18. Angle plate
19. Bushing
20. Flange
21. Securing nut
22. Seal ring
23. Asbestos cord
24. Nut
25. Screw
26, 27. Pull rods
28. Lock nut
29. Actuator rod of the MP-5 electromechanism
30, 31. Pins
32. Washer
33. Nut
34. Lug
35. Bolt

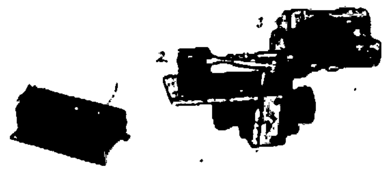

Fig. 77. Hot air bleed valve for heating inlet guide vanes
1. Cover
2. Hot air bleed valve
3. MP-5 electromechanism

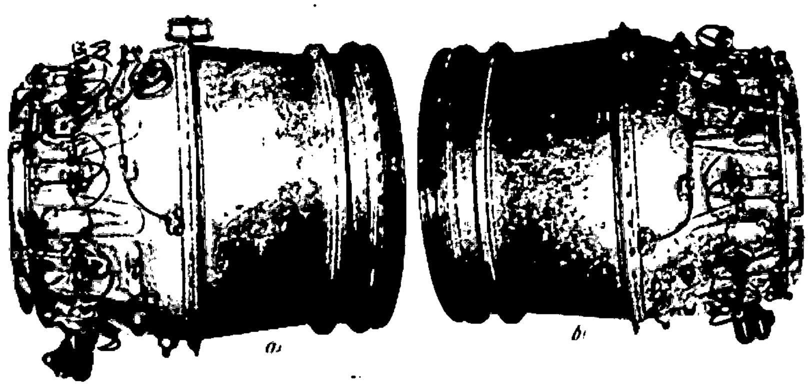

Fig. 78. Combustion chamber
a. View from the right
b. View from the left

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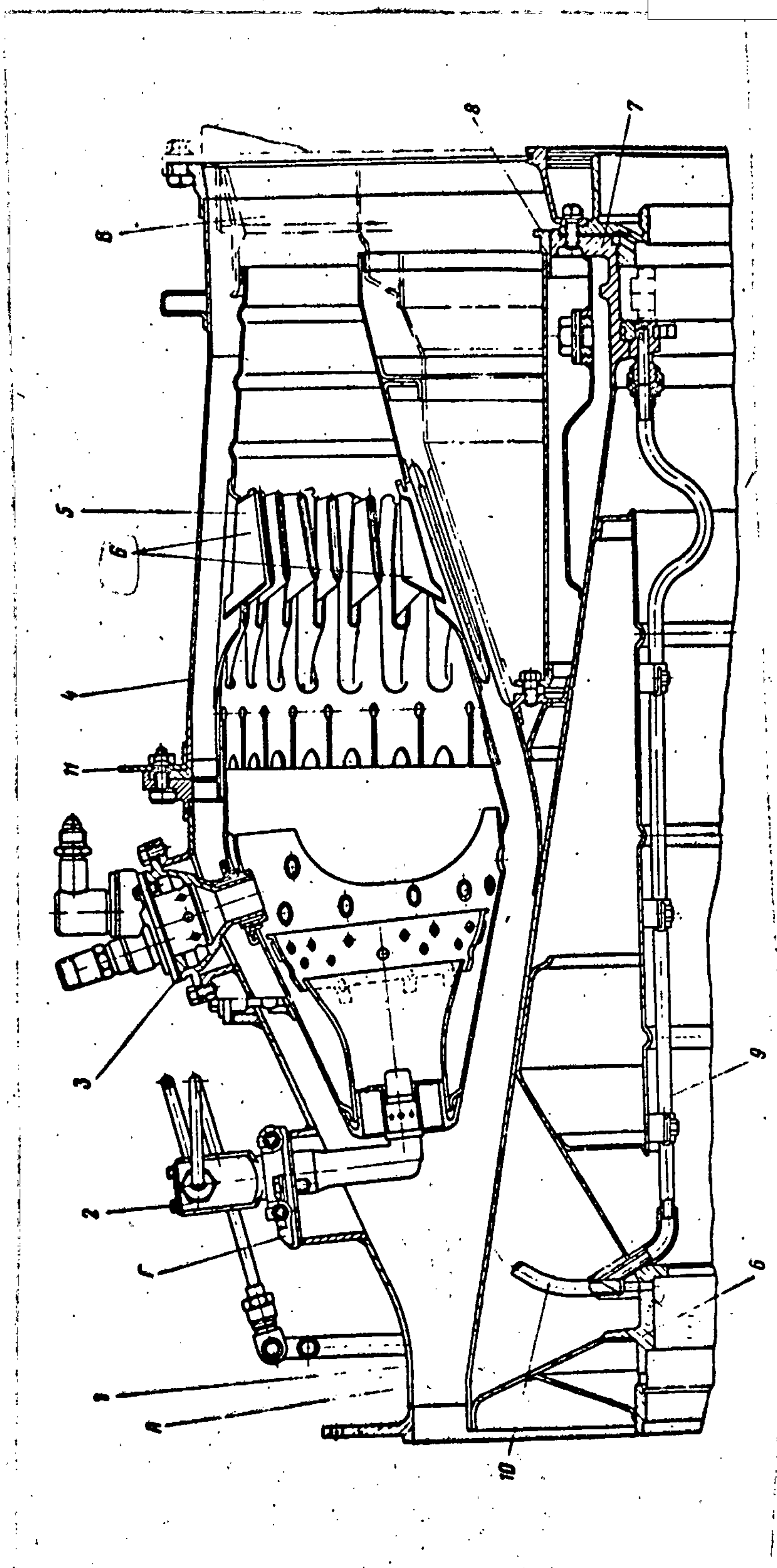

Fig. 79. Combustion chamber

1. Inlet section
2. Main fuel nozzle
3. Igniter
4. Casing
5. Burner
6. Compressor bearing housing
7. Turbine bearing housing
8. Guide housing
9. Oil supply tube to compressor bearing
10. Oil supply tube to turbine bearing

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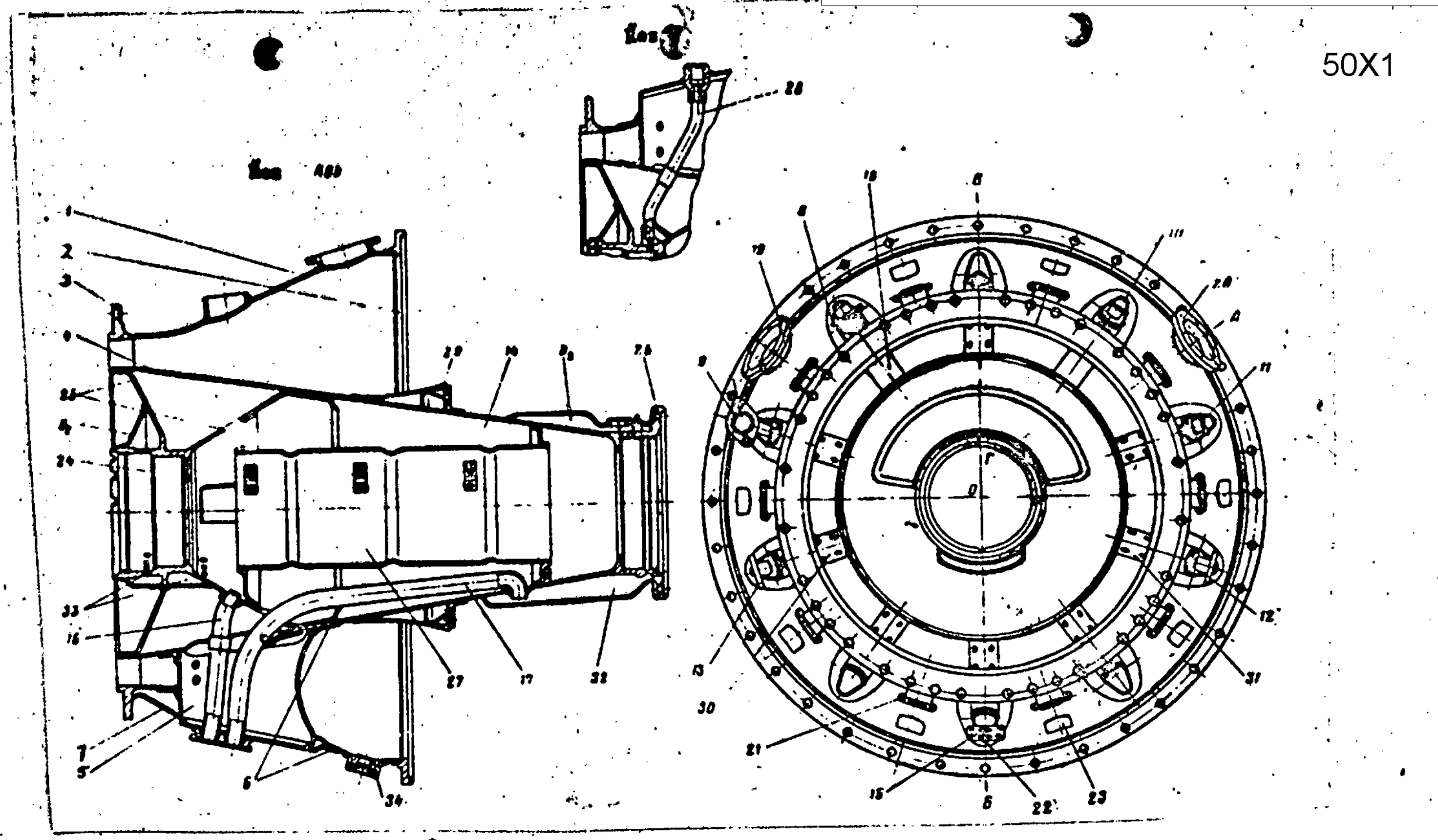

Figure 80. Inlet section of combustion chamber

1. Outer lower casing; 2. Rear flange; 3. Front flange; 4. Conical supporting section; 5. Rib; 6. Reinforcement ring; 7. Reinforcement; 8. Flange for the line which carries off the oil emulsion; 9. Flange for the line which supplies air for heating the inlet guide vanes of the compressor; 10. Mounting flange for de-aeration tubing; 11, 12, 13. Flanges for air lines to aircraft; 14. Air area; 15. Oil filter mounting flange; 16. Line for carrying off the oil from the compressor bearing; 17. Line for carrying off the oil from the turbine bearing; 18. Rib; 19, 20. Mounting flange for operational fuel nozzles; 22. Rib with oil filter mounting flange; 23. Flange for fastening the locking pins of the combustion chamber; 24. Compressor bearing housing; 25. Conical casing; 26. Turbine bearing housing; 27. Casing; 28. Oil supply tube; 29. Mounting flange for [fuel?] line cover; 30, 31. Ribs; 32, 33. Oil sump; 34. Flange

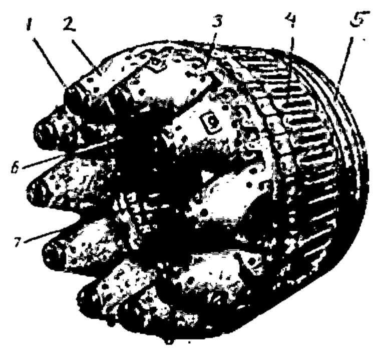

Fig. 81. Burners

1. Vortex generators
2. Done
3. Outer ring
4. Extension [secondary air mixers?]
5. Outer casing
6. Inner ring
7. Inner casing

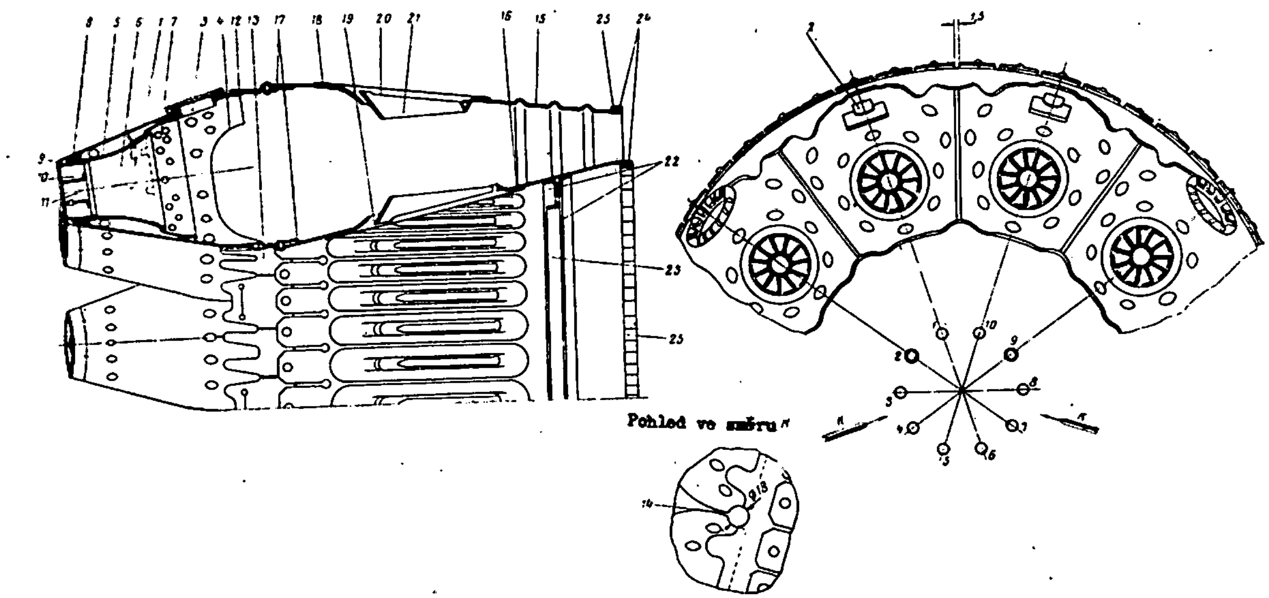

Fig. 82. Burner

1. Dome
2. Bushing
3. Floating flange
4. Slot
5. Diffuser
6. Forward section of the diffuser
7. Rear section of the diffuser
8. Vortex vane
9. Outer ring the vortex generator
10. Vortex vane
11. Sleeve
12. Outer ring of dome
13. Inner ring of dome
14. Opening for the auxiliary fuel nozzle
15. Outer casing
16. Inner casing
17. Spacer plate
18, 19. Extensions [secondary air mixers?]
20. Extension flange
21. Insert
22, 23. Flanges
24. Annular belts
25. Spacer plate.

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Fig. 83. Fuel system

1. Secondary manifold
2. Main manifold
3. Fuel supply line to the main fuel nozzle
4. Fuel supply line to the secondary fuel nozzle
5. Fuel supply line from the fuel control assembly to fuel manifolds
6. Mountings for fuel manifolds
7. Coupling

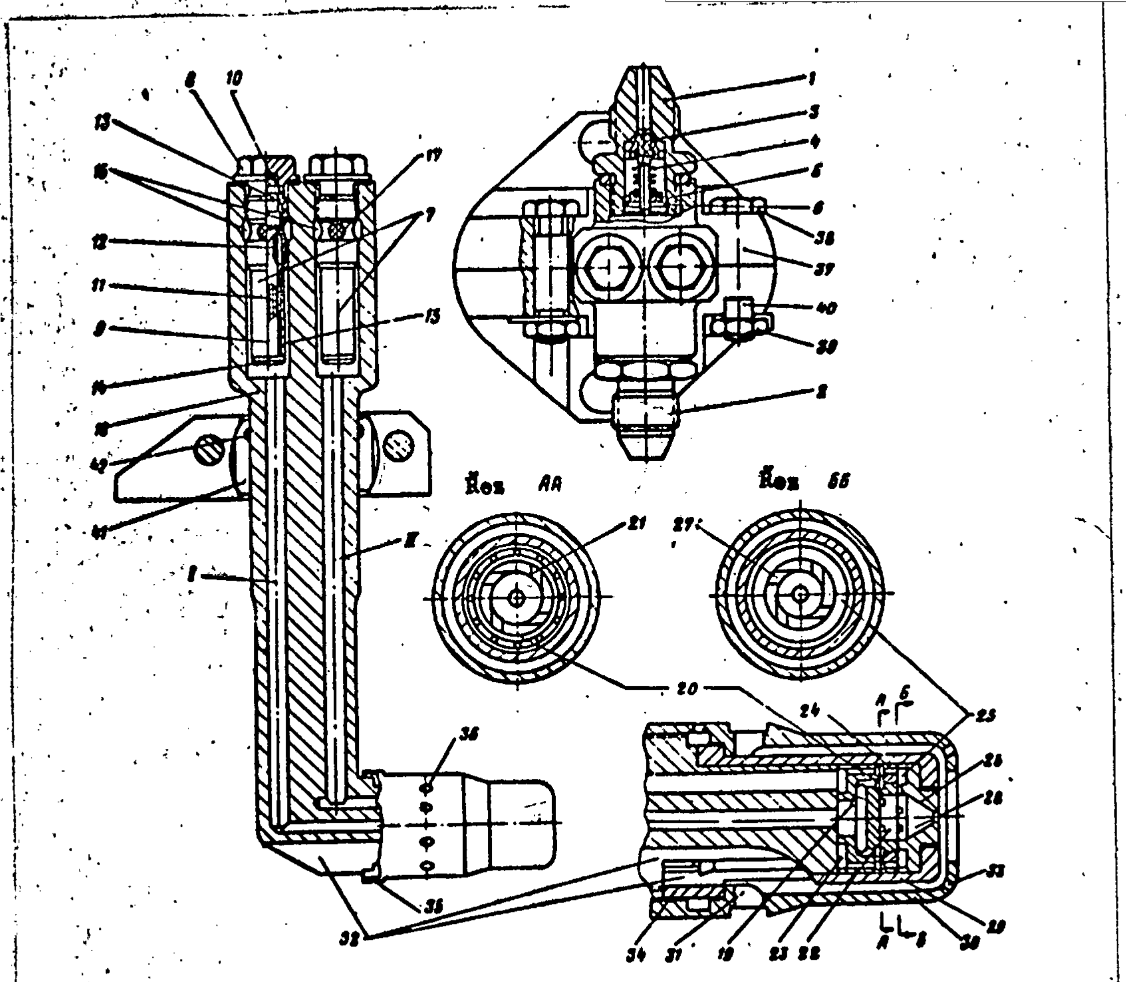

Fig. 84. Fuel nozzle - 1, 2. Tube fittings of the return valve; 3. Rubber valve; 4. Spring; 5. Stop; 6. Set ring; 7. Filter; 8. Extension [hex head bolts for filter units?]; 9. Filter insert; 10. Pin; 11. Screen; 12. Frame; 13. Journal; 14. Bushing; 15. Casing; 16. Circular groove; 17. Opening in the tube fitting; 18. Fuel nozzle body; 19. Adapter; 20. Vortex generator of the primary circuit; 21. Four tangential grooves in the vortex generator; 22. Vortex chamber; 23. Recess in the adaptor; 24. Ring; 25. Recess in the atomizer; 26. Atomizer; 27. Four tangential grooves in the atomizer; 28. Atomizer chamber; 29. Sleeve; 30. Shroud nut; 31. Two keyways in housing; 32. Machined area on head and sleeve; 33. 12 openings around the shroud; 34. Sleeve boss; 35. Shroud shoulder; 36. Ten fuel discharge outlets; 37. Fuel nozzle flange; 38. Bolt; 39. Nut; 40. Flexible lock; 41. Ring; 42. Rubber ring

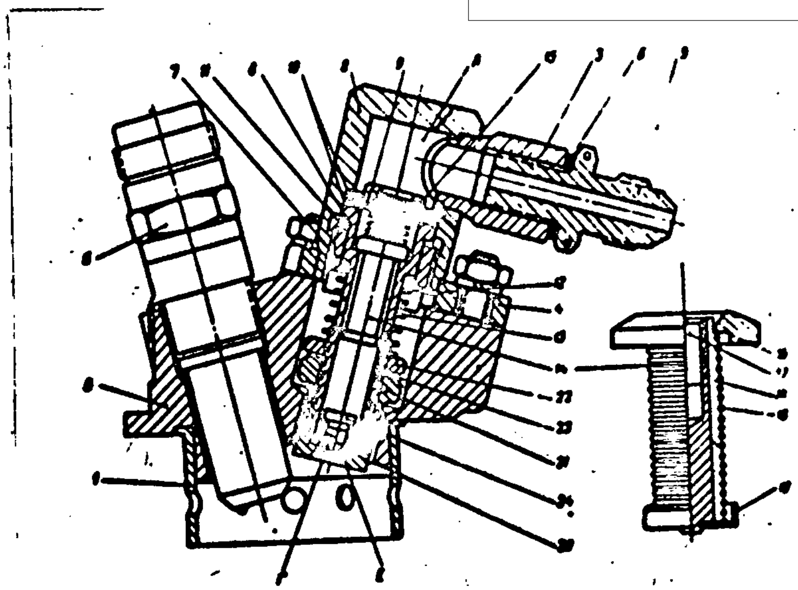

Fig. 85. Igniter

A. Starting fuel nozzle
B. SPN-4 spark igniter plug
V. Igniter body
G. Two tangentially placed openings
E. Complementary openings
ZH. Grooves
1. Igniter body sleeve
2. Starting fuel nozzle body
3. Starting fuel nozzle sleeve
4. Starting fuel nozzle flange
5. Tube fitting
6. Seal
7. Nut
8. Atomizer sleeve
9. Cap
10. Aluminum washer
11. Brass washer
12. Flexible lock
13. Spring
14. Starting fuel nozzle filter
15. Spring
16. Upper plate of the filter
17. Core
18. Nickel chromed wire
19. Plate
20. Atomizer
21. Nut
22. Lock nut
23. Lock nut
24. Blind [shroud?]

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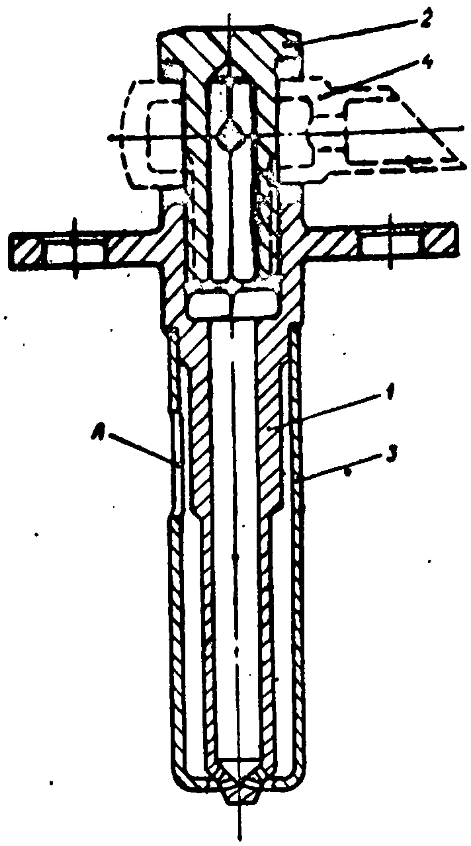

Fig. 86. Auxiliary starting fuel nozzle

1. Body
2. Bolt
3. Housing
4. Tube fitting

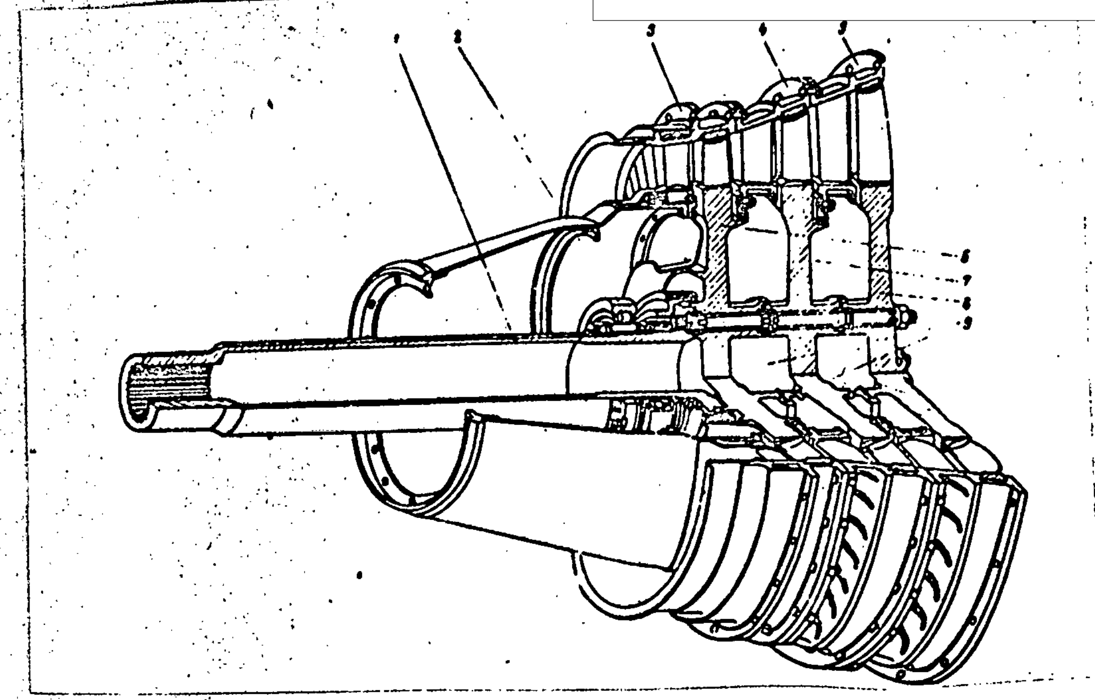

Fig. 87. Turbine - 1. Turbine shaft; 2. Roller bearing; 3. Stator vane assembly of stage I; 4. Stator vane assembly of Stage II; 5. Stator vane assembly of Stage III; 6. Disc, Stage I; 7. Disc, Stage II; 8. Disc, Stage III; 9. [word illegible] of the rotor.

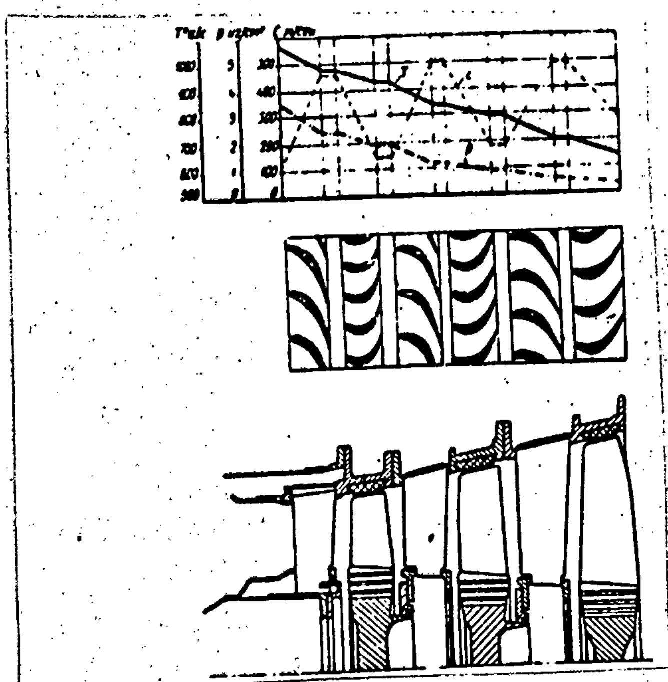

Fig. 88. Change in static heat T, pressure p, and absolute speed c in the individual stages on the central radius of the turbine

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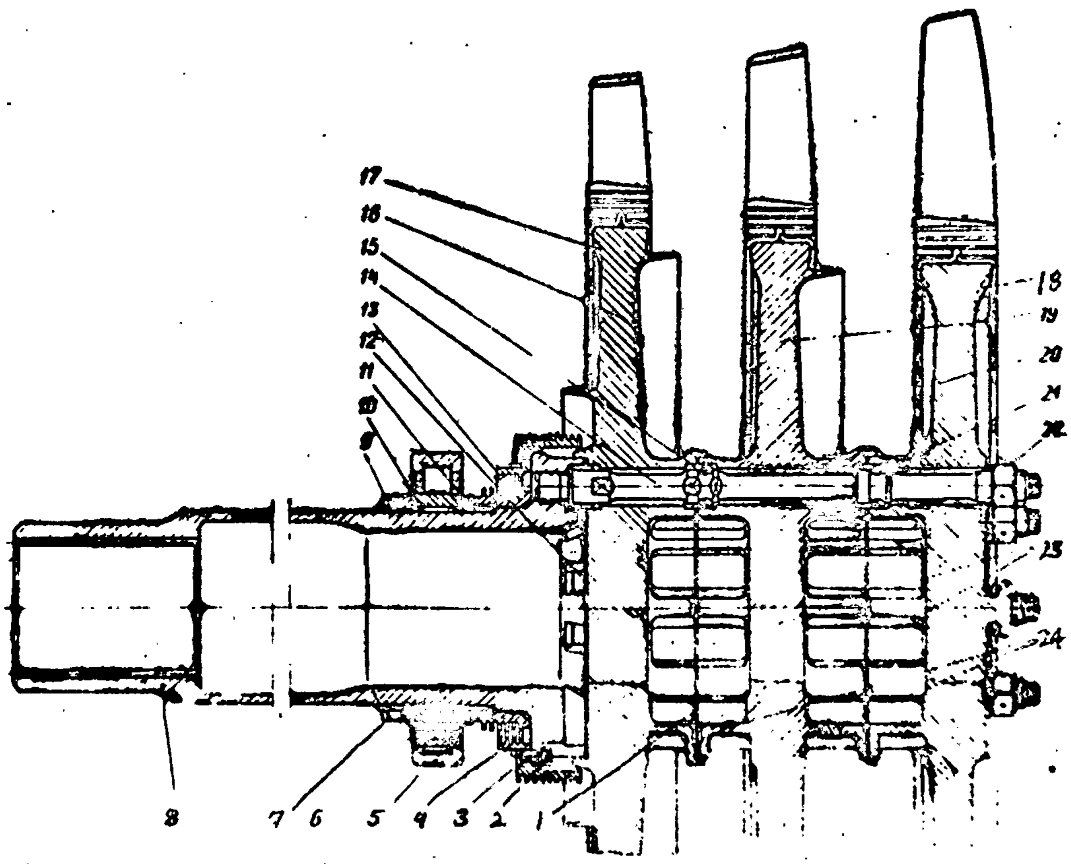


Fig. 89. Turbine rotor (cross section)

1. Spacer ring
2. Safety lock
3. Bolt
4. Baffle seal flange
5. Roller bearing
6. Supporting ring
7. Nut
8. Shaft
9. Safety lock
10, 11. Baffle for reducing flow of heat to bearing
12. Milled recess
13. Seal ring
14. Securing bolt
15. Bushing
16. Disc stage I
17, 18. Areas from which material is removed during balancing
19. Disc stage II
20. Disc stage III
21. Guide
22. Nut
23. Cavities
24. De-aeration opening

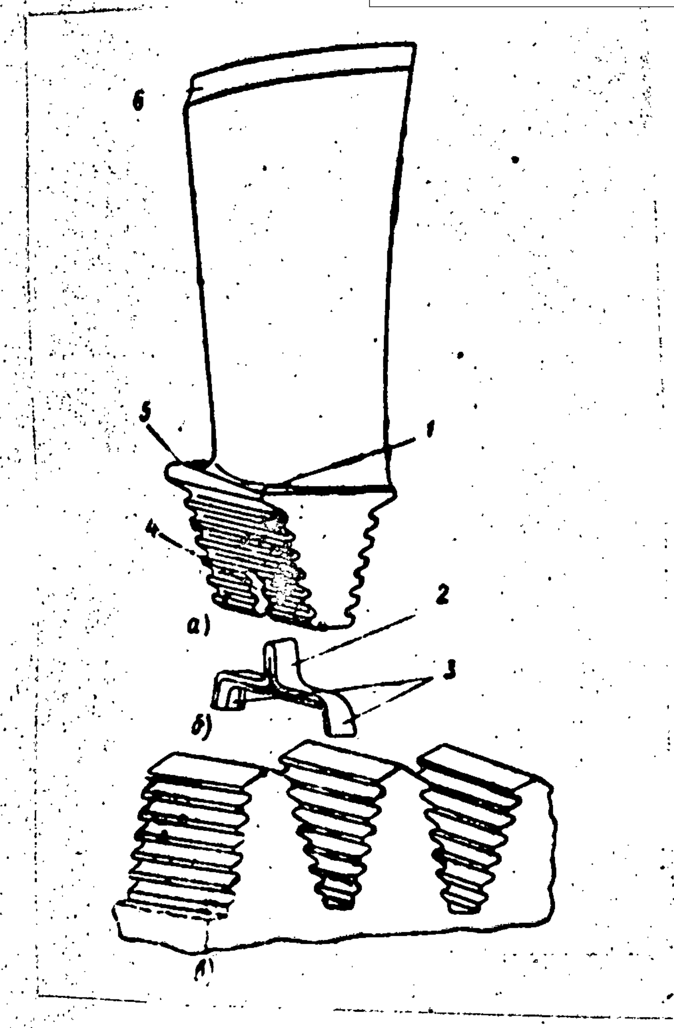


Fig. 90. Mounting turbine buckets on disc

a. Bucket
b. Safety lock
B. Disc
1. Bucket shoulder
2. Safety lock lug
3. Safety lock, bent down ends
4. Slot for lug of safety lock
5. Baffle
6. Recess.

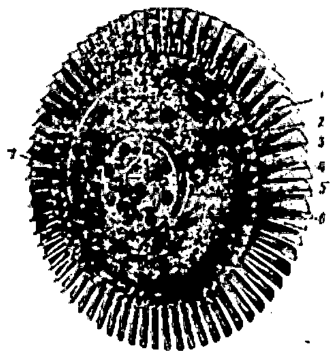


Fig. 91. Disc, Stage II (front view)
1. Peripheral section
2. Tapered plate
3. Hub
4, 7. Lightening holes
5. Holes for tightening bolts
6. Recess

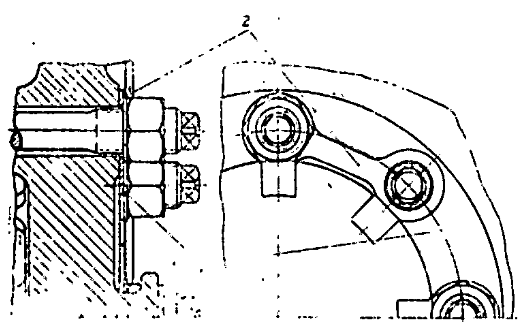


Fig. 92. Disc lock nuts
1. Safety lock
2. Shaped washer

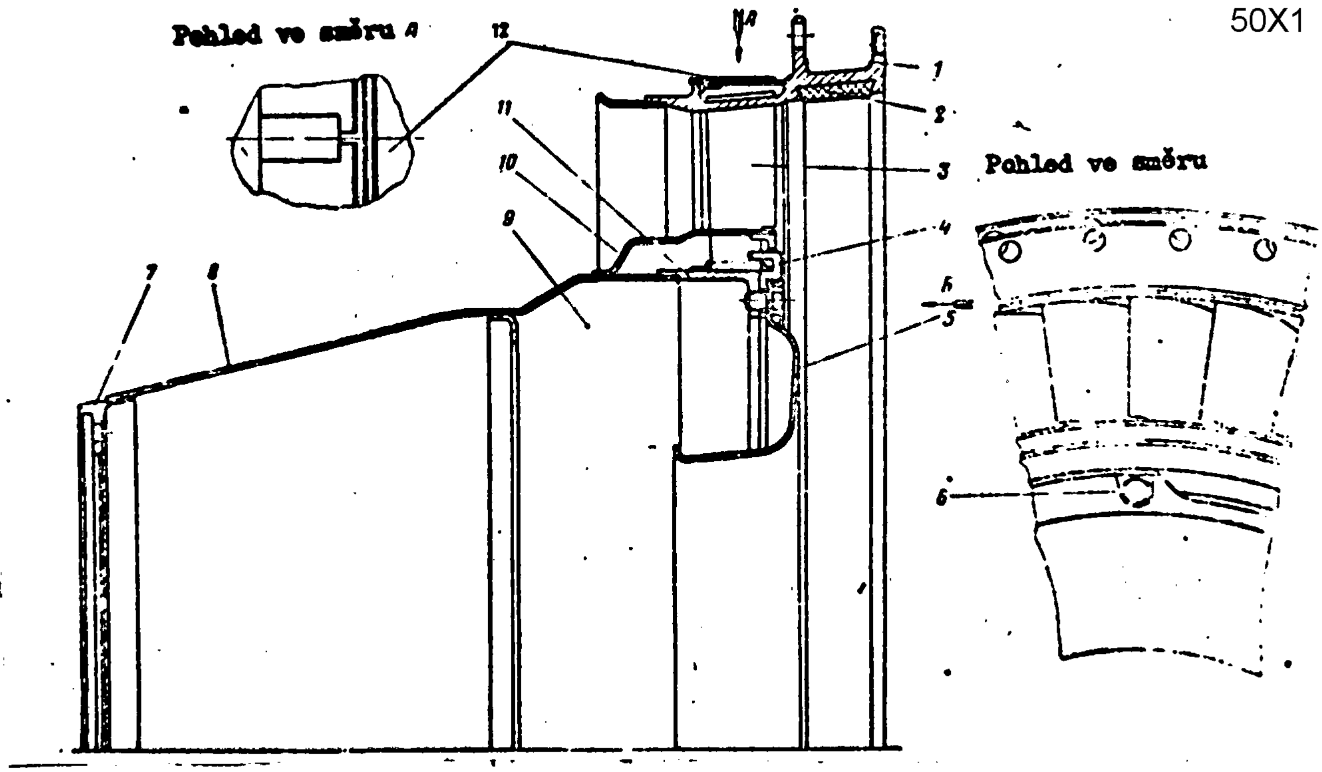


Fig. 93. Turbine nozzle assembly, stage I

1. Outer rim
2. Inserts
3. Nozzle guide vane
4. Set lock
5. Deflector
6. Bolt
7. Supporting cone flange
8. Supporting cone
9. Inner body
10. Deflector rim
11. Set rim
12. Belt

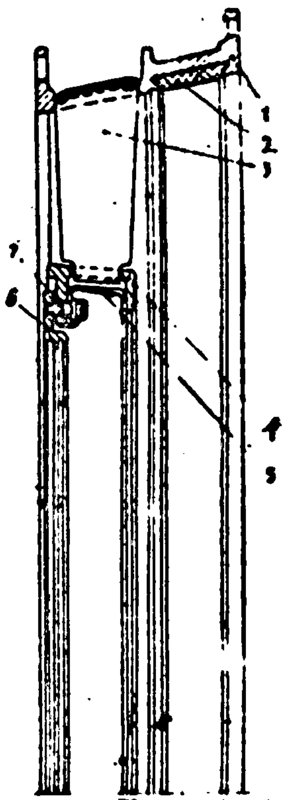


Fig. 94. Stator vane assembly of turbine
1. Outer rim
2. Metallo-ceramic insert
3. Stator vane
4. Inner rim
5. Circular insert
6. Seal ring
7. Spacer ring

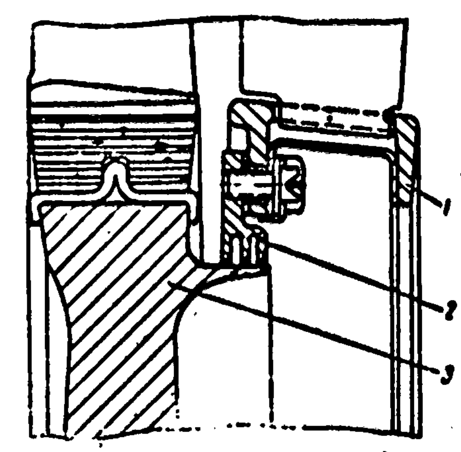


Fig. 95. Interstage packing
1. Turbine nozzle assembly, Turbine stator vane assembly
2. Seal ring
3. Turbine disc

50X1

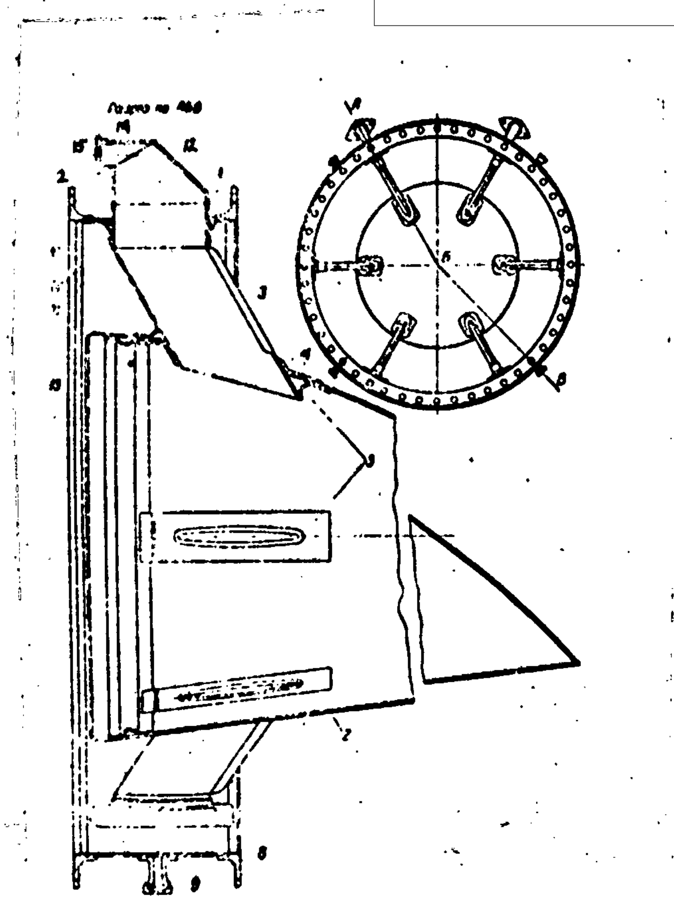


Fig. 96. Exhaust nozzle

1. Outer casing
2. Cone
3. Rib
4. Outer cup
5. Inner cup
6. Guide
7. Forward flange
8. Rear flange
9. Tube fitting
10. Cup
11. Stay
12. Extenstion
13. Reinforcement
14. Tube
15. Flange

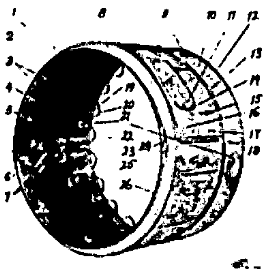


Fig. 97. Turbine housing

1. Right half of turbine housing
2, 3, 4. Air passage openings to the turbine nozzle unit
5. Inner housing (front)
6. Left half of the turbine housing
7. Reinforcement
8. Housing wall
9. Cover
10. Right rear housing body
11. "Blind" [cover plate?]
12. Wire
13. Tightening sleeve
14. Shaft flange
15. Longitudinal slots
16. Throat
17. Right front housing body
18. Shaped openings under housing
19. Nut
20. Support band
21. Cone
22. Rear inner housing
23. Diameter of the weld between the inner and outer housing
24. Iron mounting
25. Support band
26. Forward support diameter

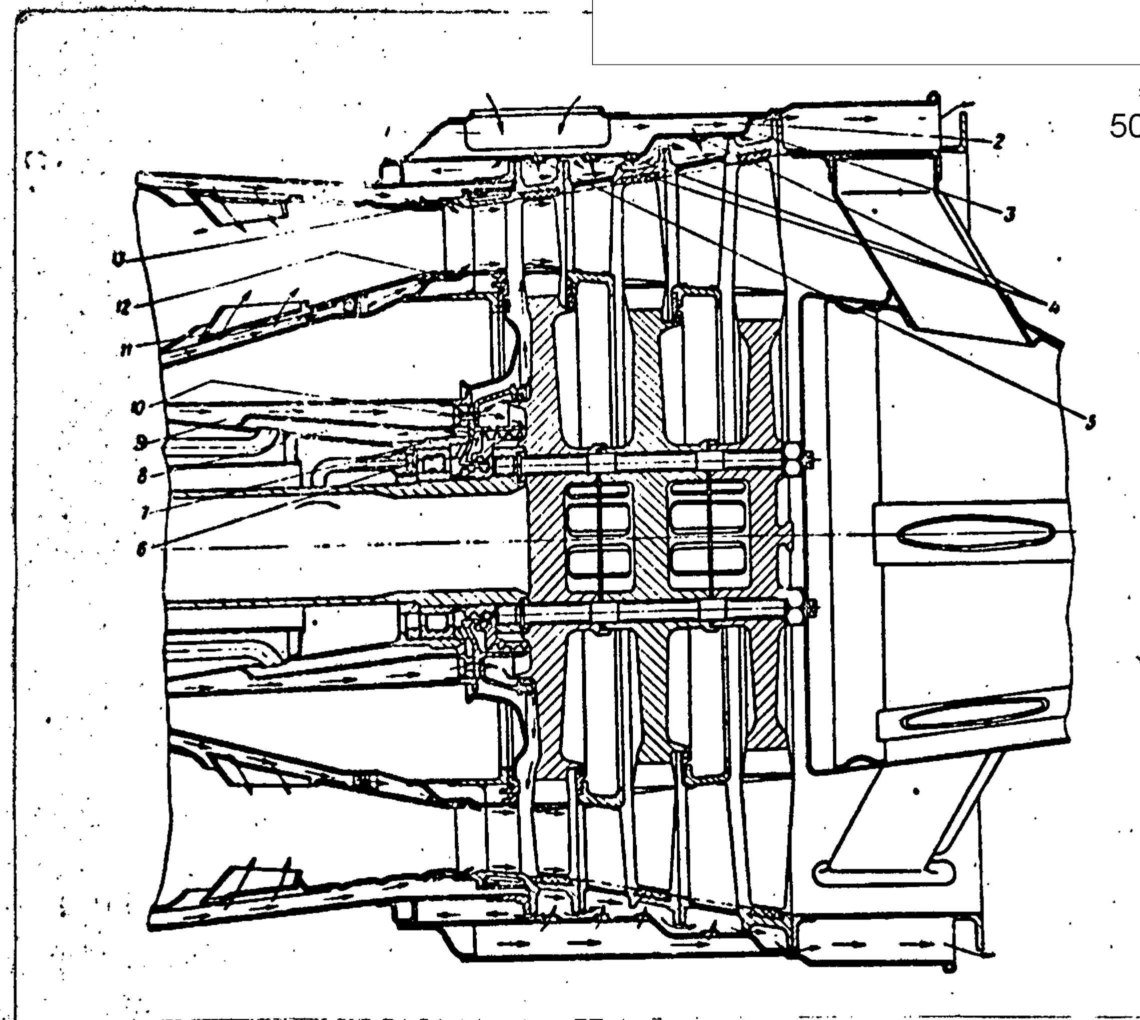
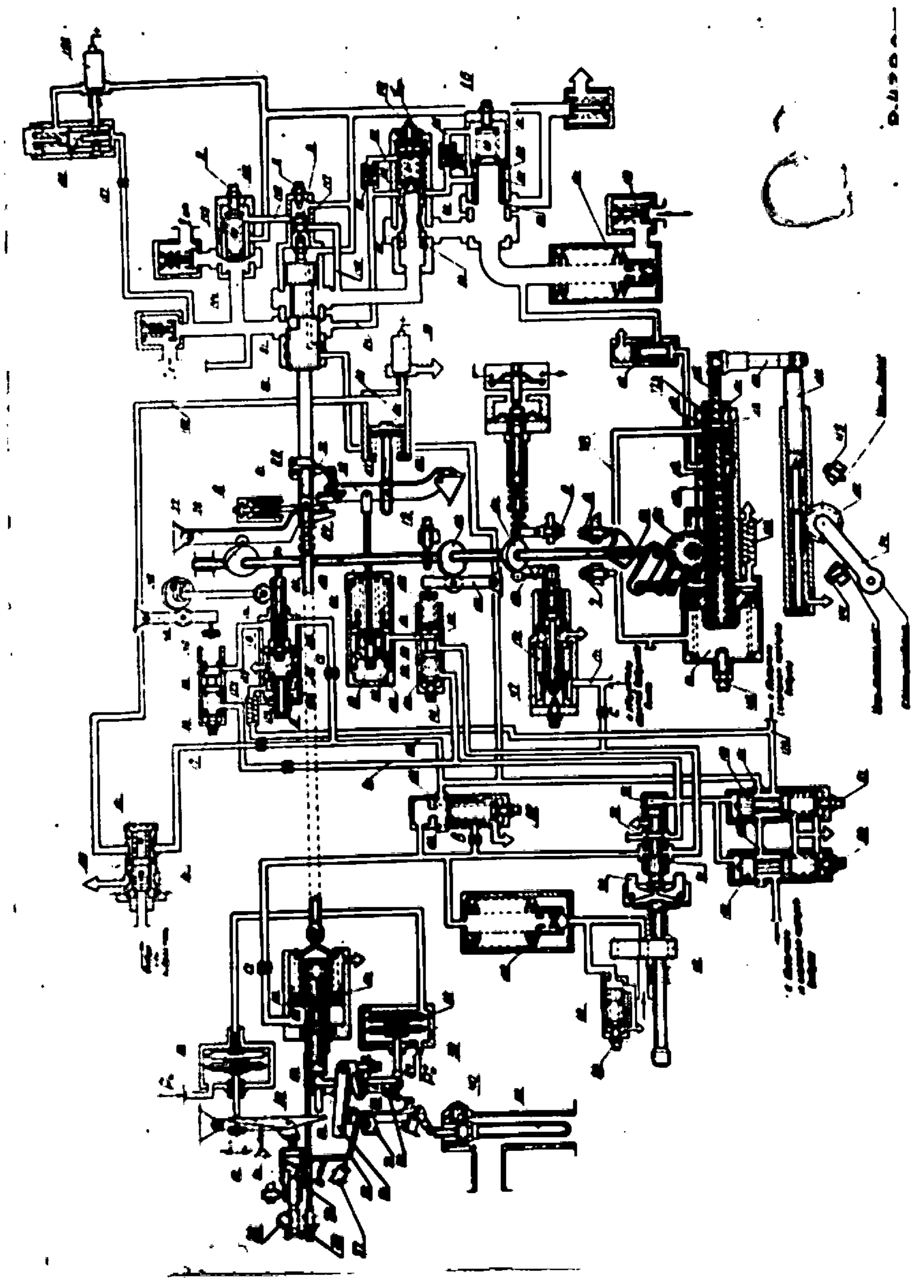


Fig. 98. Turbine cooling diagram

1. Air intake hole
2. Annular air scoop
3. Area for the air used to cool stator vanes
4, 5. Air passages
6. Roller bearing
7. Openings connecting the secondary air with the de-aeration area
8. Air bleed area
9. Area of the secondary air current
10. Openings for the passage of the secondary air current
11. Openings for the passage of the secondary air current in the seal ring
12. Clearance between the inner casing of the combustion chamber and the inner ring of stage I stator vane assembly
13. Clearance between the outer casing of the combusion chamber and the outer ring of stage I stator vane assembly



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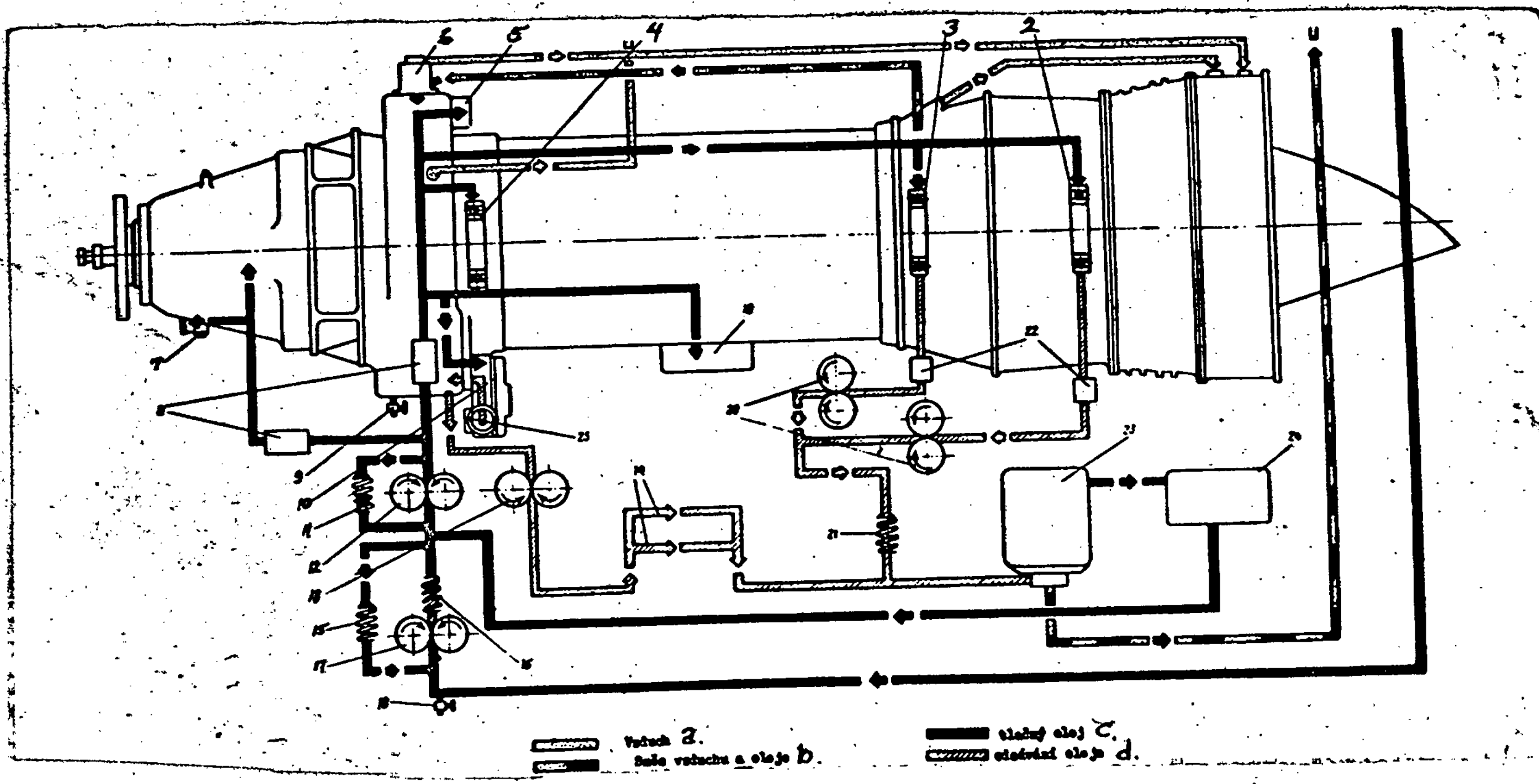


Fig. 99. Diagram of engine oil system - a. Air; b. Oil-air mixture; c. Oil under pressure d. Oil scavenge; 1. Oil tank; 2. Turbine rotor bearing; 3. Rear compressor rotor bearing; 4. Front compressor rotor bearing; 5. R-68 I propeller governor; 6. Centrifugal de-aerator; 7. IKM [torquemeter] oil pump; 8. Oil filter; 9. Drain cock; 10. Housing for accessory drives; 11. Oil pump reduction valve; 12. Pressure stage of main oil pump; 13. Scavenge stage of main oil pump; 14. Fins of forward housing; 15. Reduction valve of auxiliary pump; 16. Check valve of auxiliary pump; 17. Auxiliary oil pump; 18. Drain cock; 19. KTA unit; 20. Scavenge oil pump; 21. Check valve; 22. Double filter; 23. Air separator; 24. Oil cooler; 25. Scavenge pump in power drives housing

50X1

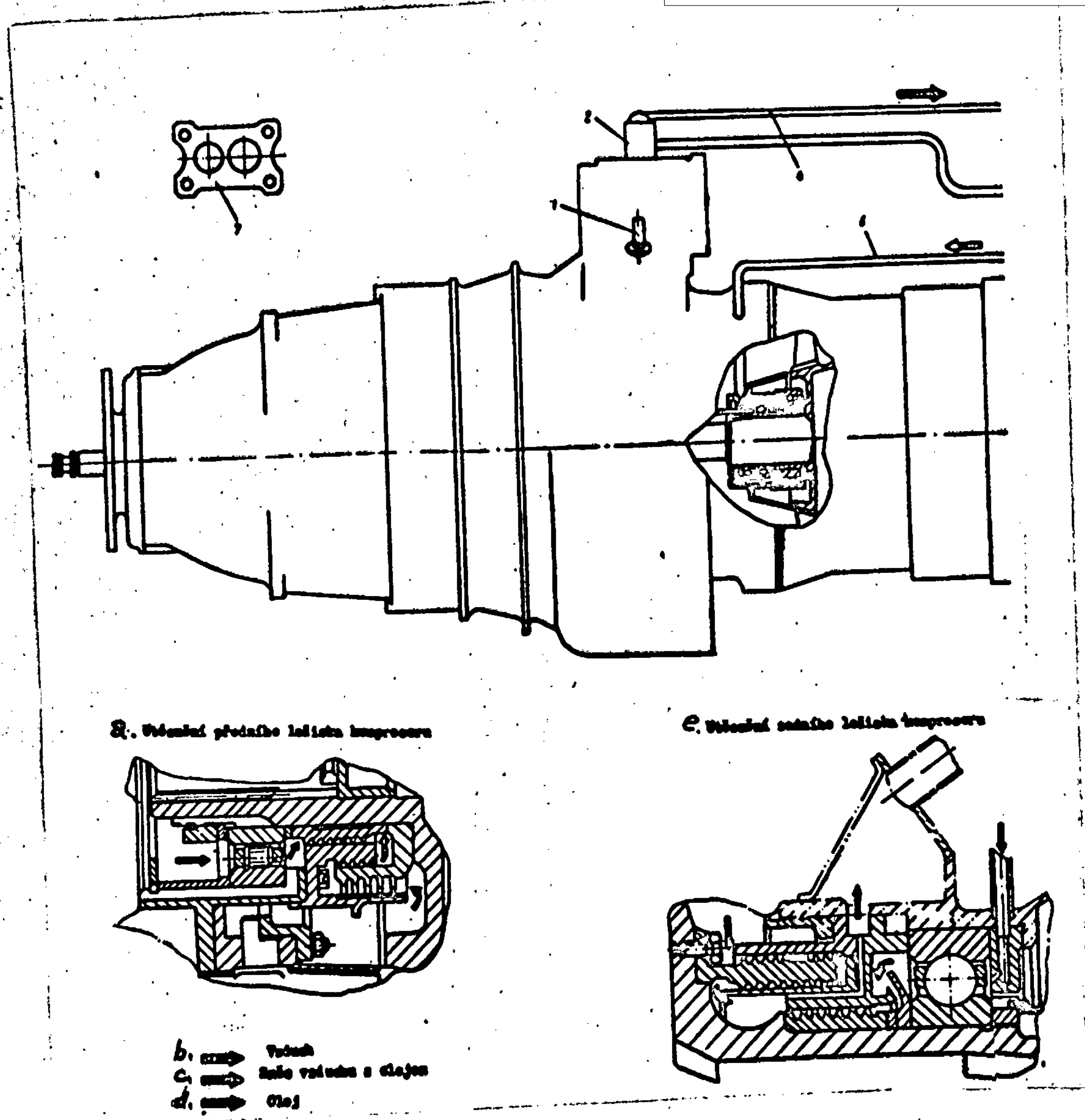
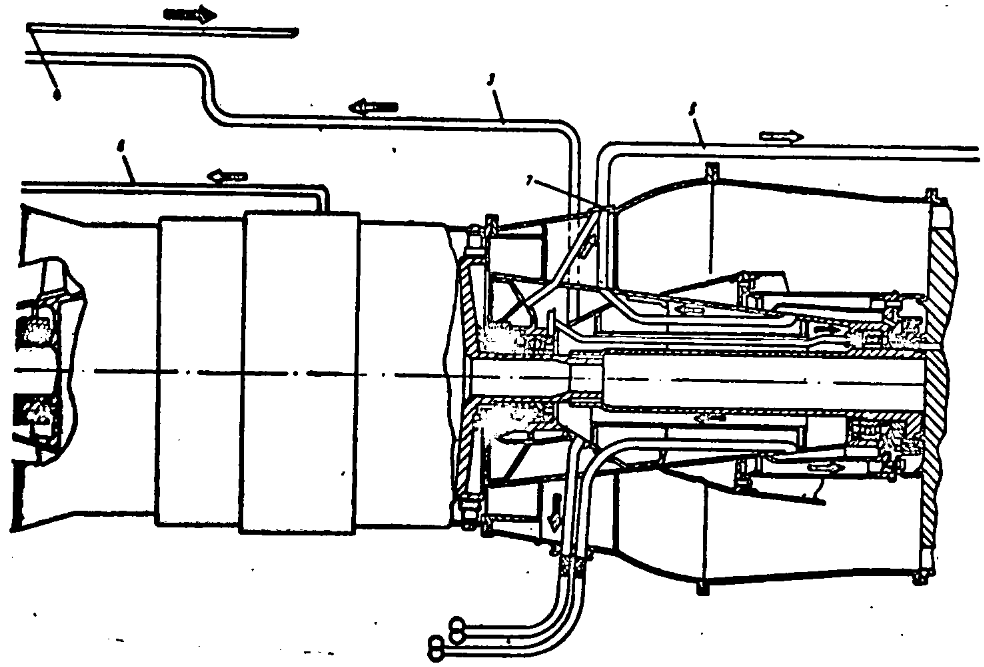


Fig. 100. Diagram of engine air vent system

a. Seal, front compressor bearing; b. Air; c. Mixture of air and oil; d. Oil; e. Seal, rear compressor bearing; f. Seal, turbine rotor; 1. Line coupling; 2. Centrifugal de-aerator; 3. Line for carrying emulsion to de-aerator; 4. Air vent line for areas behind the baffle seals of the engine rotor bearings; 6. Air bleed line from the fifth stage of the compressor to the front compressor bearing seal; 7. Adjustment washer



f Utěsnění rotoru turbíny

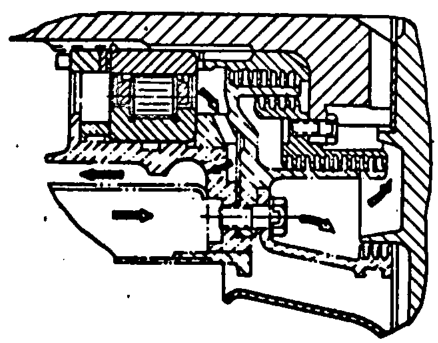


Fig. 100. (Continued)

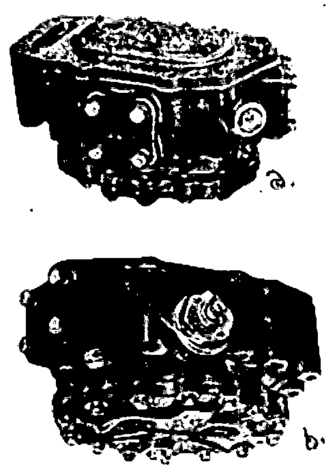


Fig. 101. GMN-20 main oil pump

a. Front view (top)
b. Rear view (bottom)

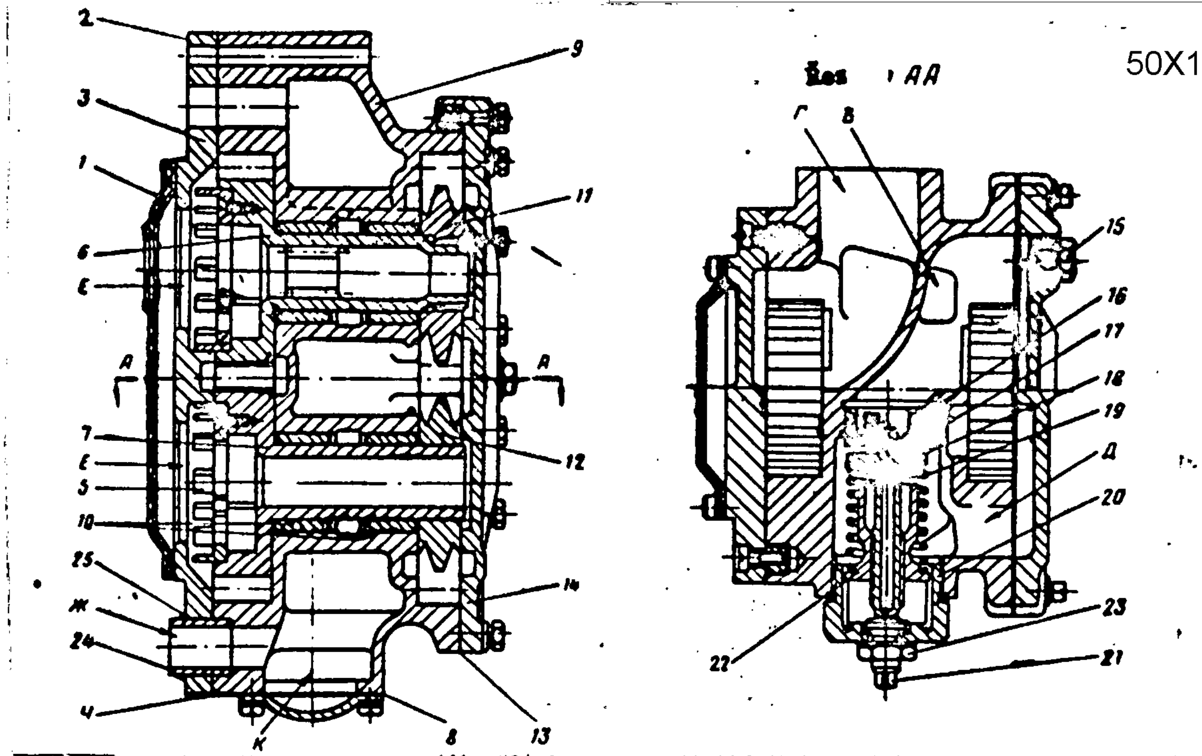


Fig. 102. GMN-20 main oil pump .

1. [Filter] screen
2. Packing (seal)
3. Top cover
4. Packing seal
5. Gear
6. Drive shaft
7. Driven shaft
8. Packing
9. Body
10. Liner
11. Drive gear
12. Driven gear
13. Packing
14. Bottom cover
15. Plug
16. Bypass sleeve
17. Valve
18. Spring disk
19. Spring
20. Protective cover
21. Adjusting screw
22. Spring
23. Lock nut [for adjusting screw
24. Oil release insert
25. Packing

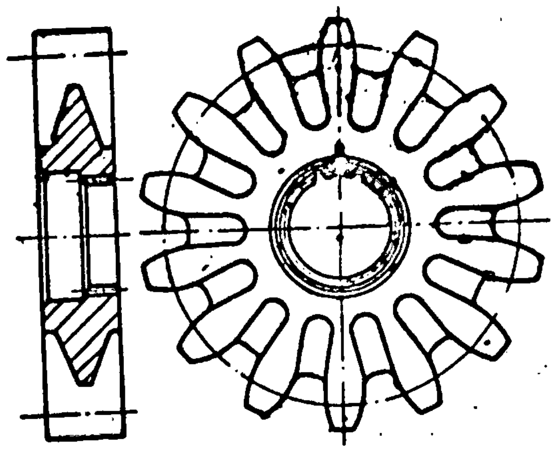


Fig. 103. Gear of pressure stage, main oil pump

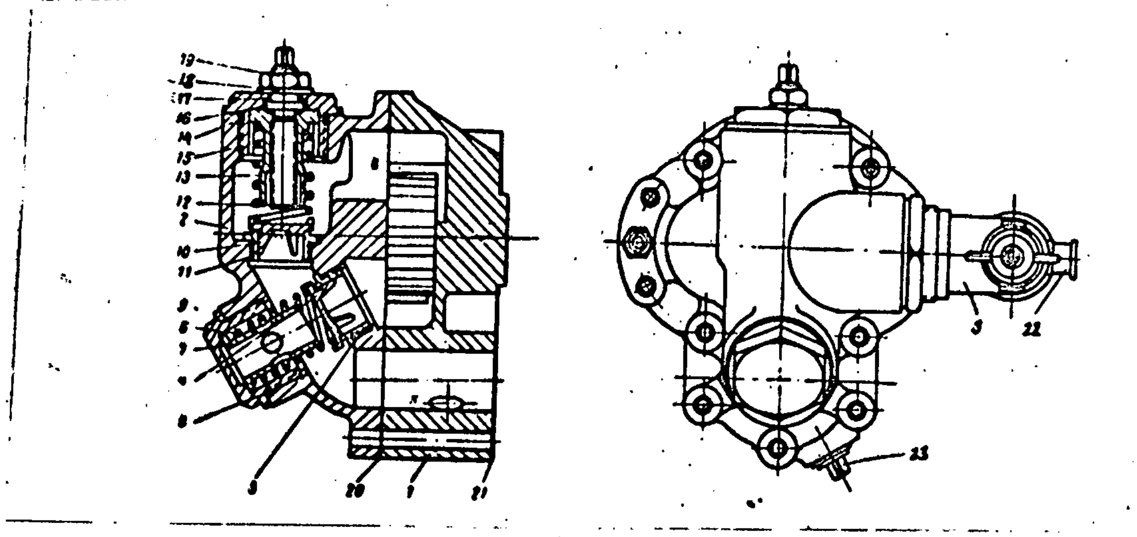


Fig. 104. MNP-20 auxiliary oil pump

1. Housing
2. Cover
3. Intake line fitting
4. Check valve
5. Insert
6. Spring
7. Spring
8. Packing ring
9. Protective cover
10. Reduction valve
11. Insert
12. Spring
13. Spring
14. Packing ring
15. Protective cover
16. Adjusting screw
17. Seal ring
18. Washer
19. Lock nut
20. Packing
21. Packing
22. Drain cock
23. Plug

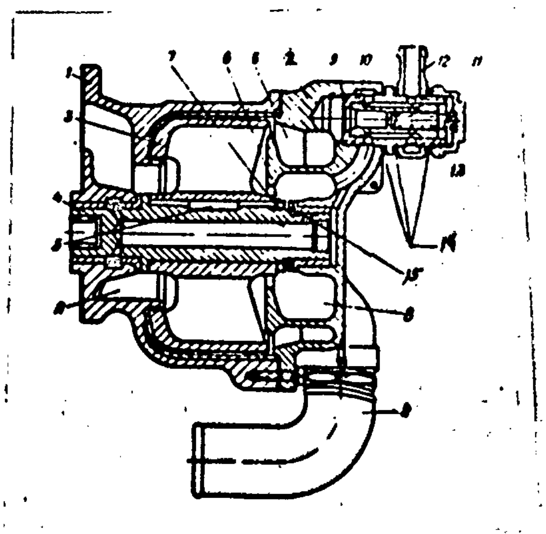


Fig. 105. VO-20 Air separator

1. Body
2. Cover
3. Rotor
4. Rotor shaft
5. Key
6. Nut
7. Lock pin
8. Oil drain line coupling
9. Relief valve body
10. Gate valves
11. Spring
12. Turnable extension
13. Cover
14. Packing
15. Thrust ring

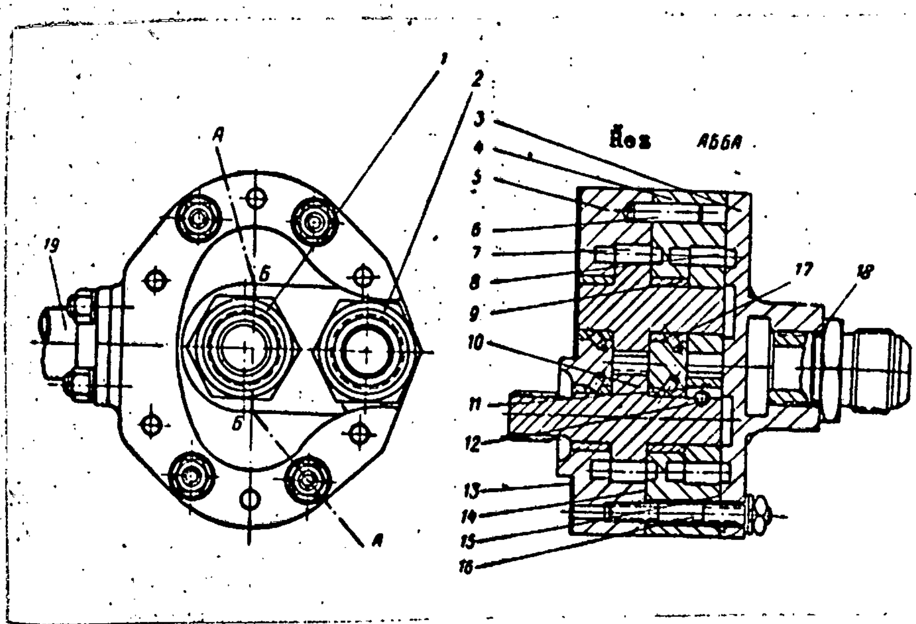


Fig. 106. MNO-20 oil scavenge pump
Cross section ABBA

1. Line fitting
2. Line fitting
3. Cover
4. Upper body
5. Lower body
6. Pin
7, 10. Second stage gear
8, 11. First stage gear
9. Sleeve
12. Balls
13. Packing
14. Packing
15. Packing
16. Bolt
17. Stop
18. Seal ring
19. Oil drain line tube

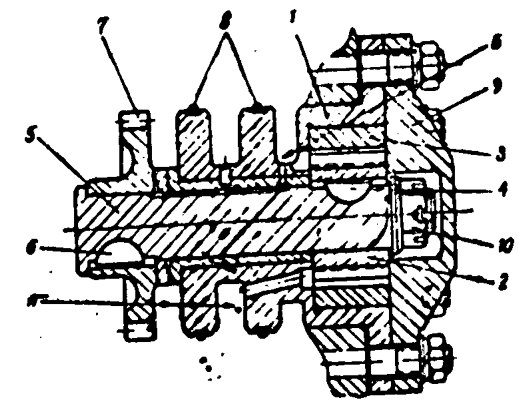


Fig. 107. Scavenge pump, d50X1 box

1. Body
2. Drive gear
3. Driven gear
4, 6. Keys
5. Drive shaft
7. Drive gear
8. Packing ring
9. Cover
10. Nut

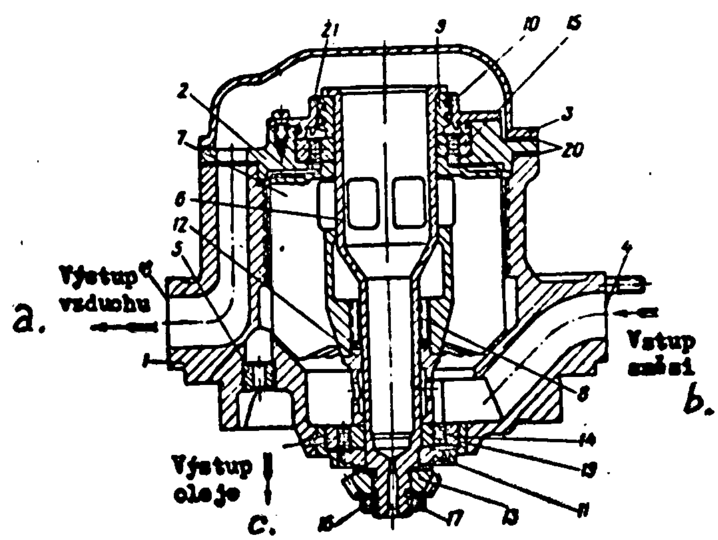


Fig. 108. Centrifugal de-aerator

a. Air exhaust
b. Mixture intake
c. Oil outlet

1. Body
2, 3. Covers
4, 18, 20. Packing
5. Nozzle
6. Rotor shaft
7. Rotor
8. Involute grooves
9. Upper insert
10. Oil seal rings
11. Baffle seal insert
12. Spacer sleeve
13. Bevel drive gear
14, 15. Ball bearing
16. Nut
17. Lock pin
18. Extension
21. Sleeve

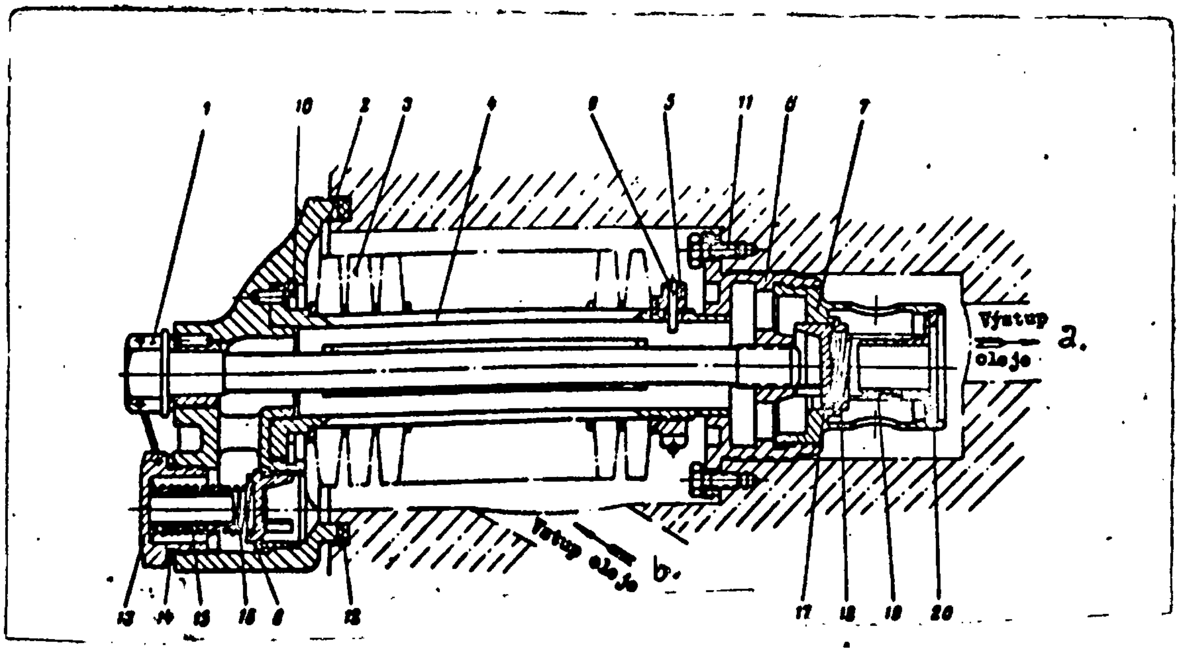


Fig. 109. The MF-20 oil filter

a. Oil output
b. Oil intake
1. Bolt
2. Cover
3. Filter insert
4. Guide
5. Nut
6. Sleeve
7. Valve body
8. Relief valve
9. Lock pin
10. Thrust ring
11. Screw
12, 14. Seal rings
13. Nut [plug]
15, 16, 18, 19. Springs
17. Valve
20. Seal ring

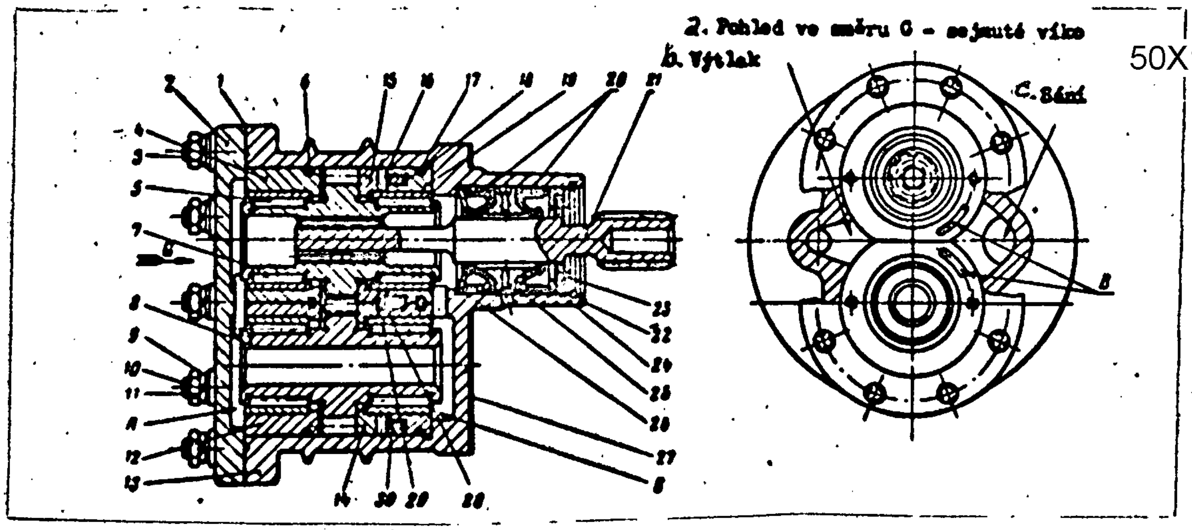


Fig. 110. MIKM oil pump

a. View in the direction of G -- cover removed
b. Delivery
c. Intake
1. Gasket
2. Covers
3. Stud bolt
4, 12. Front bearing inserts
5. Needle
6, 17. Seal rings
7. Drive gear
8. Driven gear
9. Washer
10. Lock washer
11. Nut
13. Body
14, 15. Thrust bearing
16. Rollers
18. Spring
19, 30. Rear bearing inserts
20. Cuff seals
21. Drive shaft
22. Adjustable collar
23. Thrust washer
24. Thrust disk
25. Drain port
26. Washer
27, 28. Seals
29. Insert

50X1

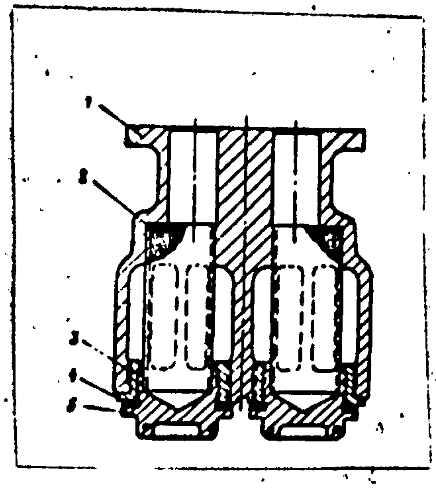


Fig. 111. Oil filter

1. Body
2. Filter screen
3. Liner
4. Seal
5. Nut [plug]

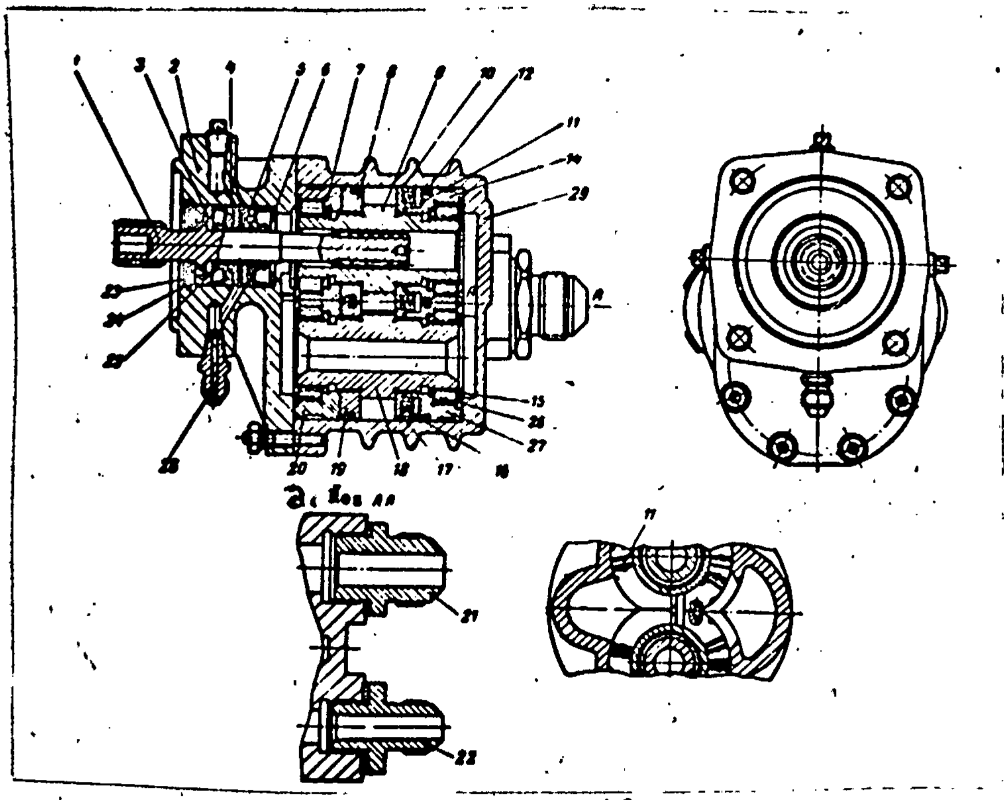


Fig. 112. 348-I fuel pump

a. Cross section AA
1. Drive shaft
2. Flange
3, 23. Retainer washers
4. Packing seal
5. Drainage [ring?]
6. Thrust ring
7, 20. Front bearing inserts
8, 19. Fixed pressure guides
9. Drive gear
10, 17. Movable pressure guides
11. Distributor rollers
12. Rubber sealing rings
14, 27. Rear bearing inserts
15. Separator [bearing cage?]
16. Spring
18. Driven gear
21. Fuel inlet fitting
24. Adjustable ring
25. Flexible ring
26. Bearing rollers
28. Drain fitting
29. Housing

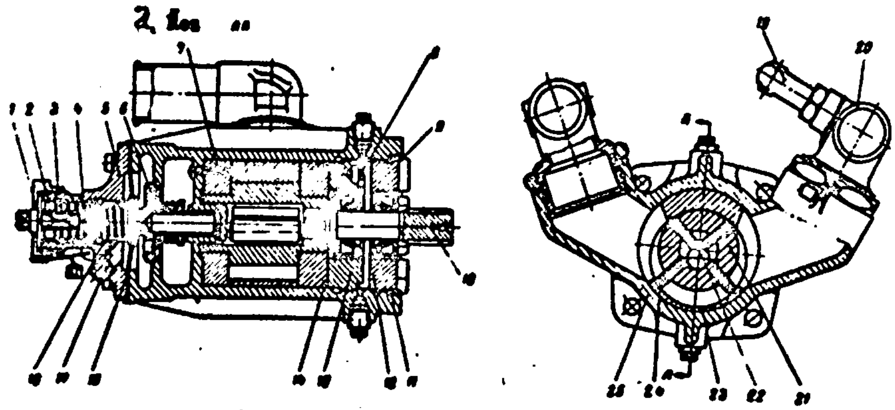


Fig. 113. 707-I fuel pump

a. Cross section AA
1. Protective cover
2. Adjusting screw head
3. Adjusting screw
4. Spring
5. Cover
6. Reduction valve
7. Pumping chamber
8, 9. Ring
10. Shaft
11. Rubber ring
12. Nut
13. Nut-cuff [seal]
14. Rubber ring
16. Diaphragm
18. Spring
17. Air passage
19. Fitting for fuel supply to starting nozzles
20. Fuel outlet to 348-I pump
21. Rotor
22. Pin
23. Casing
24. Vanes
25. Housing

50X1

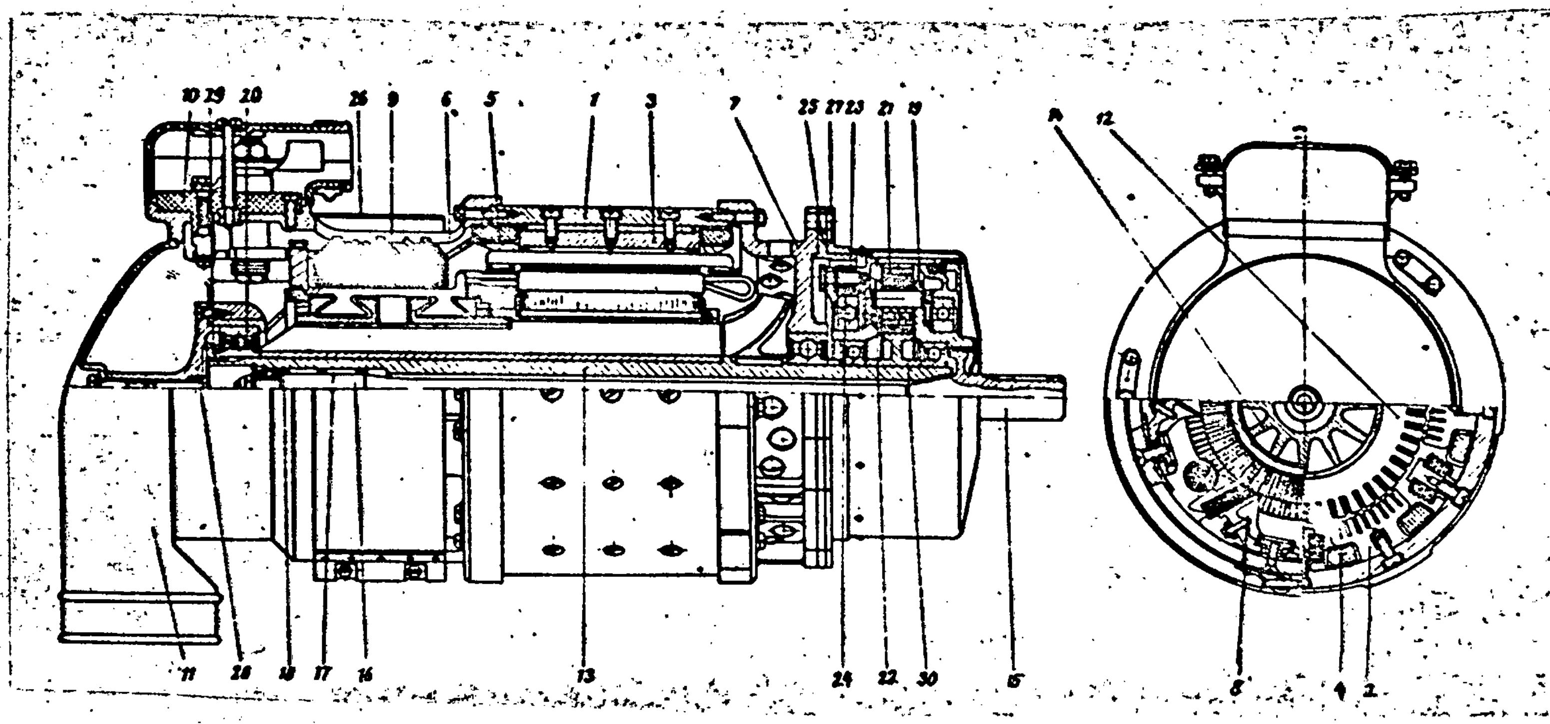


Fig. 114. STG-12TM Starter-generator

1. Housing
2. Main poles
3. Commutator poles
4. excitor winding
5. Winding of commutator poles
6. Cover
7. Front cover plate
8. Brush holder
9. Brush
10. Terminal board
11. Cover with adapter for ventilation
12. Armature
13. Shaft
14. Hollow aluminum mandrill
15. Tortion shaft
16. Freewheeling cylinder device
17. Steel cylinder
18. Cage
19. Planetary gear carrier
20. Ball bearing
21. Planet gear
22. Interior ring gear
23. Clutch dogs
24. Spring
25. Rachet
26. Covering belt
27. Reduction gear housing
28. Flange
29. Nut
30. Spur drive gear

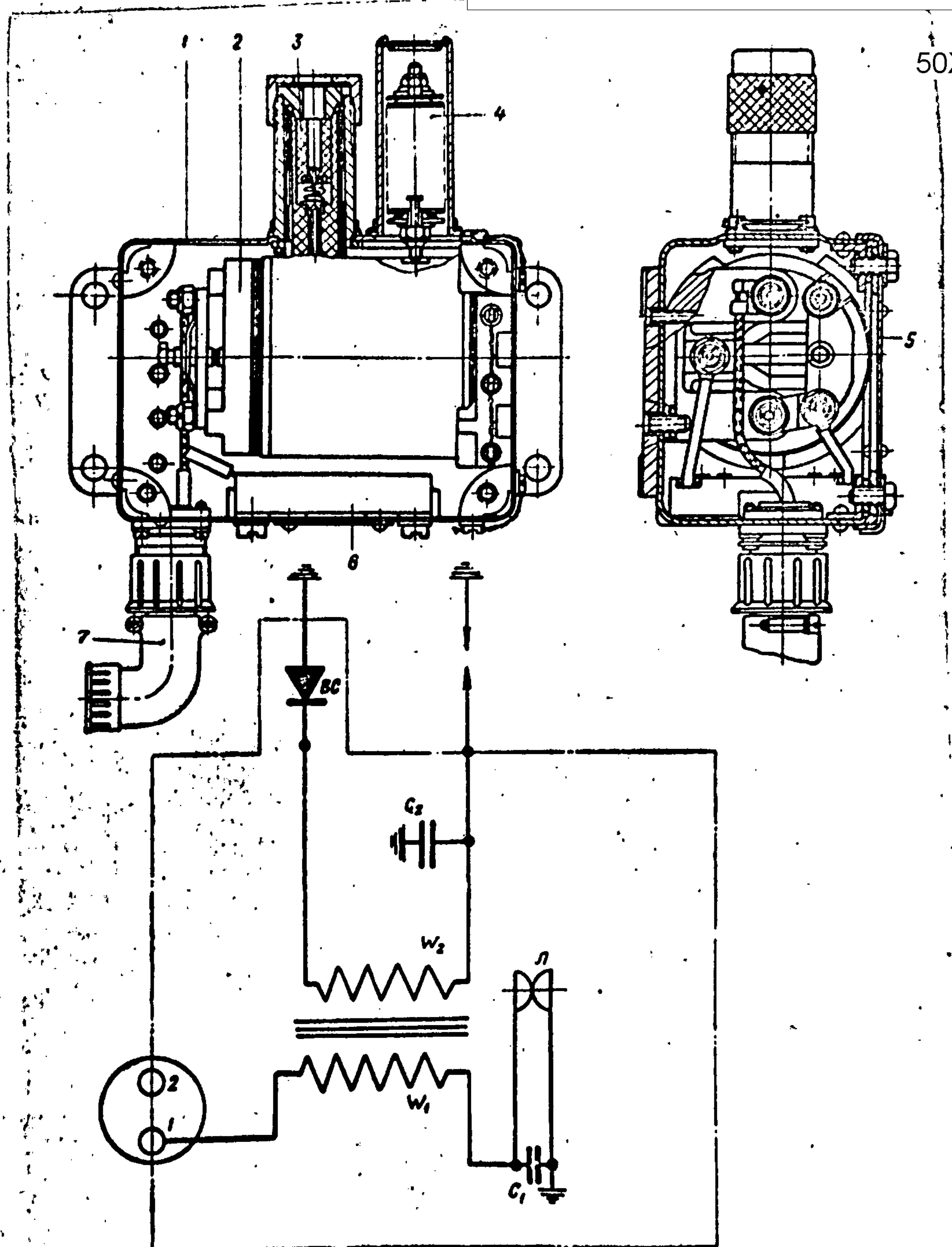


Fig. 115. KPN-4 Coil

1. Housing
2. Coil
3. Contact device
4. Selenium rectifier
5. Cover
6. Capacitor (C)
7. Plug connector

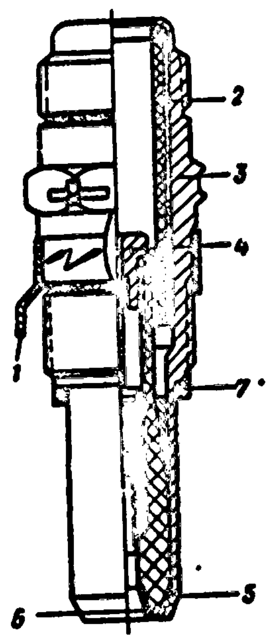


Fig. 116. SPN-4 Spark igniter plug
1. Setting ring
2. Shielding coat
3. Body
4. Insulator
5. External electrode
6. Central electrode
7. Gasket ring

50X1

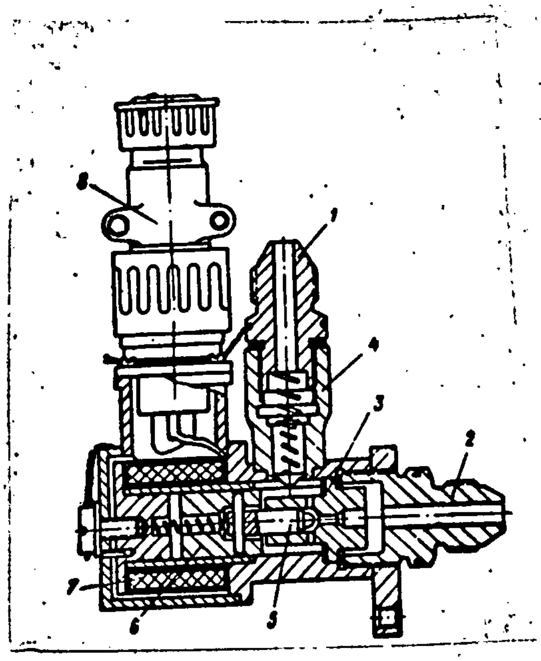


Fig. 117. Electromagnetic start fuel valve

1. Fuel intake fitting
2. Fuel outlet fitting
3. Valve seat
4. Housing
5. Valve needle
6. Core
7. Coil of magnet
8. Plug connector

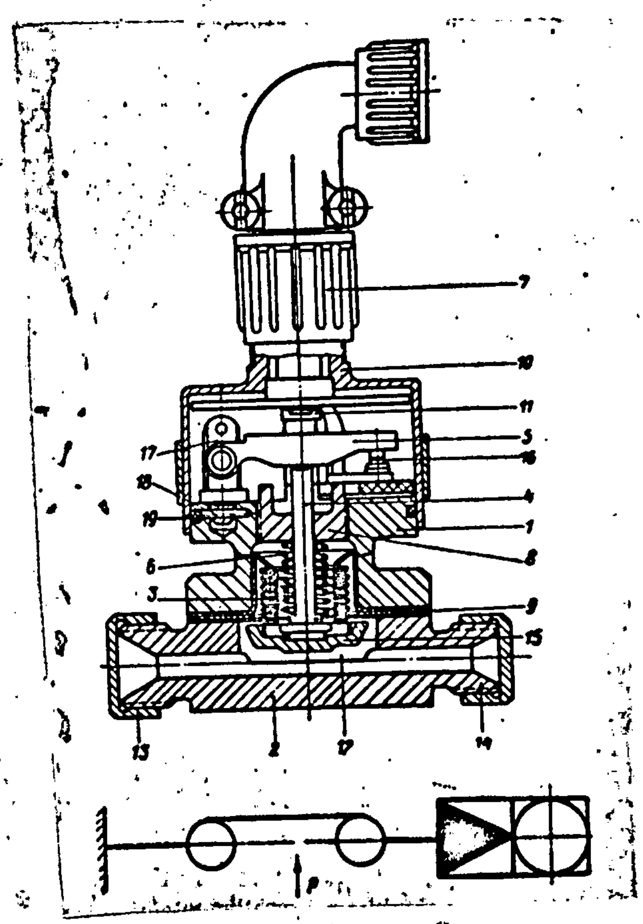


Fig. 118. VE-2S Switch

1. Body
2. Adapter shoulder
3. Metal bellows
4. Push rod
5. Lever
6. Spring
7. Plug connector
8. Set screw
9. Gasket
10. Cover
11. Reinforcing strut
12. Chamber
13. Blind flange
14. Nozzle
15. Bellows plate
16. Contact points
17. Holder
18. Pin
19. Gasket ring

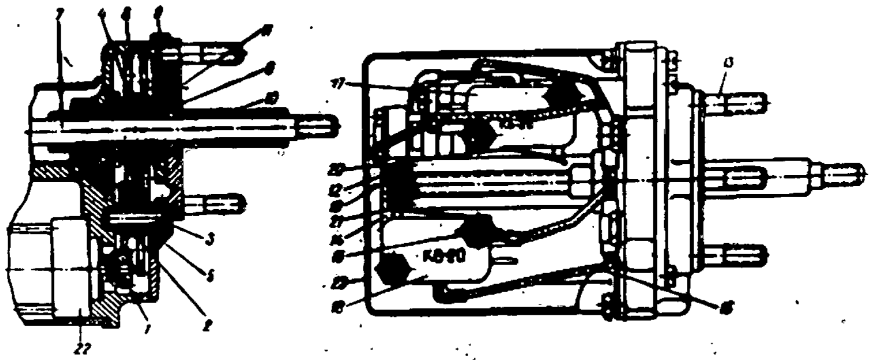


Fig. 119. MP-5 Electromagnetic device

1. Gear wheel of electric motor
2. Double gear wheel
3. Fixed shaft
4, 5. Double gear wheels
6. Nut for gear wheel
7. Actuator rod
8. Housing
9. Cover
10. Actuator rod sleeve
11. Bearings
12. Cam
13. Clamping terminal
14. Body forging
15. Lead
16. Screw
17, 18. Terminal switches
19. Cam
20, 21. Springs
22. Electric motor
23. Case

50X1

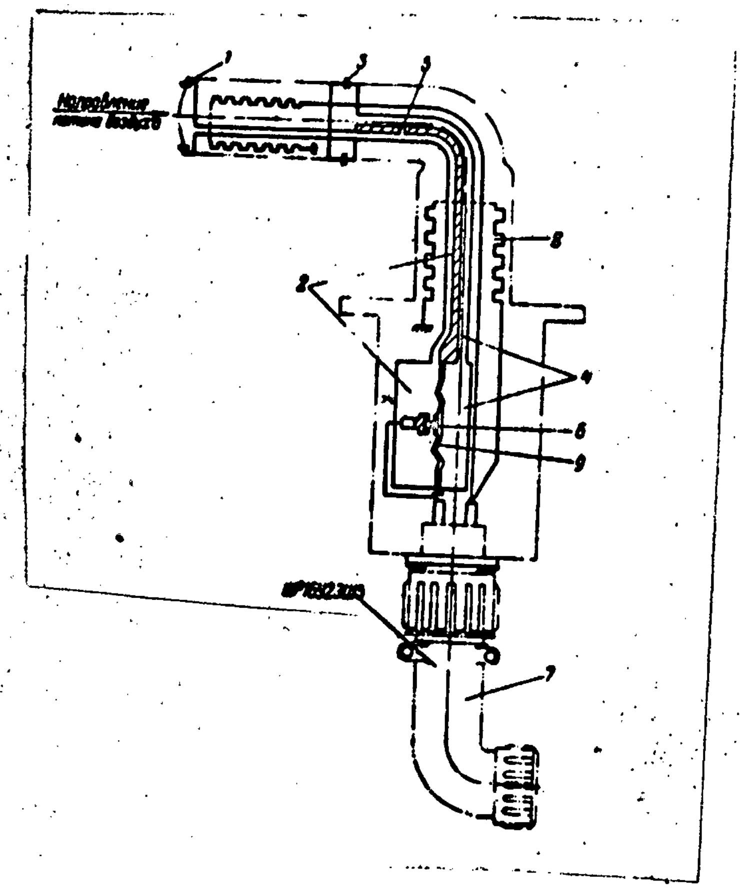
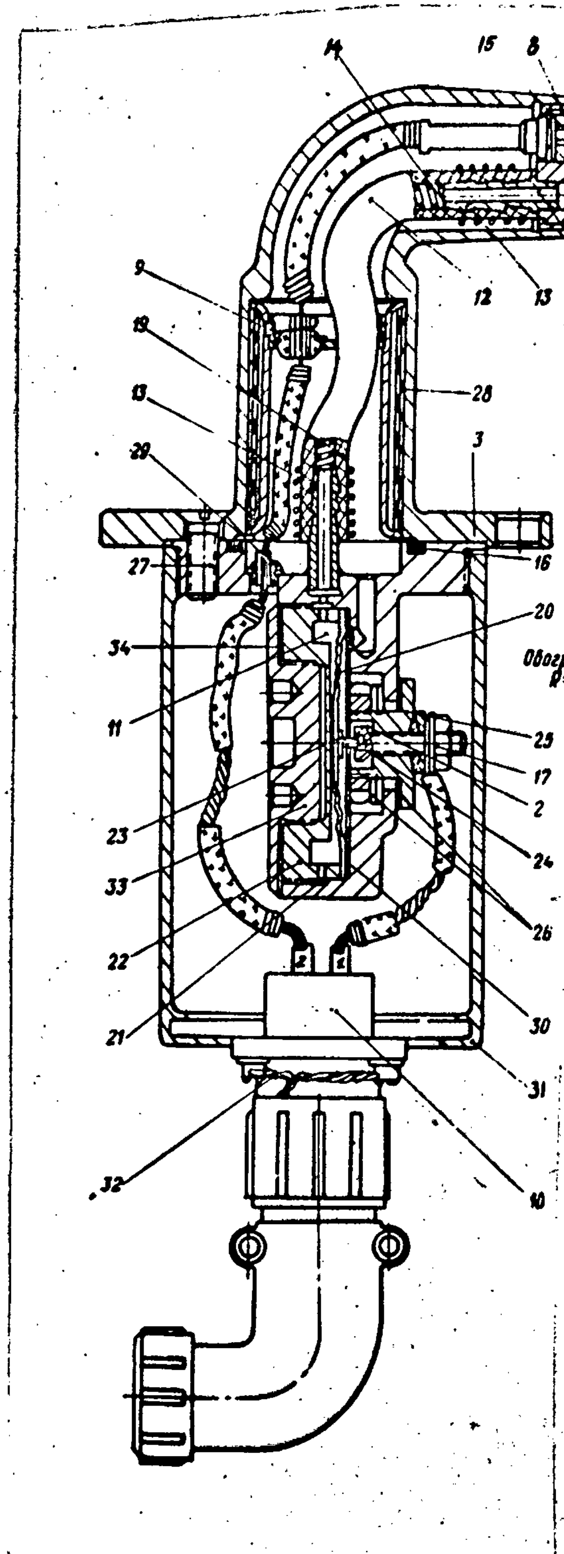


Fig. 120. Sketch of Pneumatic icing indicator SO-4A

1. General pressure openings
2. General pressure chambers
3. Static pressure openings
4. Static pressure chamber
5. Nozzle
6. Circuit breaker
7. Plug connector
8. Warming element
9. diaphragm



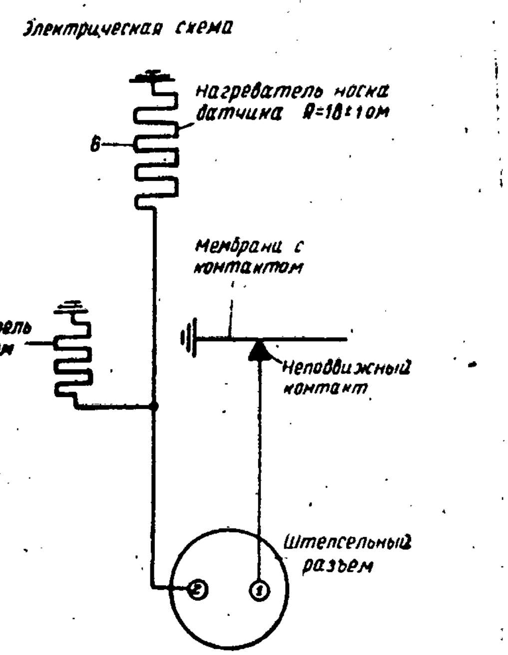


Fig. 121. SO-4A icing indicator

1. Air intake; 2. Differential pressure gauge; 3. Adapter; 4. Intake cover; 5. Tube; 6. Heating element; 7. Intake housing; 8. Tube fitting; 9. Flow-through device; 10. Opening; diameter 2.5 millimeters; 11. Static pressure chamber; 12. Rubber tube; 13. Tube nipple; 14. Spring; 15. Terminal clamp; 16. Gasket; 17. Contact nut; 18. Connector; 19. Wrapping; 20. Diaphragm; 21. Base of differential pressure gauge; 22. Nut; 23. Movable contact point; 24. Contact point; 25. Set screw; 26. Gasket; 27. Bolt; 28. Heating element; 29. Insulator; 30. Rubber gasket; 31. Outer case; 32. Safety wire; 33. Nut; 34. Rubber gasket

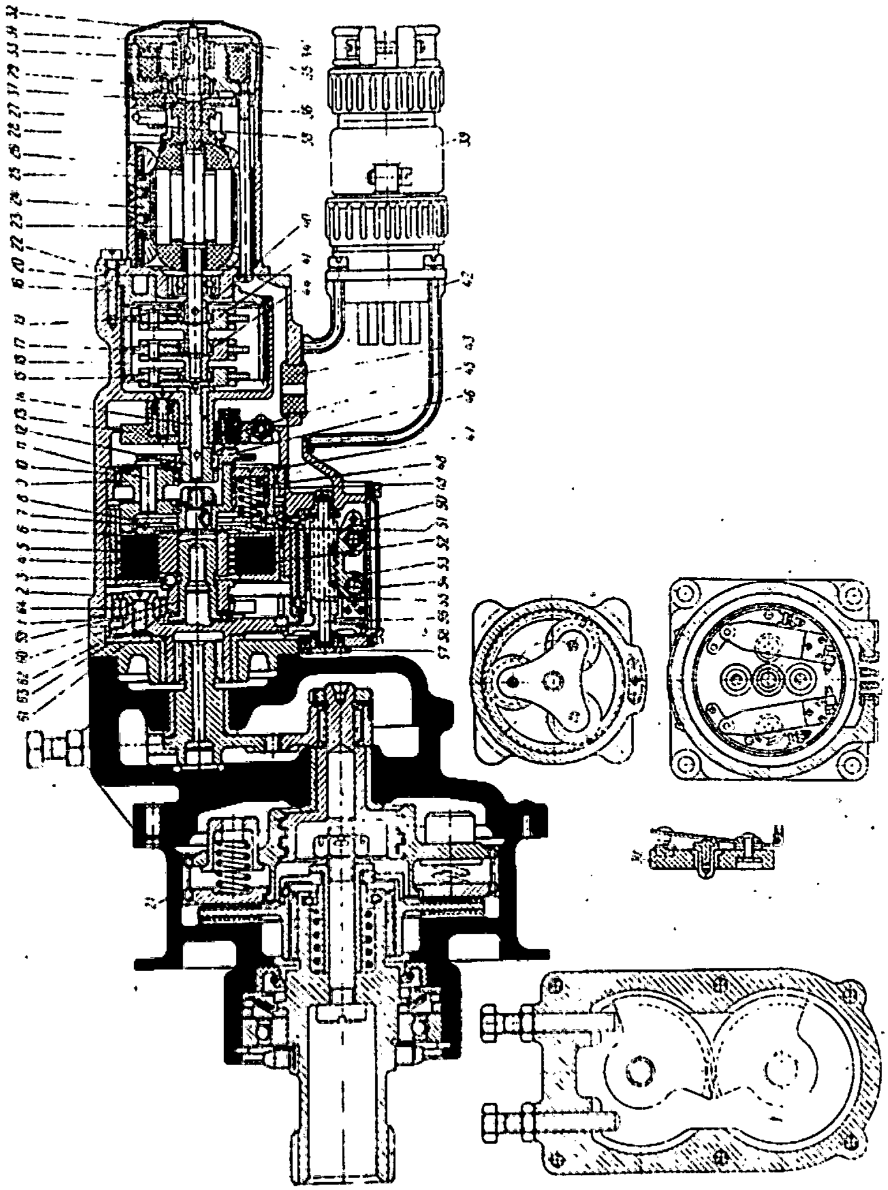


Fig. 122. MZK-2 electromechanism

Fig. 122. MZK-2 Electromechanism

1. Fixed gear
2. Housing
3. Balls
4, 5. Friction discs
6. Case
7. Ball
8. Ring
9. Planet gear, Stage IV
10. Inner ring gear
11. Shaft
12. Drive gear
13. Dog of switch
14. Lead
15. Gear wheel, stage III
16. Bolt
17. Gear wheel, stage II
18. Gear
19. Planet gear, stage I
20. Cover
21. Propeller brake
22. Plate
23. Armature
24. Terminal
25. Electric motor
26. Coil
27. Brush
28. Commutator
29. Electromagnetic clutch
30. Terminal switch
31. Brake disc
32. Nut
33. Spring
34. Ring
35. Washer
36. Cover
37. Carrier ring
38. Brush holder
39. Plug connector
40. Drive gear, stage I
41. Drive gear, stage II
42. Knee joint
43. Rubber case
44. Drive gear, stage III
45. Lifter
46. Cam
47. Blind flange
48. Spring
49. Sleeve
50. Contact spring
51. Disc
52. Friction clutch
53. Special nut
54. Cover
55. Lead screw
56. Shaft
57. Cover
58. Gear wheel
59. Small shaft
60. Output shaft
61. Drive gear, Stage V
62. Cover
63. Guide
64. Gear, stage V

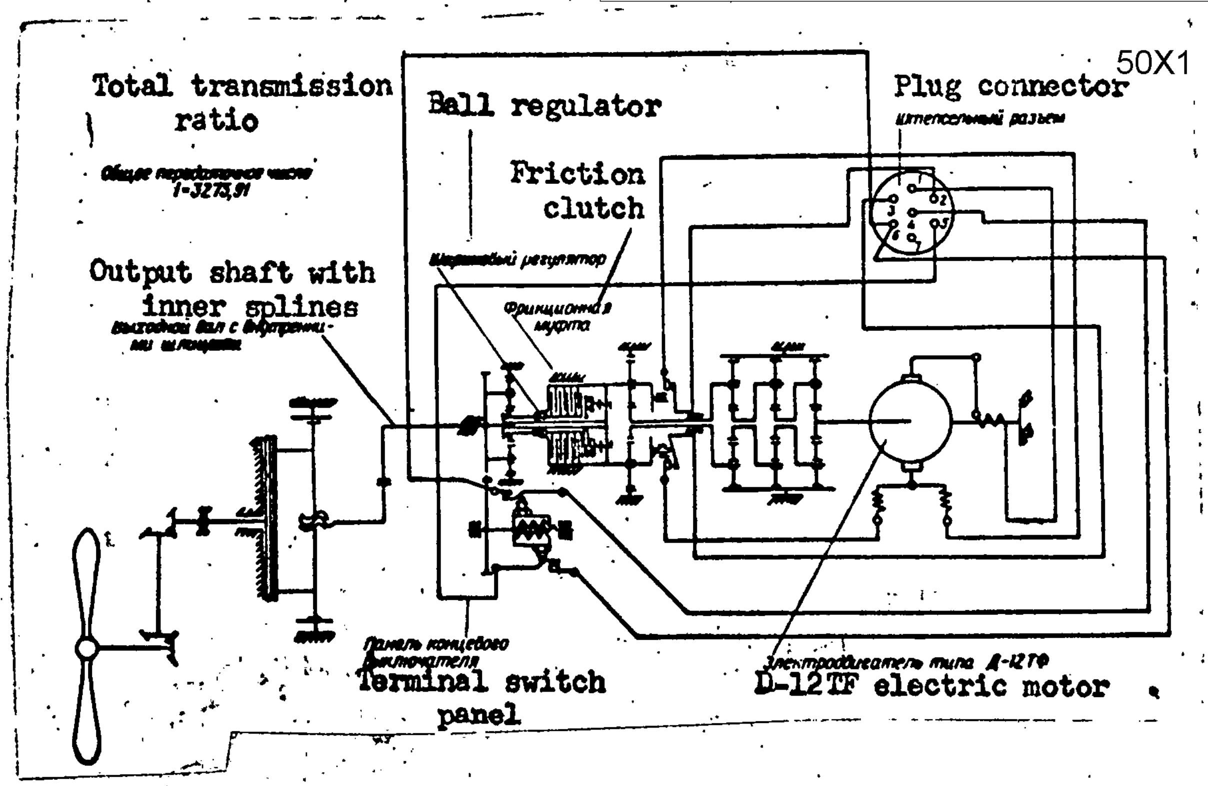


Fig. 123. Basic diagram of the MZK-2 Electromechanism

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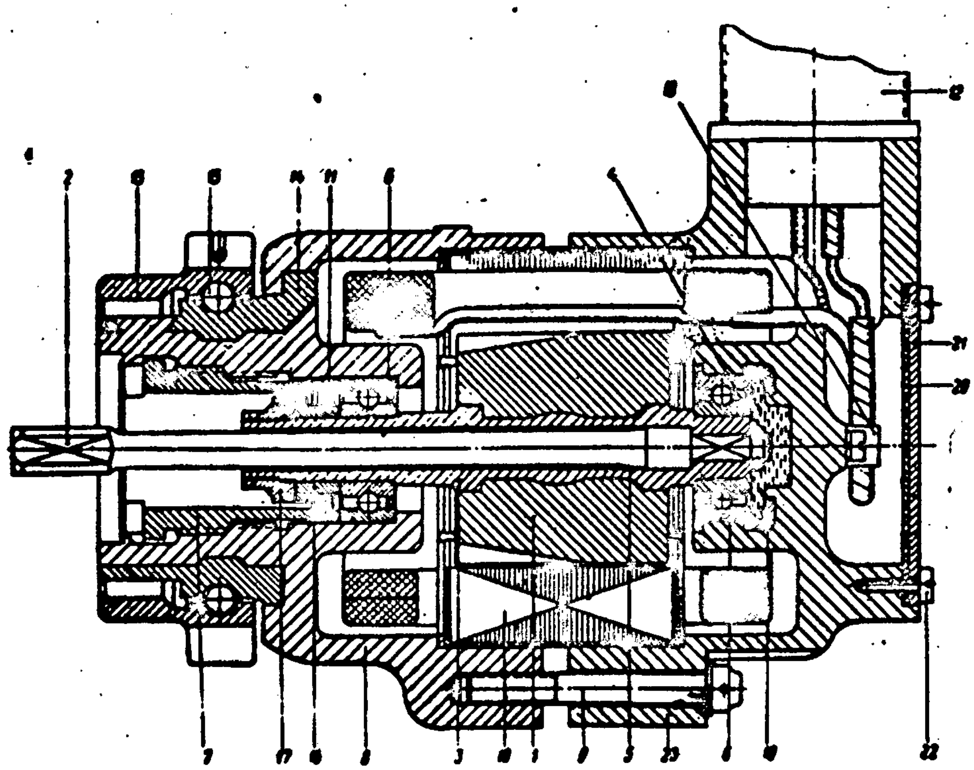

Fig. 124. DTE-2 sensor

1. Rotor
2. Drive
3. Bushing
4. Ring
5. Sleeve
6. Ball bearing
7. Nut
8. Forward cover
9. Bolt
10. Stator
11. Sleeve
12. Plug
13. Lock nut
14. Case
15. Ball
16. Case
17. Nut
18. Reinforcing strut
19. Seat
20. Gasket
21. Cover
22. Bolt
23. Cover

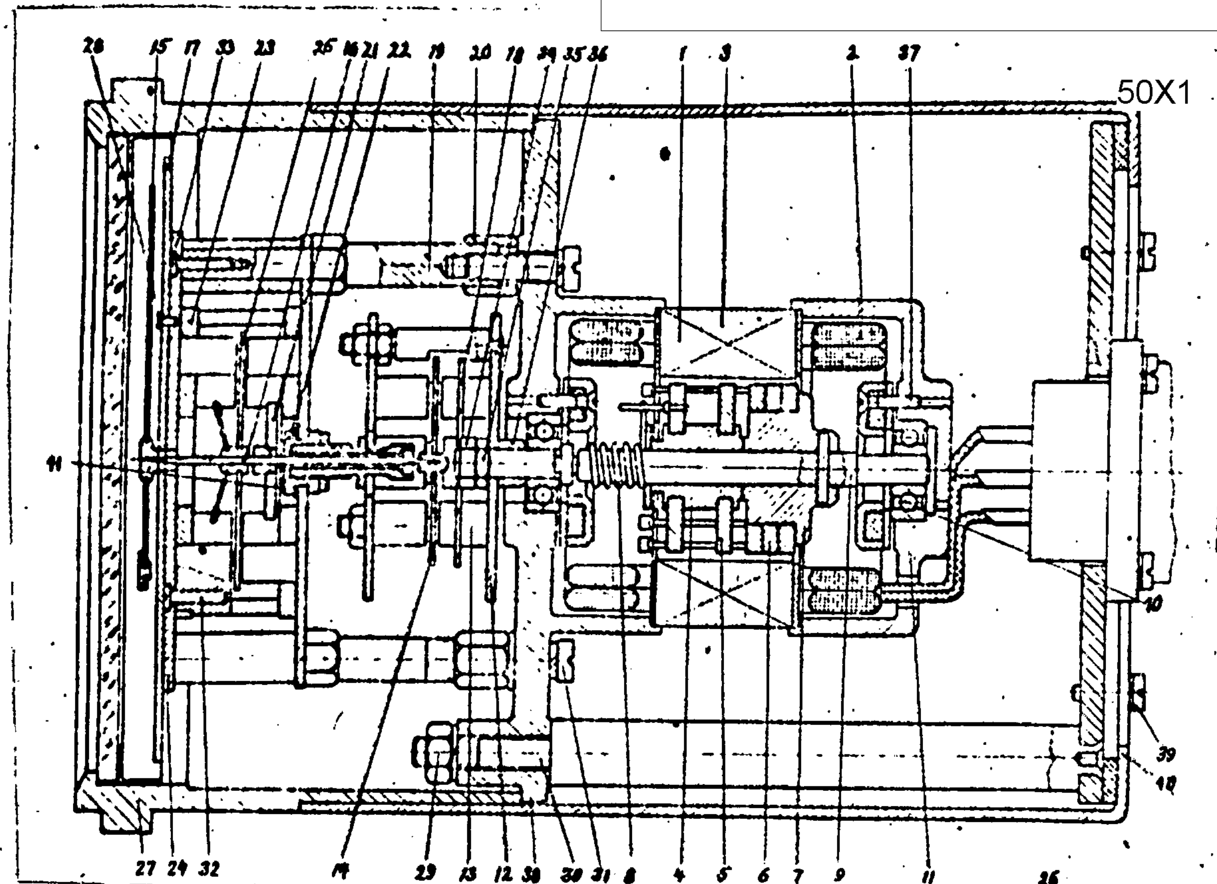

Fig. 125. ITE-2 Tachometer

1. Stator
2. Rotor winding
3. Stator
4. Rotor
5. Magnet
6. Magnetic system [called "starter element" in text]
7. Bushing
8. Spring
9. Shaft
10. Ball bearing
11. Cover
12. Magnetic system
13. Magnet
14. Disc
15. Needle indicator
16. Axis
17. Scale
18. Sensing element
19. Support
20. Nut
21. Hair [spring?]
22. Regulating lever
23. Magnetic system of suppressor
24. Bridge
25. Disc
26. Gasket
27. Case
28. Bolt
29. Nut
30. Support
31. Bolt
32, 33. Bolts
34. Lock nut
35. Nut
36. Case
37. Bolt
38. Cover
39. Bolt
40. Outer case
41. Packing

50X1

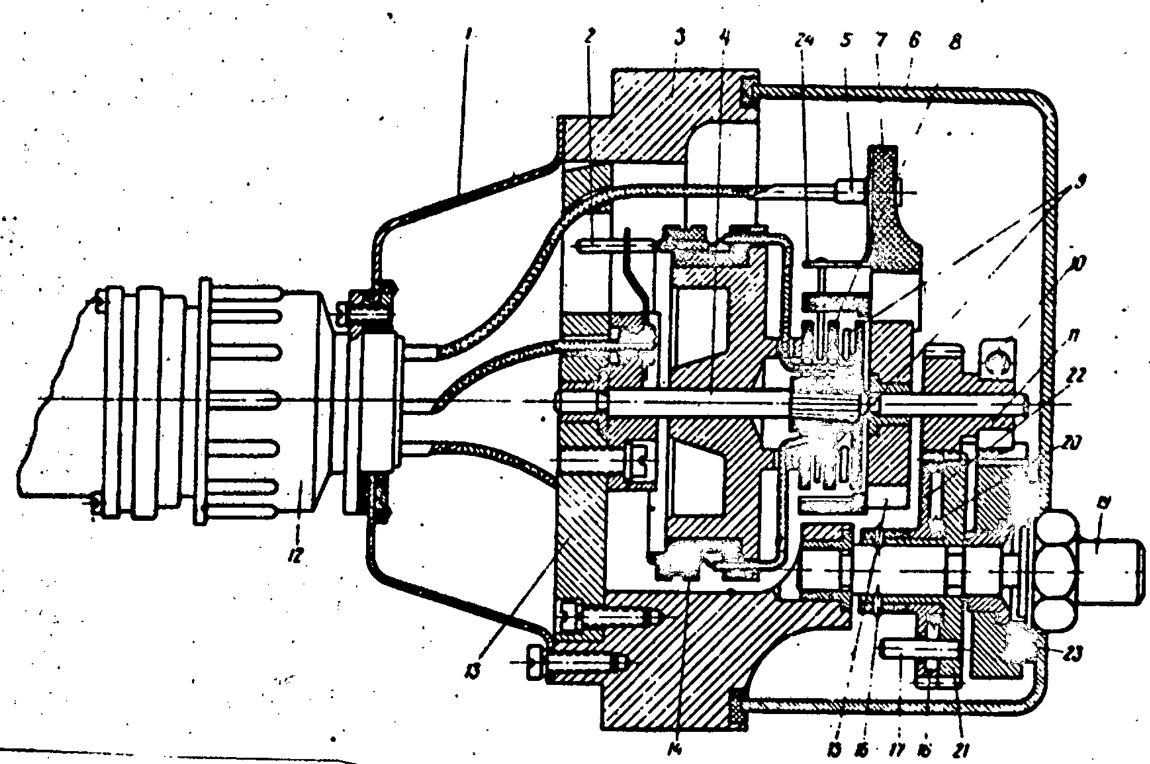

Fig. 126. UPRT-2 Transmitter

1. Cap
2. Sweeps
3. Case
4. Shaft
5. Small posts
6. Outer covers
7. Bed
8. Insulated washer
9. Spiral spring
10. Socket
11. Gear
12. Plug
13. Small disc
14. Potentiometer
15. Stop
16, 17. Pins
18. Divided gear
19. Shaft
20. Spring
21, 22. Gears
23. Bridge
24. Contact disc

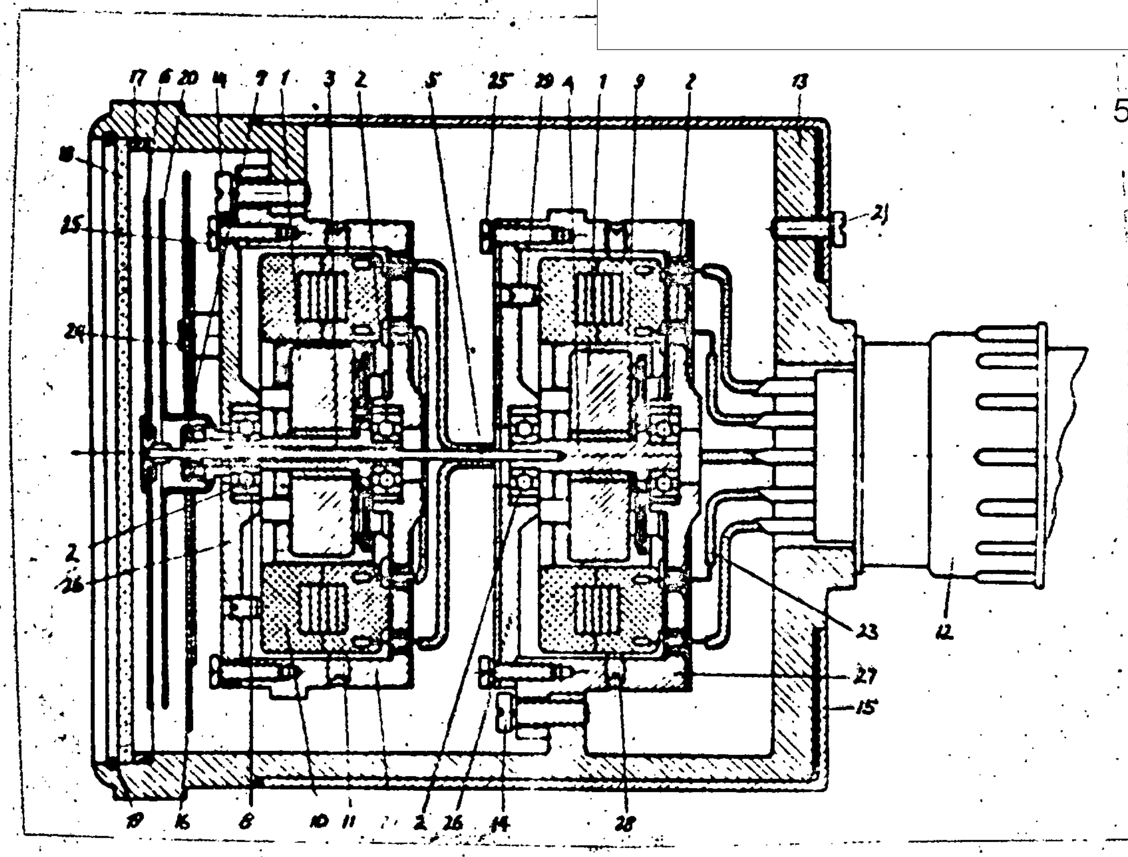

Fig. 127. UPRT-2 indicator

1. Magnet-rotor
2. Ball bearing
3. Hollow shaft
4, 5. Axles
6. Pointer
7. Nut
8. Bearings socket
9. Stator winding
10. Frame
11. "Permalon" discs
12. Plug connector
13. Body
14. Screw
15. Cover
16. Scale
17. Gasketing
18. Glass
19. Ring
20. Pointer
21. Bolt
23. Lead
24, 25. Bolts
26. Cover
27. Housing
28, 29. Bolts

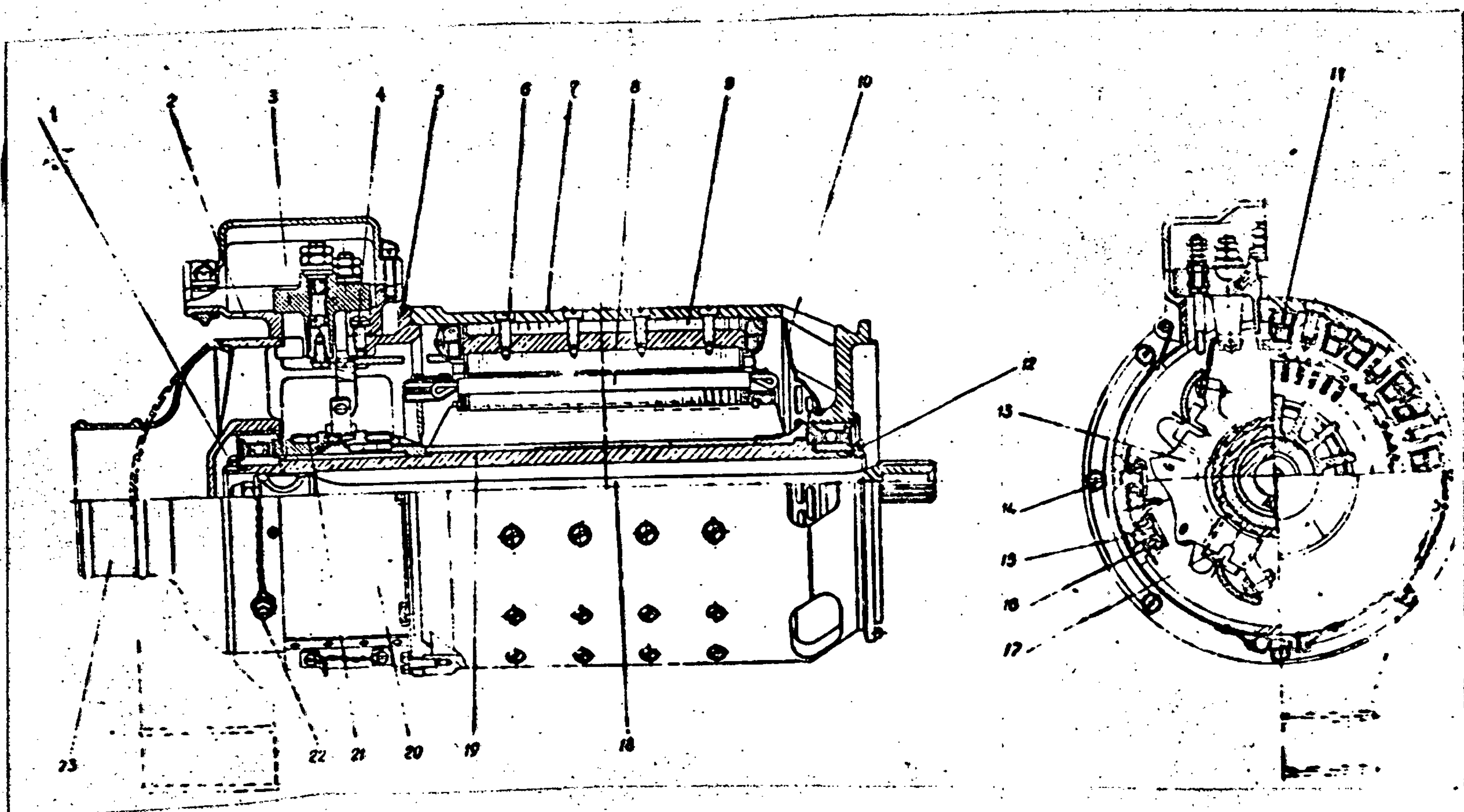

Fig. 128. SGO generator

1. Nut
2. Terminal box housing
3. Terminal panel
4. Screw
5. Front (face)
6. Screw
7. Body of generator
8. Rotor winding
9. Terminal bar
10. Cover [perforated]
11. Exciter coil
12. Nut
13. Brush holder
14. Screw
15. Screw
16. Bushing
17. Brush
18. Flexible shaft
19. Hollow shaft
20. Protective strap cover
21. Collector ring
22. Screw
23. Air intake pipe

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50X1

Fig. 129. APD-75 Automatic starting device (without cover)

1. Base plate
4. TKE52PK relay
5. TKE21PK relay
6. TKE56PK relay
7. TKE53PK relay
8. TKE22PKT relay
9. Rectifier equipped with D-7Z germanium diodes
10. PMZ2-75U program mechanism
11. SR32P10NS1 plug connection
12. SR32P8NG3 plug connection
13. SR28P7NG9 plug connection

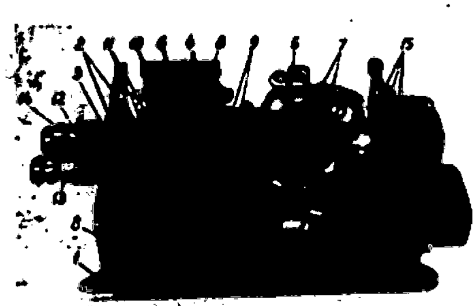

Fig. 130. PSG-2A Starter case

1. Base plate
2. KM-100 contactor
3. TKE52PD relay
4. TKE52PK relay
5. TKS602A contactor
6. TKD511A contactor
7. RUT-600D output regulator
8. PS-150-0, 16D starter resistor
9. PEV-30-30-I resistor
10. RS-25 no. 7 regulating resistor
11. RS-25 no. 8 variable resistor
12. SR28P7NS9 plug connection
13. SR32P12NS1 plug connection
14. PEV-10-51-I resistor
15. Clamp screw

50X1

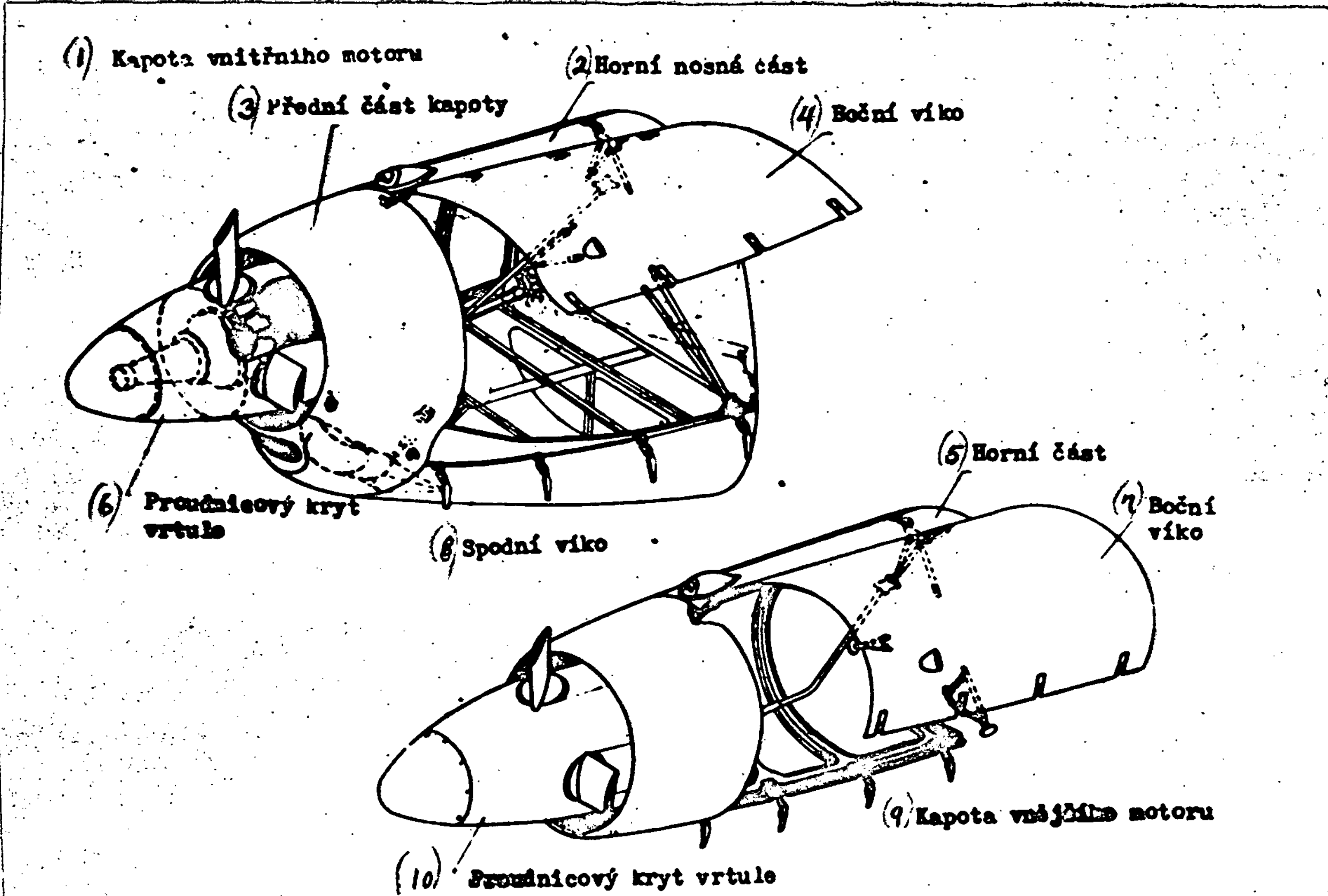

Fig. 131. Engine cowlings

1. Inboard engine cowling
2. Upper support structure
3. Front section of cowling
4. Side panel
5. Upper panel
6. Propeller hub fairing
7. Side panel
8. Lower panel
9. Outboard engine cowling
10. Propeller hub fairing

50X1

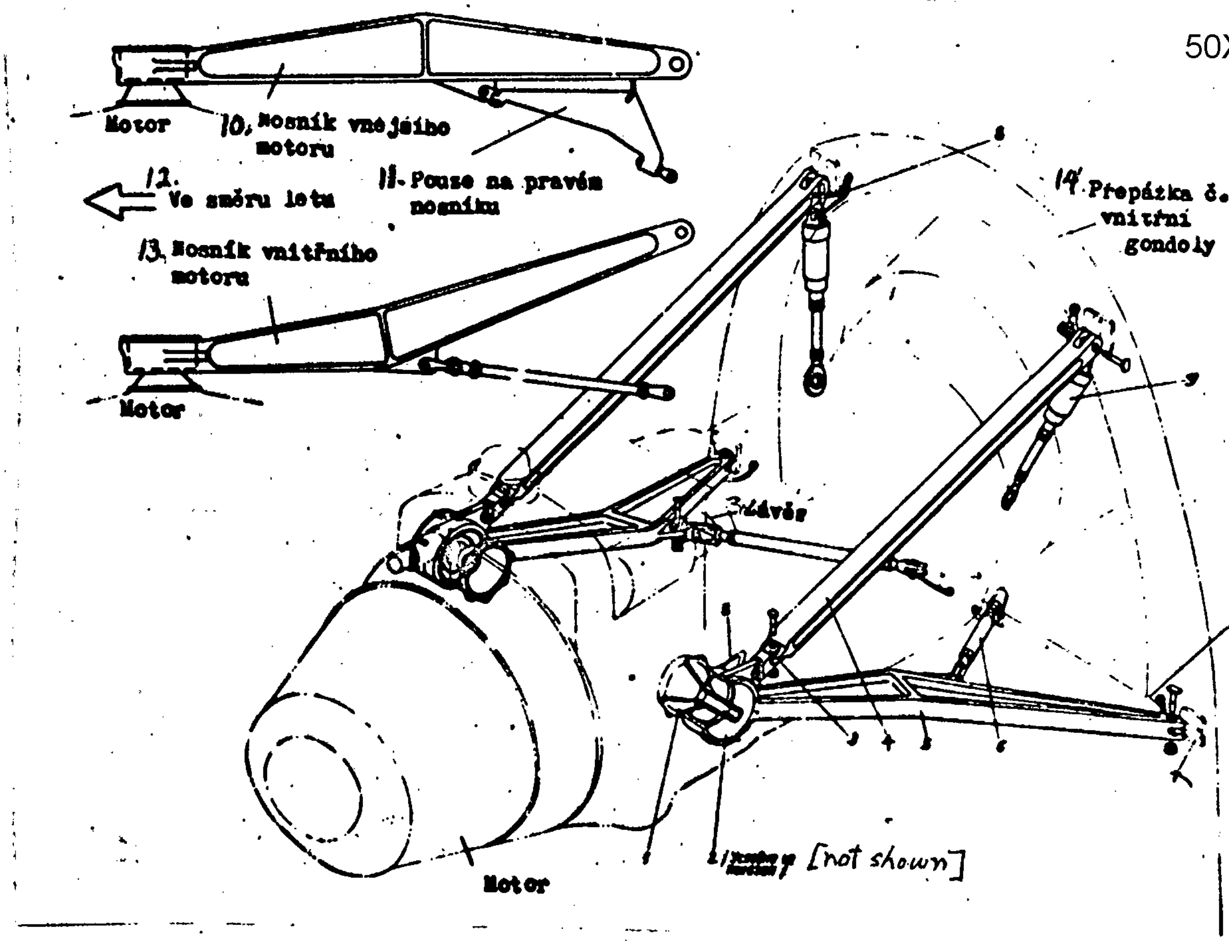

Fig. 132. Engine mounting

1. Front trunnion
2. Shock absorber
3. Mounting suspension bracket
4. Upper strut
5. Bottom girder
6. Strut
7. Mounting bracket
8. Bridge link
9. Rear shock strut
10. Outboard engine girder
11. On right girder only
12. Forward
13. Inboard engine girder
14. Bulkhead no. 1 of inboard nacelle

50X1

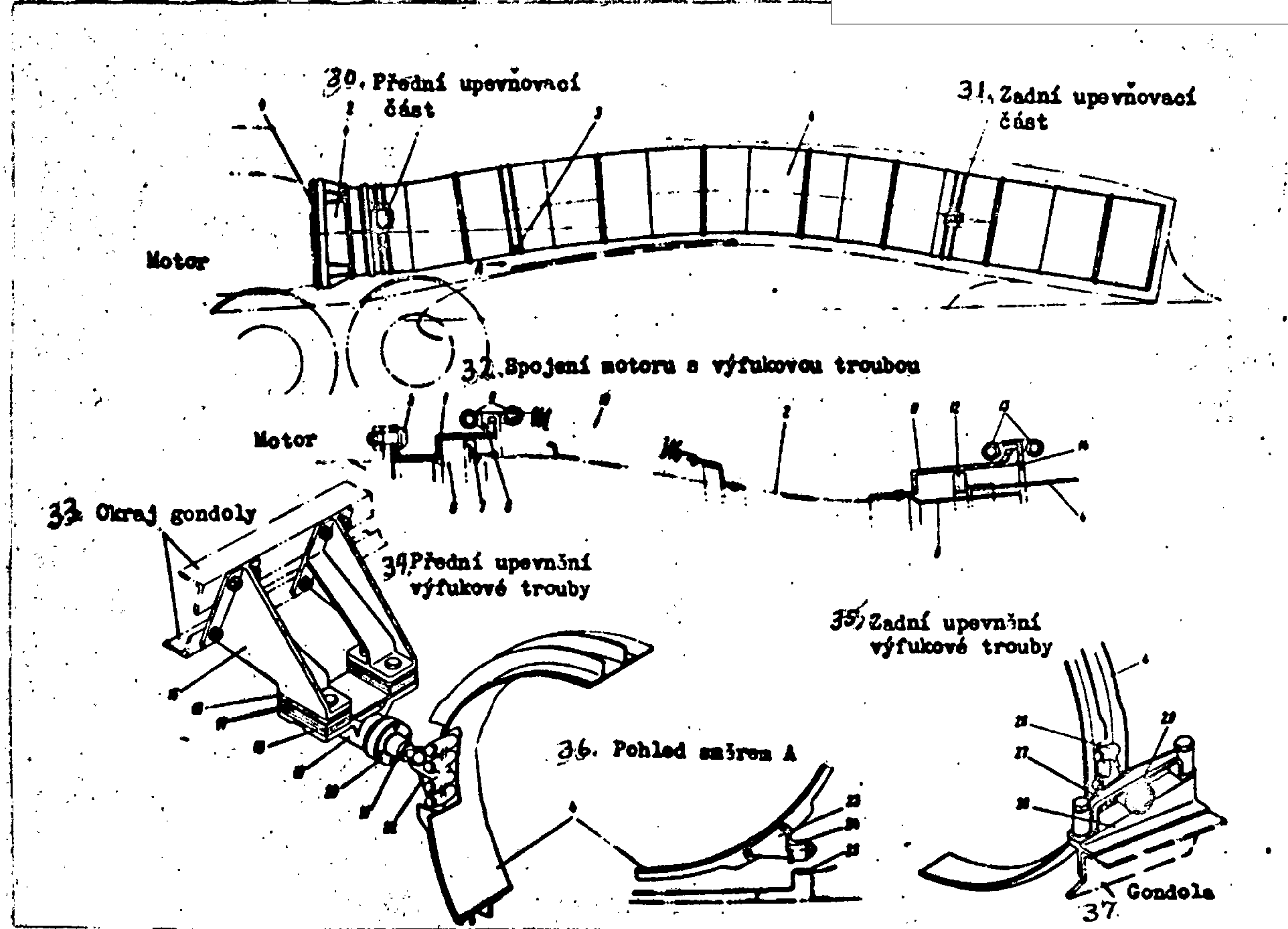

Fig. 133. Exhaust pipe

1. Adaptor flange
2. Cone
3. Support
4. Exhaust pipe
5. Flange attach bolt
6. Baffle
7, 12. Ring
8, 14. Contact collar
9, 13. Bushing below clamping screws
10?. Spring
11. Flange
15. Forged member
16, 17, 18. Shims
19. Forged member
20. Bushing
21. Pin
22. Cushion
24. Support
25. Guide
26. Support
27. Retainer
28. Support guide
29. Roller of rear support
30. Front attach section
31. Rear attach section
32. Connection of engine with exhaust pipe
33. Edge of nacelle
34. Front attach of exhaust pipe
35. Rear attach of exhaust pipe
36. View in direction A
37. Nacelle

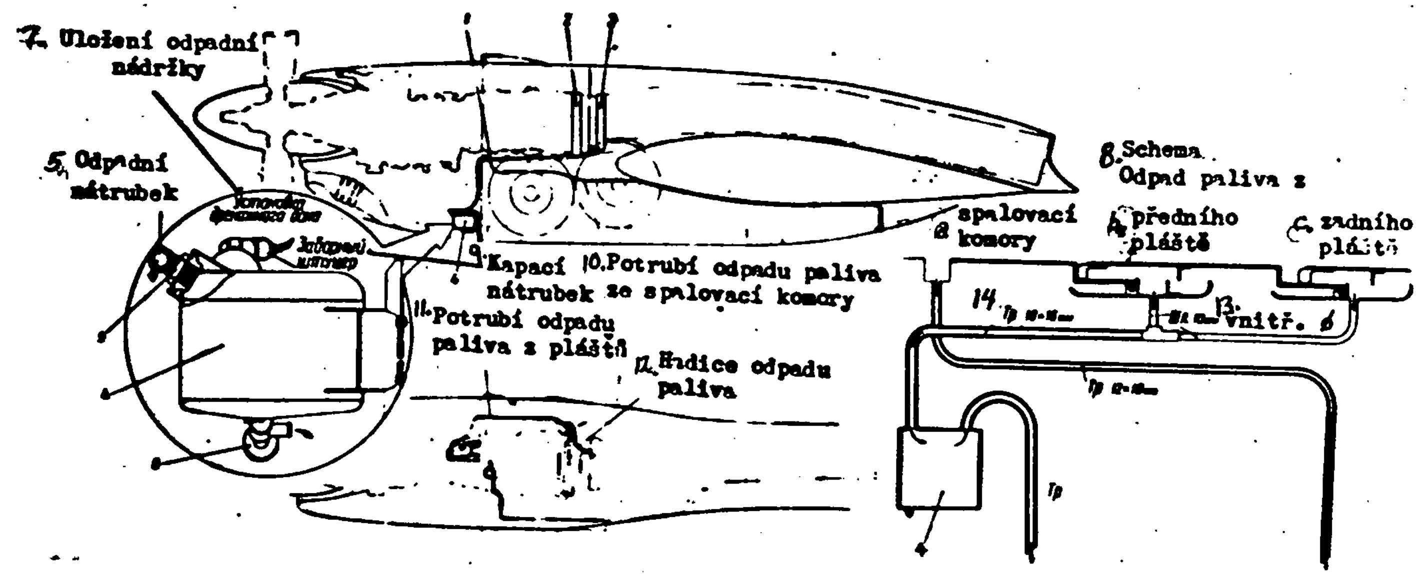

Fig. 134. Drains, Inboard Engines

1. Combustion chamber drain
2. Front fuel collector of exhaust pipe cone
3. Rear fuel collector
4. Fuel collection tank
5. Drain coupling
6. Drain cock
7. Installation of the drain tank
8. Diagram of fuel drainage from:
   a. Combustion chamber
   b. Front jacket [shroud]
   c. Rear jacket
9. Inlet coupling
10. Fuel drain pipe from combustion chamber
11. Line for drainage of fuel from panels
12. Fuel drain hose
13. Hose, 10 mm diameter
14. Tp [tubing]

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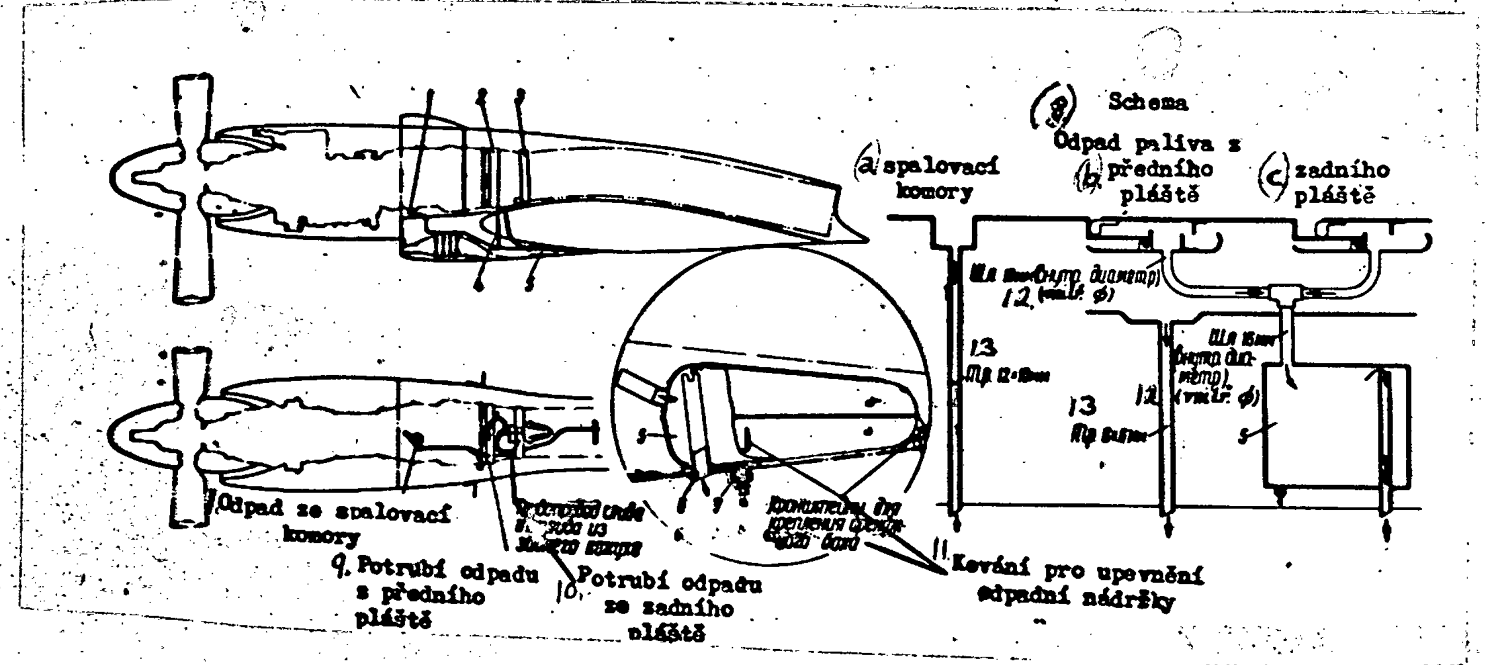

Fig. 135. Drains, Outboard Engines

1. Combustion chamber drain
2. Front fuel collector of exhaust pipe cone
3. Rear fuel collector
4. Drain from storage tank of horizontal shield
5. Fuel collection tank
6. Drain tube
7. Drain cock
8. Diagram of fuel drainage from:
   a. Combustion chamber
   b. Front jacket [shroud]
   c. Rear jacket
9. Line drainage from front jacket
10. Line for drainage from rear jacket
11. Drainage tank mounting bracket
12. Inside diameter of hoses, 10 and 16 mm.
13. Tubing, 12 x 10 mm and 8 x 6 mm

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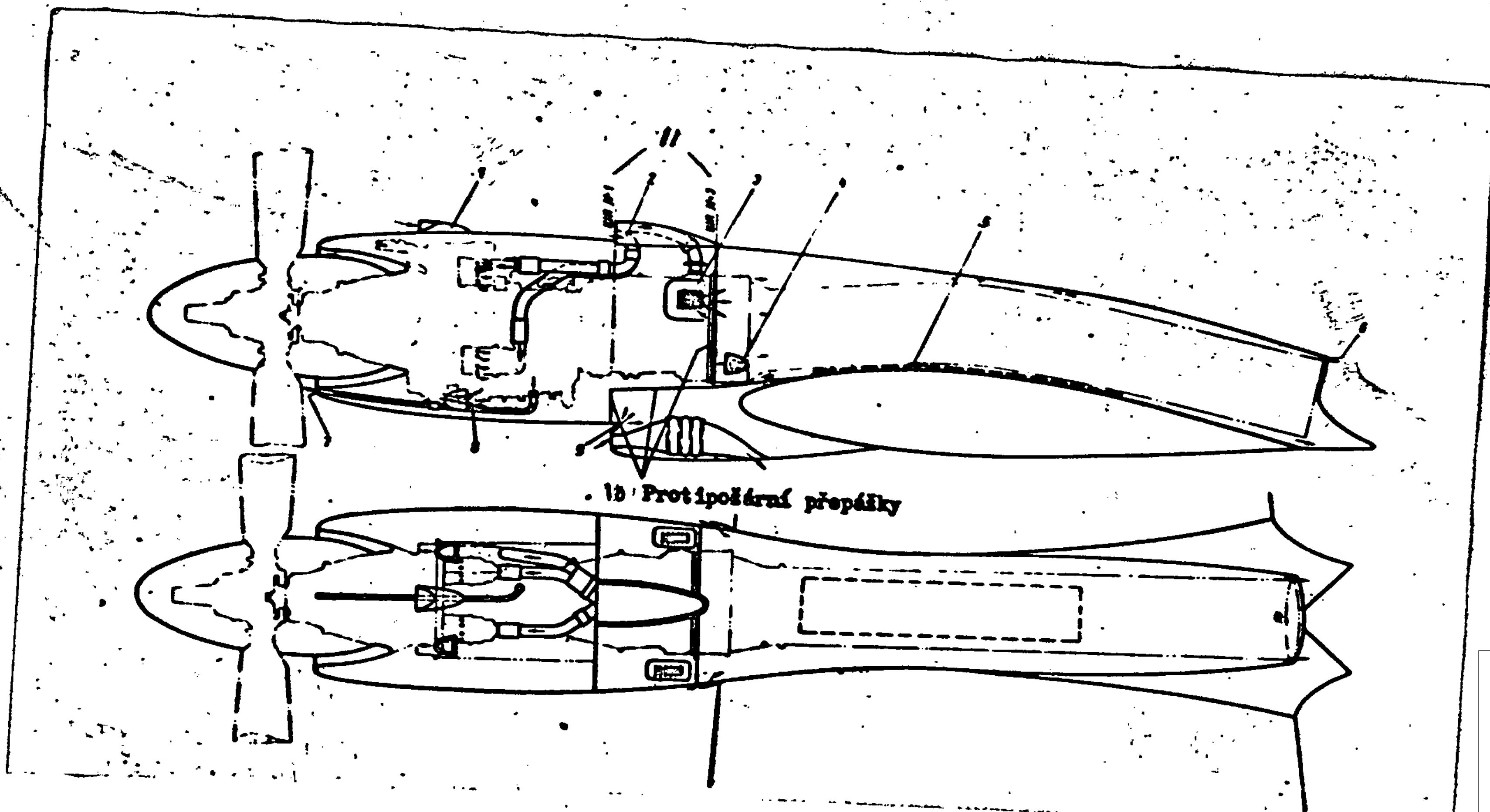

Fig. 136. Cooling system, outboard nacelle

1. De-aerator, air scoop
2. Air scoop for cooling generators and body of turbine
3. Louvres
4. Air scoop for exhaust pipe
5. Shield
6. Discharge of air from exhaust area
7. Air intake for KTA "termopatron"
8. Air scoop for engine bay
9. Air scoop for oil cooler
10. Firewalls
11. Bulkheads, Nos 1 and 3

50X1

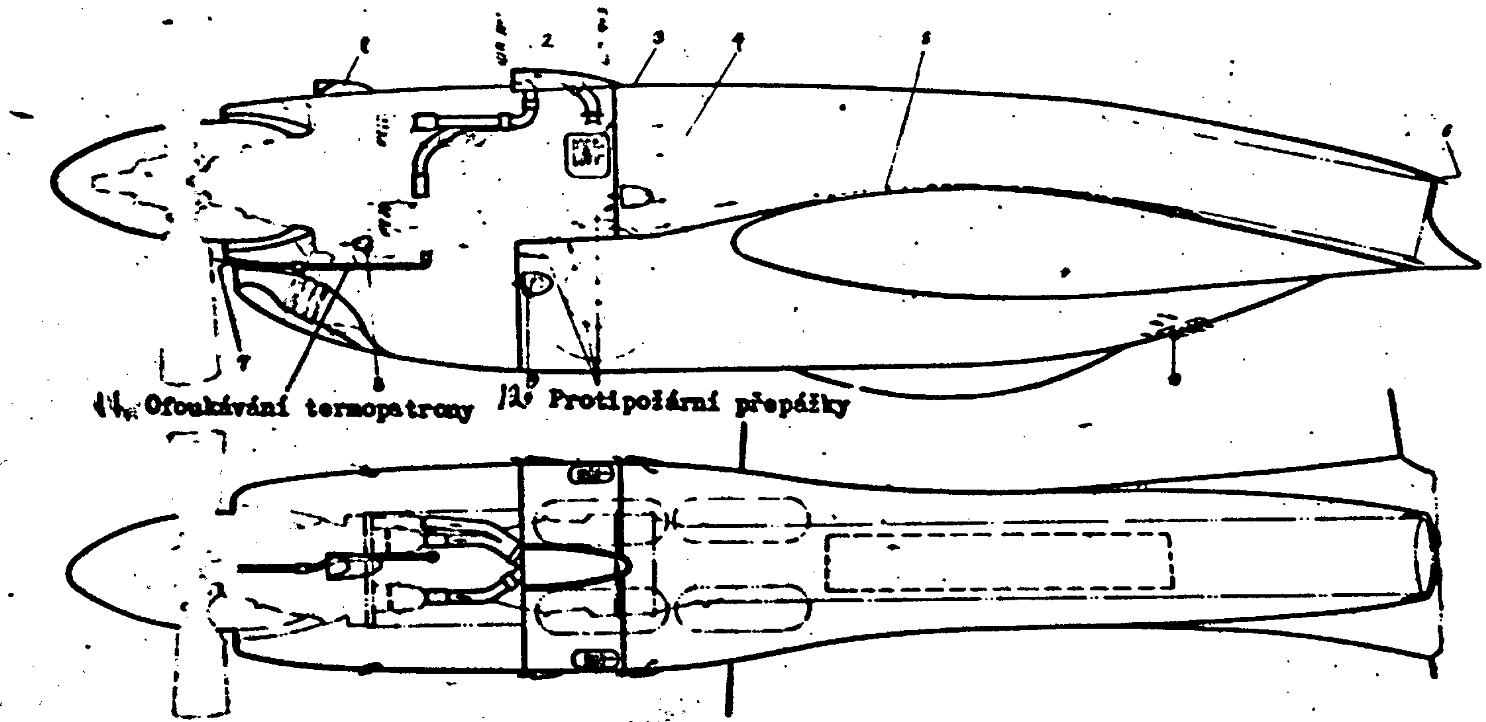

Fig. 137. Cooling system, inboard nacelle

1. De-aerator air scoop
2. Air scoop for cooling generators and turbine body
3. Jalousie slot
4. Air scoop for exhaust pipe
7. Intake for cooling KTA thermal cartridge (termopatron)
8. Air scoop for engine bay
9. Scoop for landing gear bay
10. Louvres for landing gear bay
11. Ventilator for "termopatron"
12. Firewalls
13. Bulkheads, Nos 1 and 3

50X1

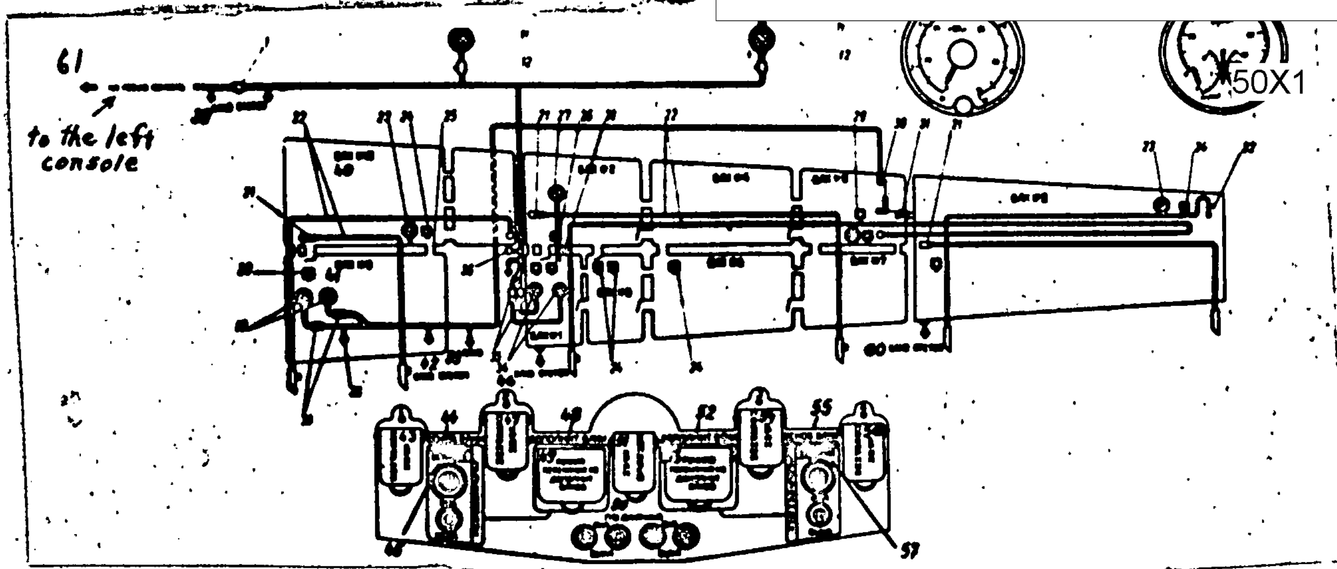

Fig. 138. Fuel system

1. Check valve
2. SDU3-0.35 pressure indicator
3. Pressure guage transmitter from EMI-3R assembly
8. Transmitter of RTMS-1, 2A-Bl flow meter
9. 724100 fine filter
11. TF-6 coarse filter
12. Fire shutoff valve
13. Starting fuel valve
14. Starting nozzle
15. Operating nozzles
16. Fuel control assembly
17. 661A pump
18. 7071 auxiliary pump
19. PNV-2G transfer pump
20, 24, 26, 29. SETS-280 fuel guage transmitter
21. Air vent check valve
22. Air vent tubing
23. Fuel filler neck
25. Inter-tank air vent
27. PNV-2G remaining fuel transfer pump
28. SDU2A-0.18 pressure indicator
30. Float valve
31. Float valve
32. Air vent safety valve
34. PNV-2G overflow pump
35. Check valves
36. SDU-2-0.18 pressure indicator
37. Left control panel/desk
38. RTMS-1, 2A-Bl flow master
39. Sediment drain
40. Tank 10
41. Tank 9
42. Sediment drain
43. Fire valve [no 1 engine]
44. Main tank
45. Transfer of remaining fuel
46. Sediment drain
47. Fire valve [no 2 engine]
48. Auxiliary tanks
49. Manual pump from auxiliary tanks
50. Pumps
51. Cross over valve
52. Auxiliary tanks
53. Manual pump from auxiliary tanks
54. Fire valve [no 3 engine]
55. Main tanks
56. Fire valve [no 4 engine]
57. Transfer of remaining fuel
58. Tank in use
59. Drain
60. Sediment drain
61. I [group] circuit
62. II [group] circuit
63. For AI-20
64. Pilots' instrument panel
65. Cross-over switch of fuel gauge from the SETS-280 assembly
66. Two-stage counter indicator of fuel gauge from the SETS-280 assembly
67. Fuel pressure gauge from the EMI-3R assembly
68. Intake pumping disengaged
69. Transfer pumping from auxiliary tanks
70. 800 liters of fuel remaining
71, 72. Minimum fuel pressure

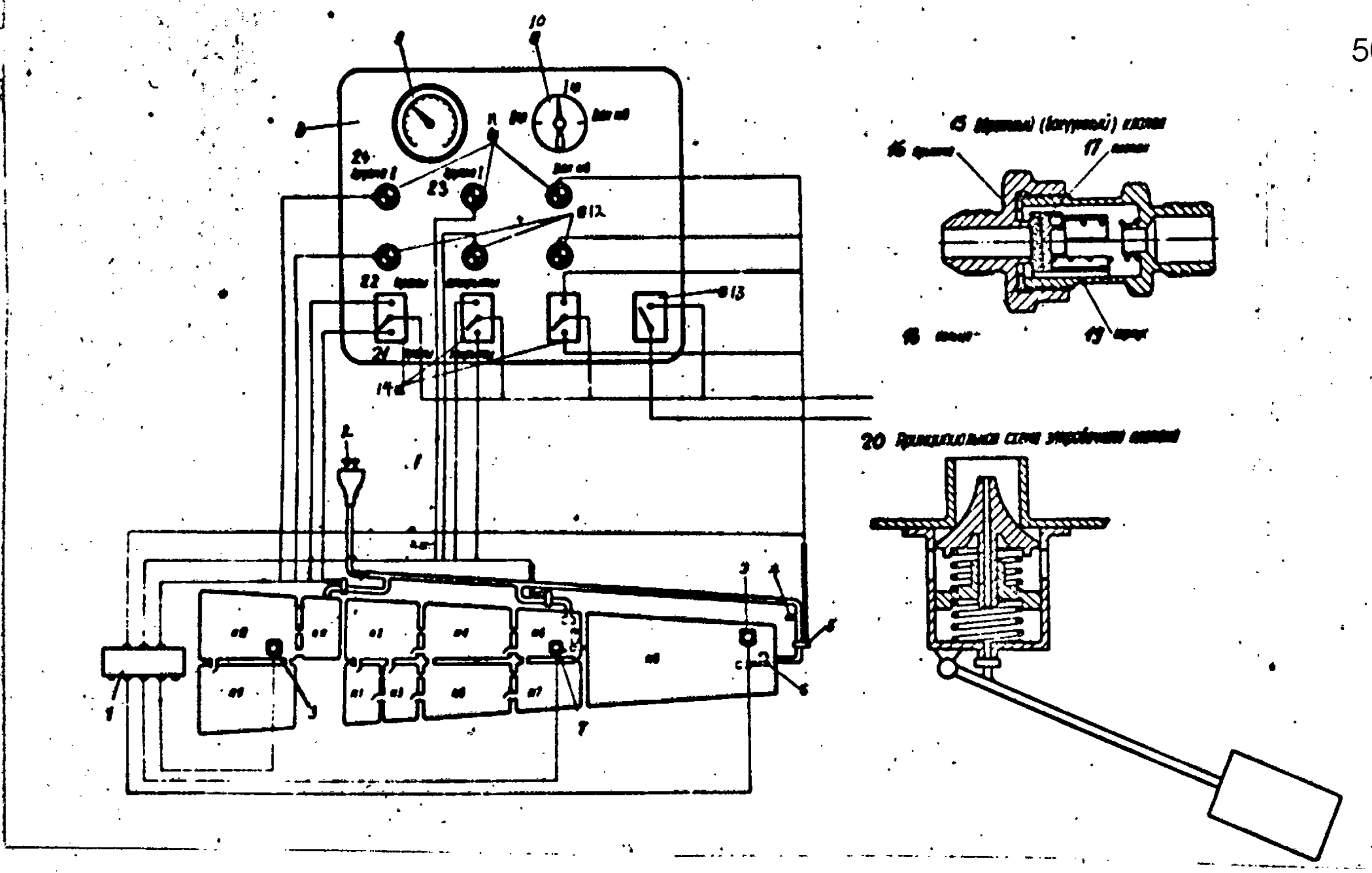

Fig. 139. Pressure fueling system
(from below)

1. SETS-280 [pressure] amplifier
2. Fuel filler neck
3. SETS-280 fuel gauge transmitter
4. Check valve
5. Fueling cock
6. Fueling valve
7. SETS-280 fuel gauge transmitter
8. Fueling control panel
9. Feul gauge [no 8 tank]
10. Fuel gauge cross-over switch
11. Green signal light--valves open
12. Red signal light--valves closed
13. Main fueling disconnect switch
14. Cross-over switch for fueling valves
15. Check (vacuum) valve
16. Cap
17. Valve
18. Ring
19. Housing
20. Main diagram of fueling valve
21. Valves closed
22. Valves open
23. Group I
24. Group II

50X1

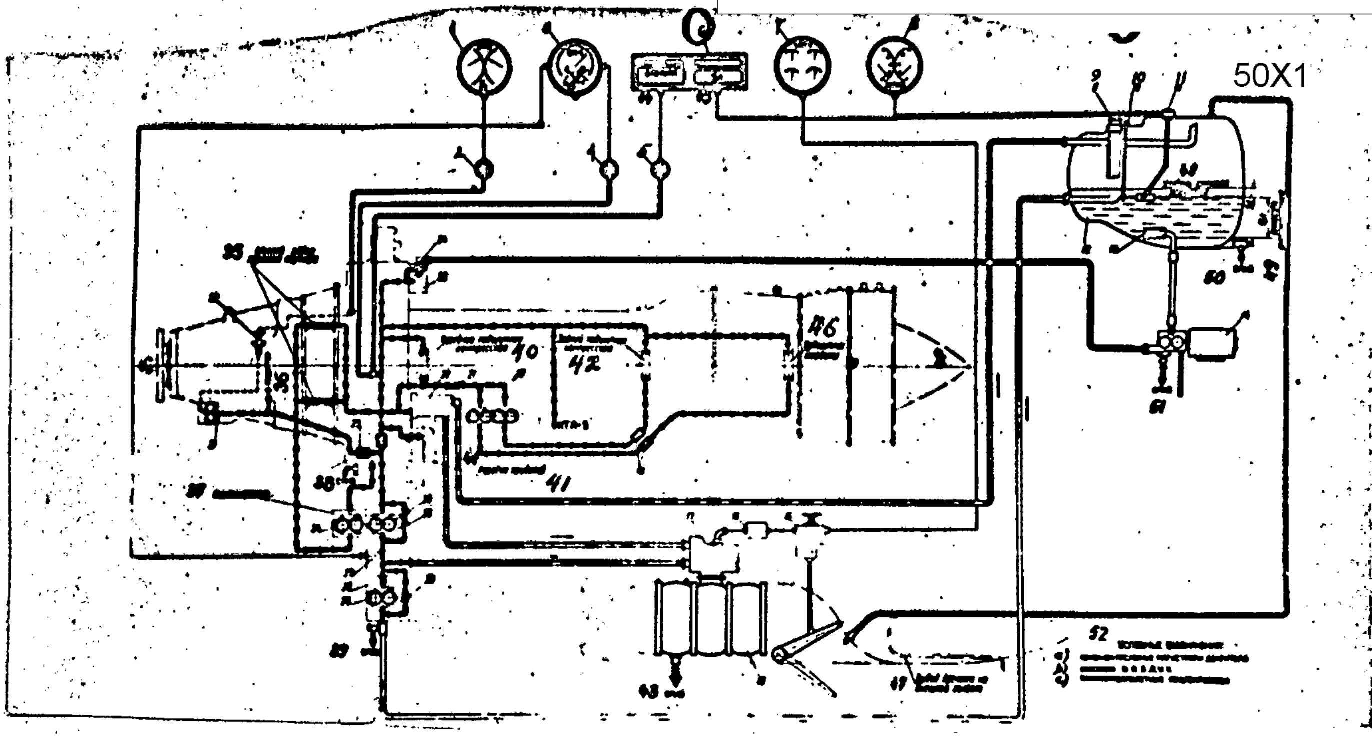

Fig. 140. Oil system

1. Oil pressure indicator in the IKM-2 I-100; 2. Oil pressure transmitter in the IKM-D-100; 3. EMI-3R instrument; 4. Oil pressure transmitter in P-10; 5. Pressure drop warning transmitter of SDU 6-3.9; 6. Signal transparency [plate?]; 7. Position indicator of oil cooler flaps; 8. Oil gauge; 9. Filler neck; 10. Measuring stick; 11. MES-1897 A oil gauge; 12. Oil tank; 13. Feathering oil filter; 14. NF-2 TA-1 feathering pump 15. Flap MVP-2V oil cooler control mechanism; 16. 1100 control box; 17. 1074 thermostat; 18. 875 cooler; 19. Filter for center and rear bearings; 20. MNO-20 scavenge pump; 21. Check valve; 22. VO-20 separator; 23. Oil filter; 24. Pressure stage of GMN-20 pump; 25. Pressure stage of GMN-20 pump; 26. Reduction valve; 27. P 1 intake oil temperature transmitter; 28. Check valve; 29. MNP-20 auxiliary oil pump; 30. Reduction valve; 31. MIKM pump; 32. IKM mechanism [torquemeter]; 33. R-68 propeller governor; 34. Governor pump; 35. Heating the forward crankshaft casing ribs; 36. To the reducer; 37. Oil accessory; 38, 39. Drains; 40. Front compressor bearing; 41. Instrument box; 42. Rear compressor bearing; 43. Drain; 44. Minimum pressure; 45. Remaining oil, 5 liters; 46. Turbine bearing; 47. Drain line leading out of outboard nacelle; 48. Oil level indicator; 49. Oil supply for feathering (15 liters); 50. Outlet; 51. Outlet; 52. Legend: a. Oil line of engine; b. Air; c. Oil lines of aircraft

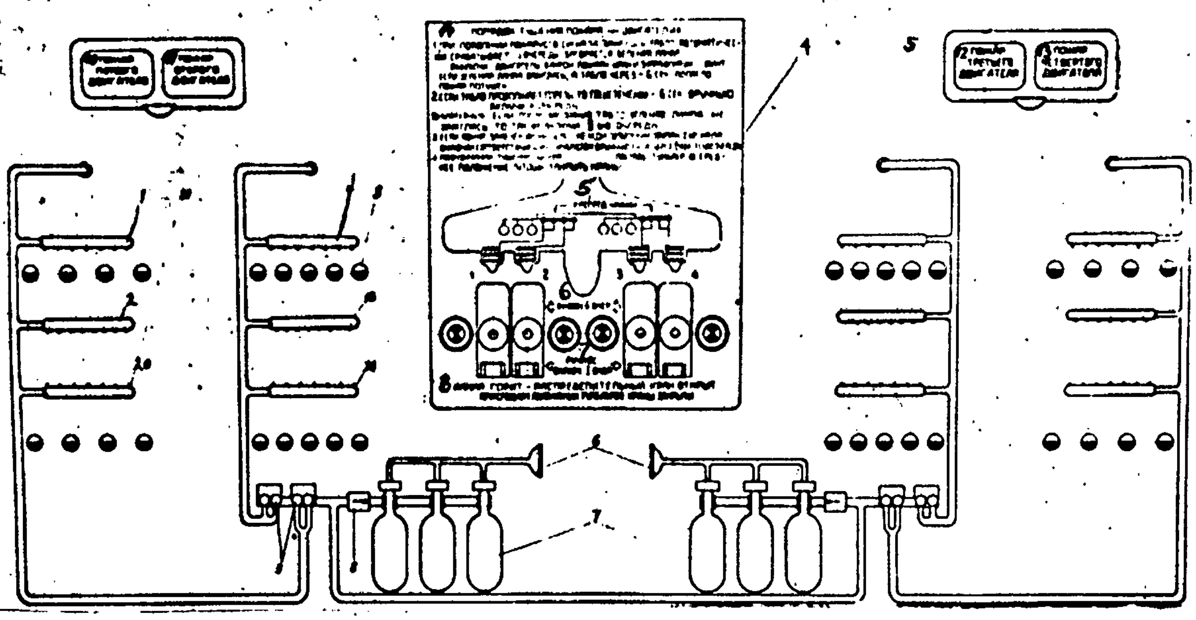

Fig. 141. Fire extinguishing system

1, 2, 13, 20, 21. Spray heads
3. Fire signal [sensors?]
4. Plate with operating instructions
5. Red fire warning light (plate type)
6. OSUZ-1s signal disk (for automatic signalling of emptying of the extinguisher device)
7. OS-8 extinguishers
8. Check valve
9. No 781400 distributor valve units
10. Fire in engine no 1
11. Fire in engine no 2
12. Fire in engine no 3
13. Fire in engine no 4

Procedure in Extinguishing Engine Fire

1. When the fire signal lights up (the [red] plate lights up), seris I. is automatically actuated (the green light goes on). Switch off the engine, shut off the fire valve, and feather the propeller. If the green light and the [red] plate go off after 3 to 6 seconds, the fire is extinguished.
2. If the [red] plate is still lighted, turn on series II after 6 seconds.
ATTENTION: If the green light does not go on after the [red] plate lights up, switch on series II.
3. If you see a fire, do not wait for the warning light, and turn on series I manually by the appropriate switch and series II after 6 seconds.
4. When the fire is out, set the toggle switch in the middle position to shut off the valves.

1, 2, 3, 4. Engines 1 to 4
5. Distributor valves
6. Switching of series II
7. Manual switching of series I
8. If the light is on -- the distributor valve is open-- with the toggle switches in the middle position, the valves are closed.

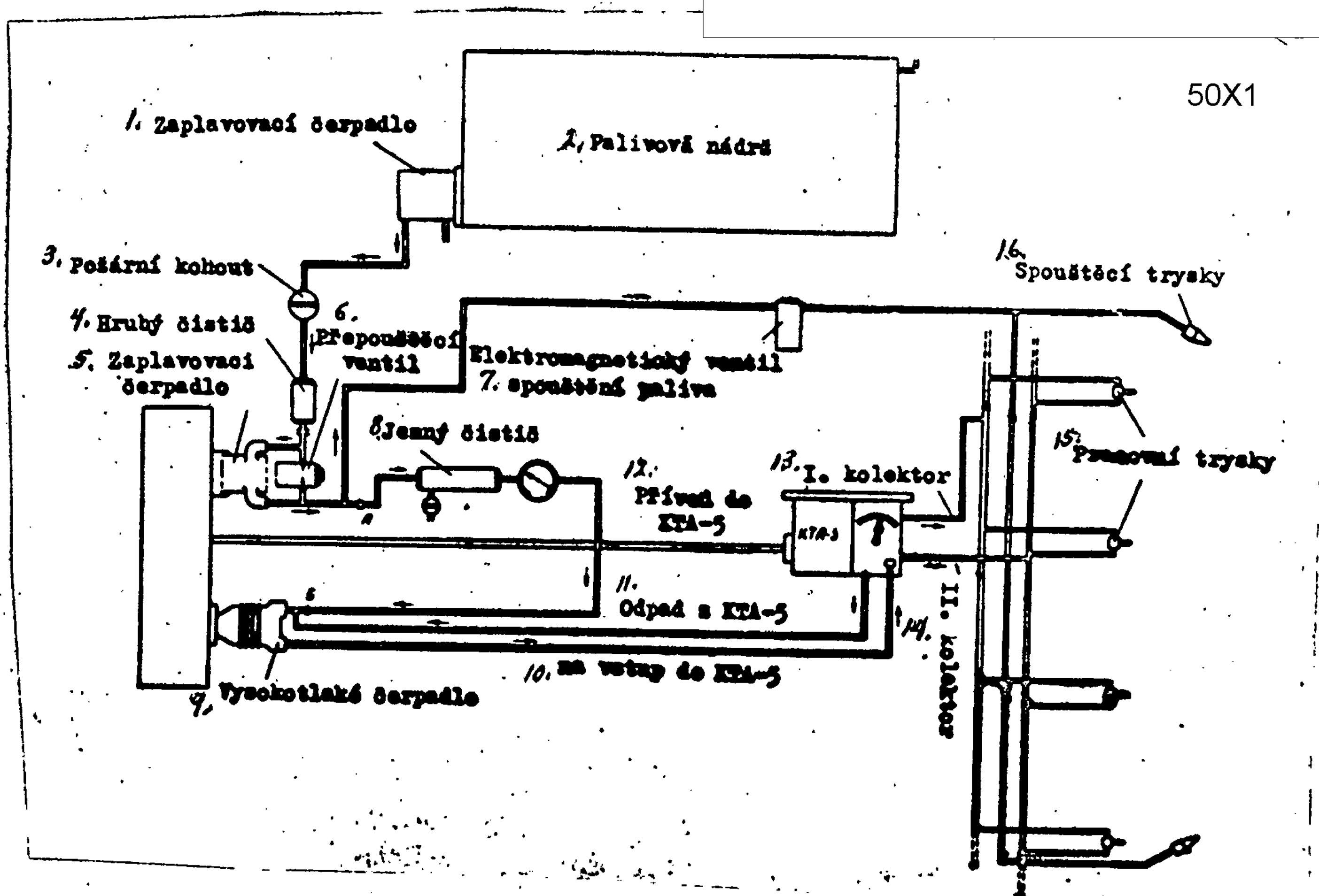

Fig. 142. Fuel system diagram

1. Boost pump
2. Fuel tank
3. Fire valve
4. Coarse filter
5. Boost pump
6. transfer valve
7. Electromagnetic valve, starting fuel
8. Fine filter
9. High pressure pump
10. To intake of KTA-5
11. Outflow from KTA-5
12. Feed to KTA-5
13. Manifold I
14. Manifold II
15. Operating nozzles
16. Starting nozzles

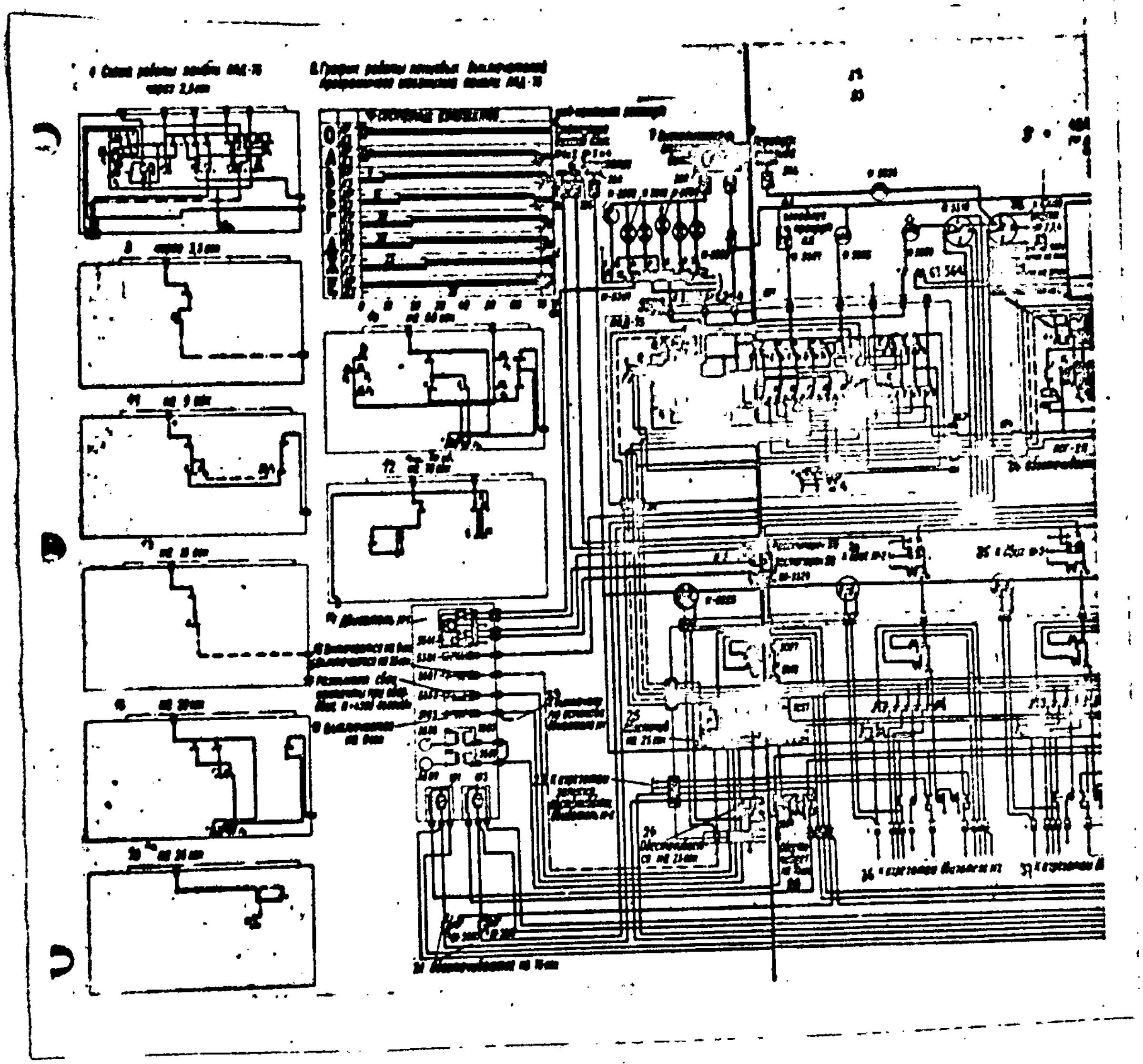

Fig. 143. Engine starting diagram [translator's note: pp 35-37 presumably contain the Czech equivalent, translated below, of the original Russian heading on this diagram reproduced on pp 38-41.]

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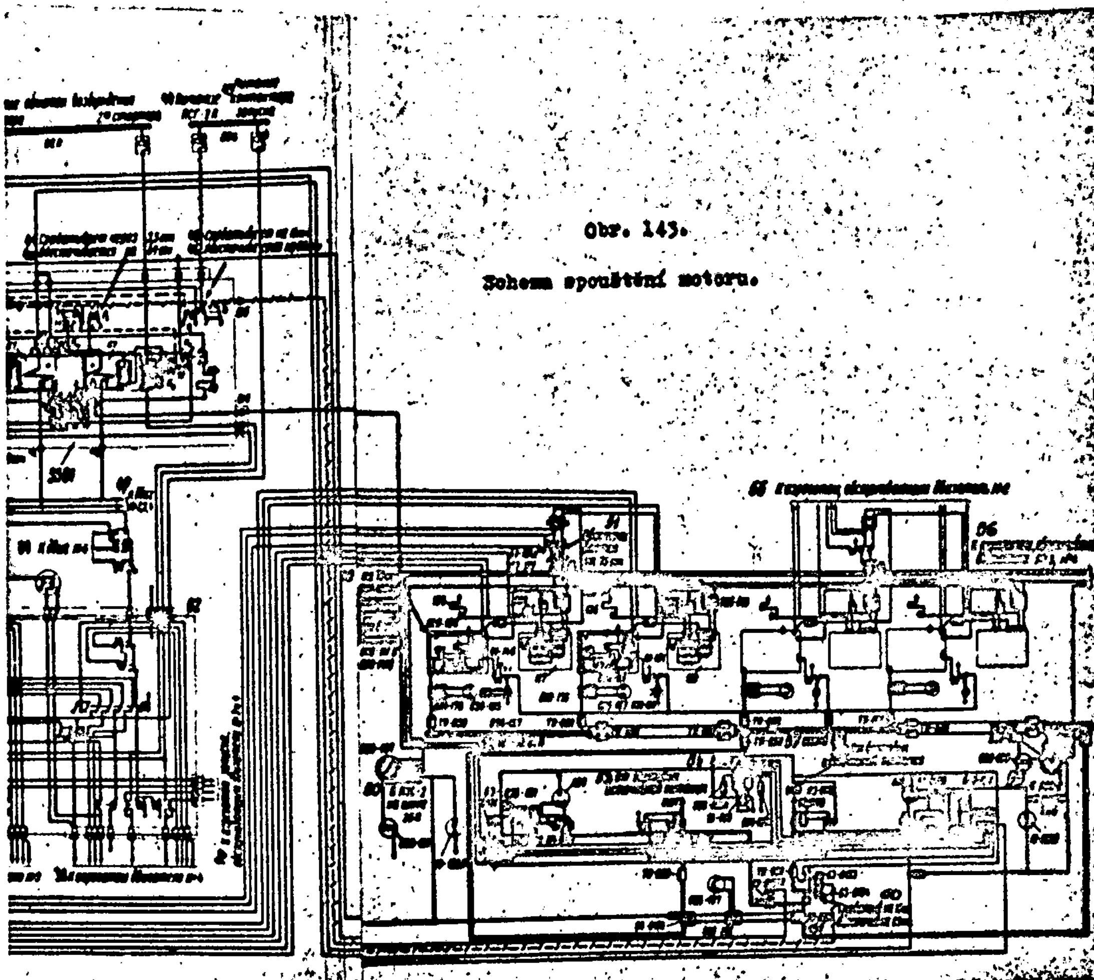

Obr. 143.

Schema spouštění motoru.

Fig. 143. ENGINE STARTING DIAGRAM

Numbers of the Panel Plates and Disconnect Equipment	Designation of the Diagram	Accessory	Type
11		Pilot's left control panel	
15		Pilot's central control panel	
16		Pilots overhead electric panel	
25		Navigator's central radio panel	
26		Central radio panel "rtg" ["rtg" unidentified]	
026		Servicing direct current sources	
62		Starting relay box	
63		Panel of relays for storage batteries	
65		Fire equipment control box	
81		Central [electrical?] distribution box for left outboard nacelle	
81 A		Bus bar of distribution box for left outboard nacelle	
	101	Generator No 1, engine No 1	STG-12TMO
	103	Generator No 1, engine No 2	STG-12TMO
81 A	109	Switch for generator No 1, engine No 1	DMR-400 AM
81 A	111	Switch for generator No 2, engine No 1	DMR-400 AM

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	117	Voltage … ator No 1, engine No 1	RN-180
	119	Voltage regulator, generator No 2, engine No 1	RN-180
025	125	Rheostat for regulating voltage, generator No 1, engine No 1	VS-2S
026	127	Rheostat for regulating voltage, generator No 2, engine No 1	VS-2S
	133	Compensating resistance, generator No 1, engine No 1	BS-12000
	135	Compensating resistance, generator No 2, engine No 1	BS-12000
026	141	Disconnect switch, generator No 1, engine No 1	2V-45
026	143	Disconnect switch, generator No 2, engine No 1	2V-45
81	149	Signal relay of disengagement of generator No 1, engine No 1	TKE-21PD
81	151	Signal relay of disengagement of generator No 2, engine No 1	TKE-21PD
026	157	Signal light of disengagement of generator No 1, engine No 1	SM-30 (in the armature) SLC-51 (red)
026	159	Signal light of disengagement of generator No 2, engine No 1	SM-30 (in the armature) SLC-51 (red)
026	165	Ammeter of generator No 1, engine No 1	A-2

026	167	Ammeter of generator No 2, engine No 1	A-2 50X1
81 A	173	Shunt of ammeter of generator No 1, engine No 1	v S-2
81 A	175	Shunt of ammeter of generator No 2, engine No 1	v S-2
63	181	Disconnect relay for generators of engine No 1 when ground source is engaged external	TKE-52PD
63	181a	Disconnect relay for generators of engine No 1 from the aircraft network during starting	TKE-52PD
026	185	Voltmeter for left generators	V-1
10	185a	Voltmeter of ignition sources of left group	V-1
026	186	Voltmeter of right generators	V-1
10	186a	Voltmeter of ignition sources of right group	V-1
026	187	Change over switch for left voltmeter	"llpln" not identified]
026	187a	Disconnect switch for left group of batteries	KV-P-A-S
026	188	Change over switch for right voltmeter	"llpln"
026	188a	Disconnect switch for left group of batteries	KV-P-A-S
	189	Front recepticle for external source	
	190	Front recepticle for external source	

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026	191	Signal light of front recepticle for external source	SM-30 (in armature) SLC-51 (red)
026	191a	Diode	DG-C22
026	192	Signal light for rear socket of recepticle external source	SM-30 (in armature) SLC-51 (red)
026	192a	Diode	DG-C22
026	195	Changeover switch with aircraft "ktg." Airport charging--(batteries)	2PIN-45
16	196	Battery emergency disconnect switch	KV-P-V-S
026	197	Battery Ammeter	A-1
026	198	Change over switch of battery ammeter	2PN-20
	0165	Battery	
	0166	-"-	
	0167	-"-	
	0168	-"-	
63	0169	Switch contactor of first left battery	KM-600D
63	0170	Switch contactor of first right battery	KM-600D
63	0172	Relay of first left battery	TDE-210

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63	0173	Switch of second left battery	KM-600D
63	0174	Switch of second right battery	KM-600D
63	0175	Relay of second left battery	TDE-210
63	0176	Relay of second right	TDE-210
63	0177	Switch of front recepticle of external source	TKT-101D
63	0178	Switch of rear recepticle of external source	TKT-101D
63	0179	Relay of front recepticle of external source	TDE-210
63	0180	Relay of rear recepticle of external source	TDE-210
63	0181	Relay of front recepticle disengaging generators	TKE-52PD
63	0182	Relay of rear recepticle disengaging generators	TKE-21PD
63	0183	Switch changing over sources from 24 volts to 48 volts	TKS-611A
63	0184	Switch changing over sources from 24 volts to 48 volts	TKS-611A
63	0185	Shunt of battery ammeter	ŠA-46
63	0186	Shunt of battery ammeter	ŠA-46
63	0187a	Switch activating starting circuit of engines	KM-600D
	5500	Automatic starting unit of engines.	APD-75
	49	Intermediate relay P_8	

51	Progra [redacted]	
52	Electric motor of programmed mechanism	D-2P
53	Electromagnet of motor of programmed mechanism	EMS-18A
54	Limit disconnect switch of cams of programmed mechanism	KV-1-20
55	Control relay P_1	TKE-56PK
56	Electric motor relay P_2	TKE-52PK
57	Intermediate relay P_3	TKE-52PK
58	Ignition relay P_4, at 24 volts	TKE-21PK
59	Switch-on relay over output regulator P_5	TKE-53PK
60	Relay for cold cranking P_6	TKE-52PK
61	Locking relay P_7	TKE-21PK
62	Diode	
$Š_1$	Plug connection	ŠR32P10NŠ1
$Š_2$	Plug connection	ŠR32P8NG3
$Š_3$	Plug connection	ŠR28P7NG9
5501	Ignition box for generator starters	PSG-2A
67	Output regulator	RUT-600D
68	Ignition resistance	PS-150-0 16A
69	Switches K_1 and K_2, switching on the ignition resistance	KM-100
70	Switches K_5 and K_6, switching on the output regulators	TKD-511A

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	71	Switch K_3, switching on the feed armature of the starter generator	TKS-602A
	72	Intermediate relay R_1, R_2, and R_4	TKE-52PK
	73	Intermediate relay R_3	TKE-52PK
	74	Regulator, resistance	RS-25, No. 8
	78	Resistance	PEV-30-30sM
	79	Regulator resistance	RS-25, No. 7
	80	Resistance	PEV-10-51-1
	$\check{S}_4$	Plug connection	ŠR28P7NŠ9
	$\check{S}_5$	Plug connection	ŠR32P12NŠ1
	5185	Electromagnetic switch for turning off the engine	MKT-4
11	5505	Starting main disconnect switch	V-45
11	5506	Signal light for activity of the APD-75 ignition automatic unit	(in the armature) SLC-51 (green)
11	5507	Disconnect switch for cold cranking	KV-P-V-S
11	5508	Starter disconnect button	VK2-140v-1
11	5509	Engine starting button	204KS
11	5510	Disconnect switch for engine selection	E6.722.106
11	5515	Change-over switch for propeller (brake), engine No 1	KV-P-V-S

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11	5519	Signal light for braking engine No 1 propeller	(in the armature) SLC-51 (green)
11	5523	Air start button, engine No 1	GR3,604.004
11	5525	Button for transfer of fuel	205KS
65	5529	Relay blocking starting during propeller braking	TKE-52PD
	5541	Mechanism of propeller brake, engine No 1	MZK-2
	5553	Disconnect switch for electric motors	VE-2S
	5561	Electromagnetic valve releasing fuel	in KTA-5F
	5565	Ignition coil	KPN-4
	5569	Ignition coil	
	5581	Electromagnetic valve transferring fuel	in KTA-5F
	5585	Spark igniter plug	SPN-4
	5589	Spark igniter plug	SPN-4
11	5591	Relay check of signal lights	TKE-56PD
11	5592	Button checking signal light	205KS
62	5607	Intermediate relay disengaging starter from starting circuit during generator operation phase	TKE-21PD
62	5611	Switch engaging the starter charge during starting	KM-600D

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62	5613	Switch engaging the charge during starting	KM-600D
62	5619	Intermediate relay disengaging starter from ignition circuit during generator operating phase	TKE-21PD
62	5627	Relay turning on signals for starting	TKE-56PK
62	5631	Relay engaging electromagnetic valve releasing fuel	TKE-52PK
62	5635	Ignition circuit switch	KM-25
62	5639	Switch engaging the exciter winding of the first starter, engine No 1	TKD-511A
62	5634	Switch engaging the exciter winding of the second starter, engine No 1	TKD-511A
63	5647	Relay blocking starting	TKE-21PD

1. Operation diagram of APD-75 program mechanism after 2.5 seconds
2. Operating diagram of limit disconnect switches of APD-75 program mechanism
3. After 3.5 seconds
4. Contact made
5. Braking the propellers of engines Nos 1, 2, 3, and 4.
6. Ignition
7. Signal of braking propellers
8. Transfer of fuel
9. Starting on the ground
10. At 68 seconds

11. For 9 seconds

12. For 70 seconds

13. For 15 seconds

14. Engine 1

15. Is turned on for 9 seconds

16. Is turned off for 25 Seconds

17. Disengages its contacts when the engine is rotating at 4,500 to 6,500 rpm

18. For 20 seconds

19. Switches of for 9 seconds

20. For 25 seconds

21. The current is cut off for 75 seconds

22. To the starting units of engine No 2

23. To the disconnet switches stopping engine No 1

24. The current is cut out for 25 seconds

25. The current is cut out for 25 seconds

26, 27. The current is cut out for 75 seconds

28. In the un-arrested position

29. In the arrested position

30. To engine No 2

31. Cranking when cold

32. To engines Nos 2, 3, and 4

33. Connected for 9 seconds -- the current is cut off for 73 seconds

34. The current is cut off for seconds

35. To engine No 3

36. To accessories, engine No 2

37. To accessories, engine No 3

38. To accessories, engine No 4

39. To engine No 4

40. Cuts off the current for 69 seconds

41. Connects [current] for 3.5 seconds

42. Charging the exciter winding of the first and second starter

43. Power supply for the starter contactor

44. Power supply of the PSG-2A

45. Connects for 15 seconds

46. Cuts off the current for 68 seconds

47. To engines No 2, 3, and 4

48. To accessories for starting engines No 3 and 4

49. The 400 A switch turns on the generator for 75 seconds (with the engagement of the disconnect switch 026-141C026-143)

50. To the AZS-2 automatic safety [fuse] on the 25 A bus

51. The current is cut off for 75 seconds

52. 81 A bus

53. From aircraft power sources

54. Socket

55. Tothe accessories of engine No 2

56. To the accessories of engines No 3 and 4

57. 82 A bus

58. From aircraft power sources

59. To the AZS-2 automatic safety on the 26 B bus

60. Connects for 15 seconds

61. Cuts off the current for 68 seconds

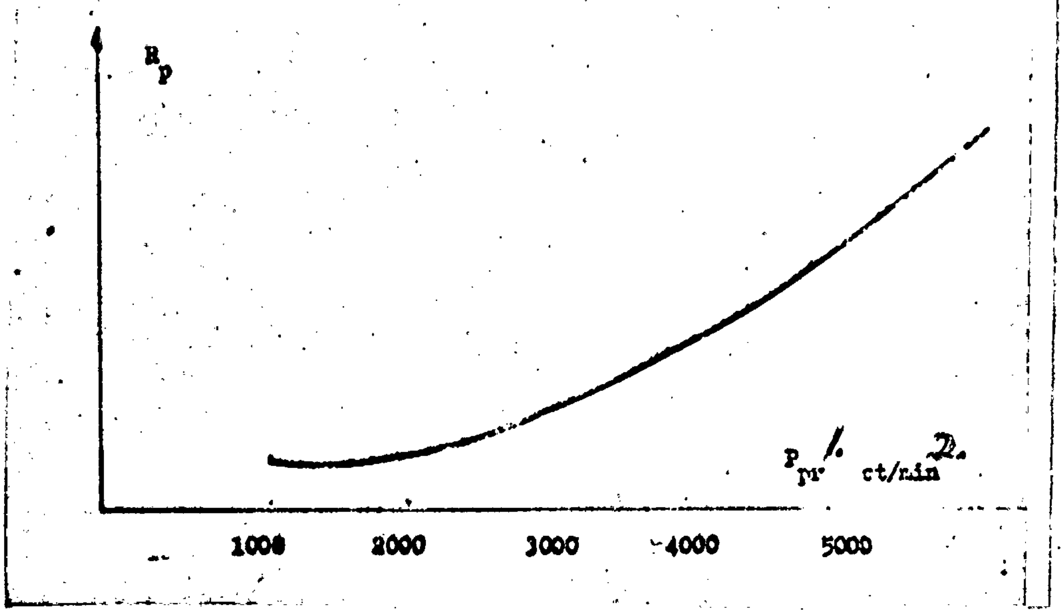

Fig. B. Change in Oil control pressure P_p with oil pump rpm

1. "P_{pr}" pressure [presumably]
2. Revolutions per minute

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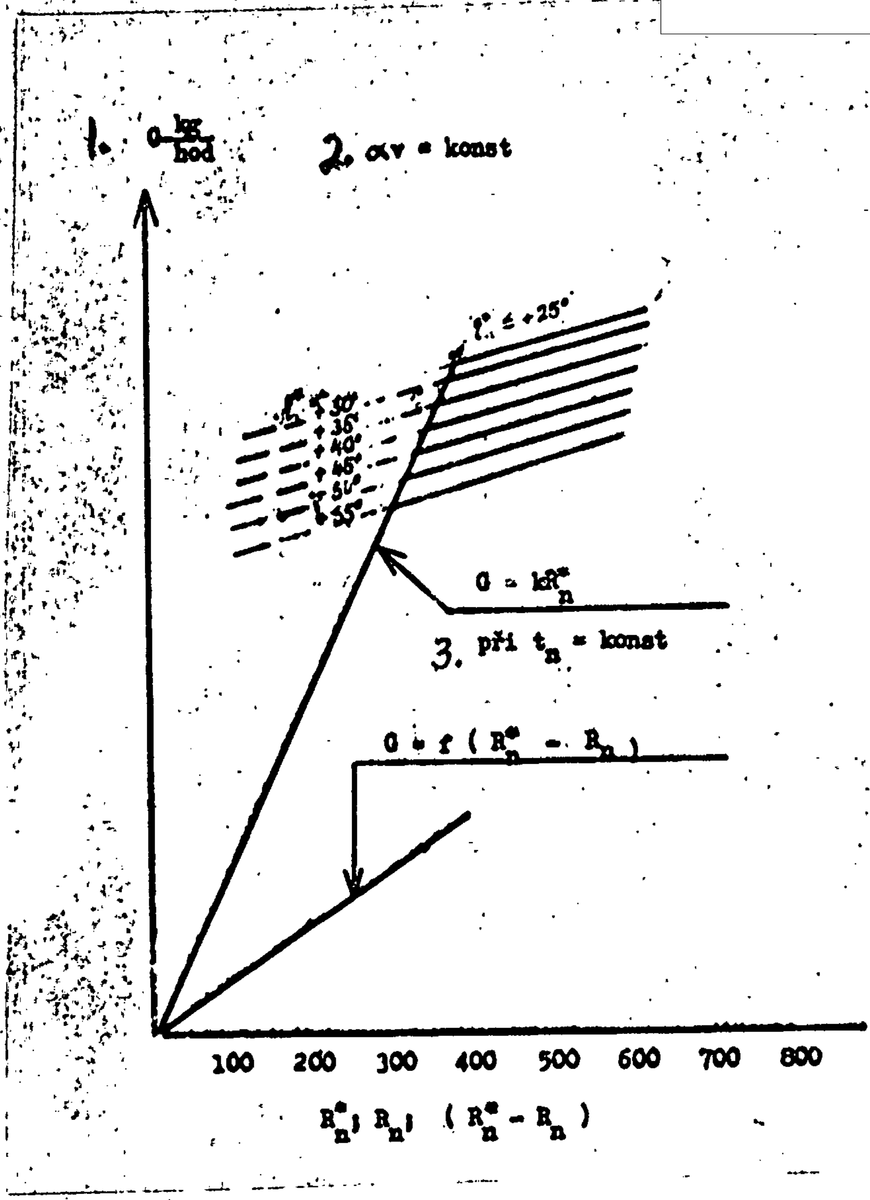

Fig. G. Change of fuel consumption with respect to compressor inlet air pressure

1. G, kilograms per hour
2. αv = constant
3. $G = KR_n^*$ with t_n = constant

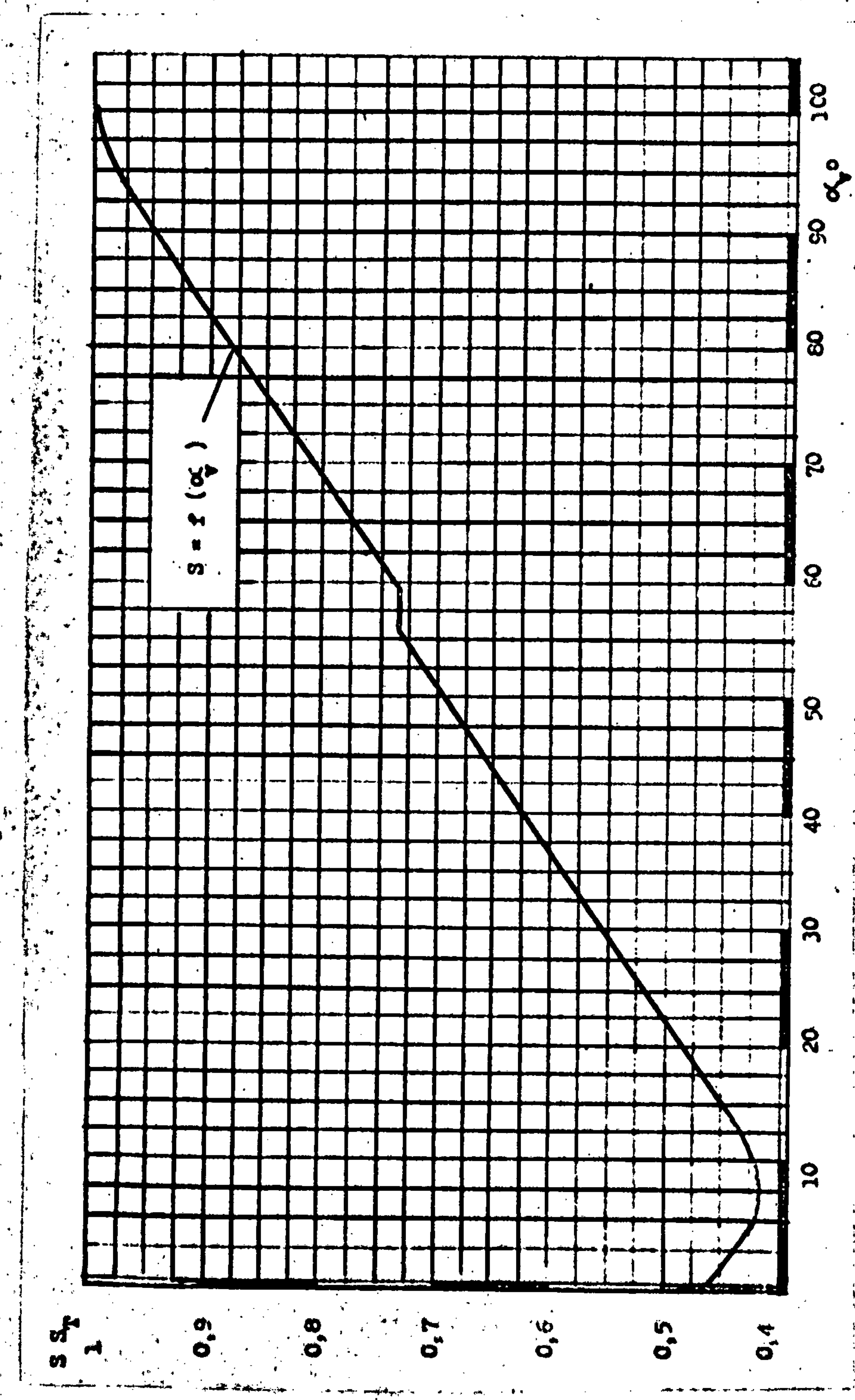

Fig. D. Change of fuel consumption according to engine mode

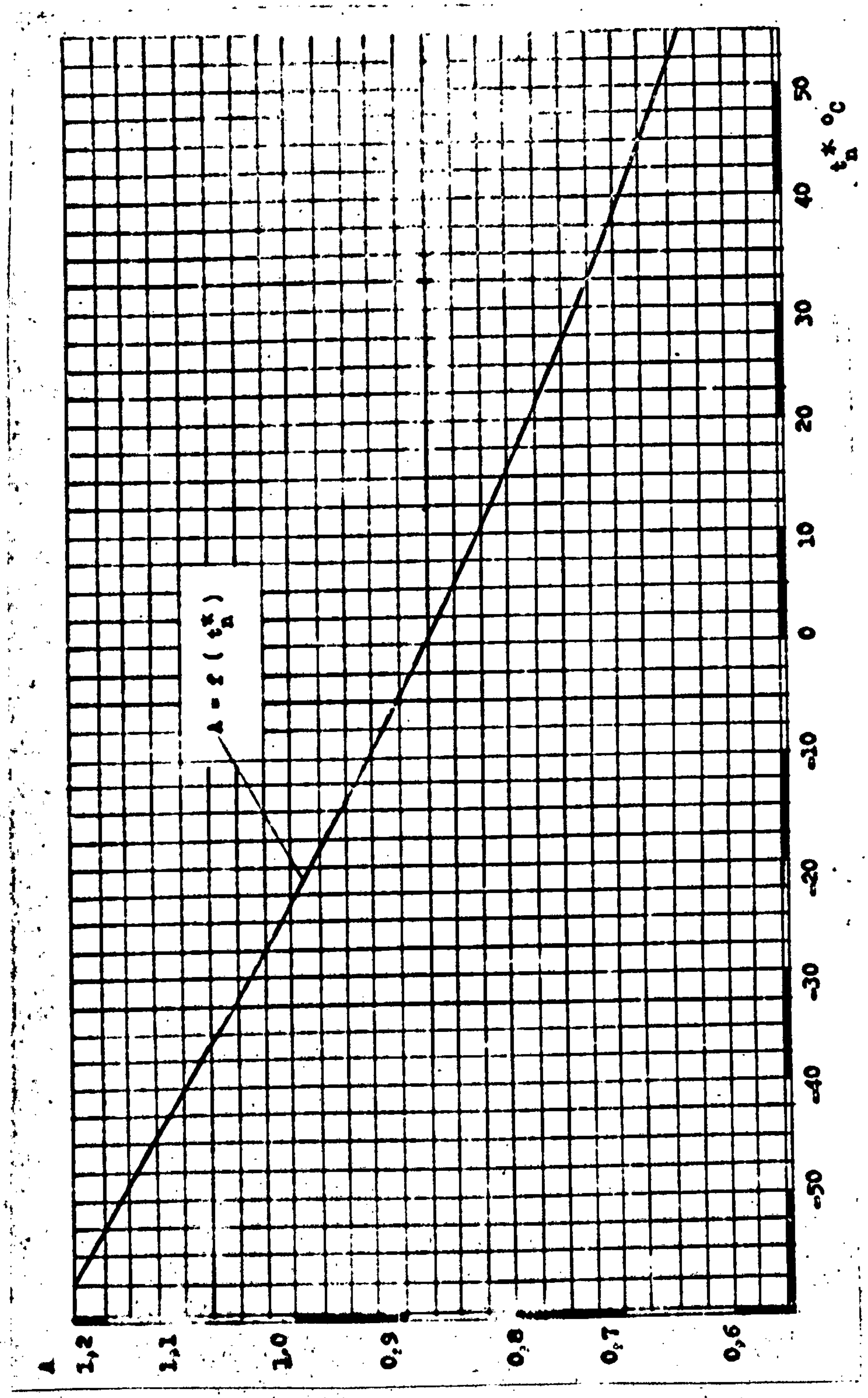

Fig. E. Change of fuel consumption according to inlet air temperature

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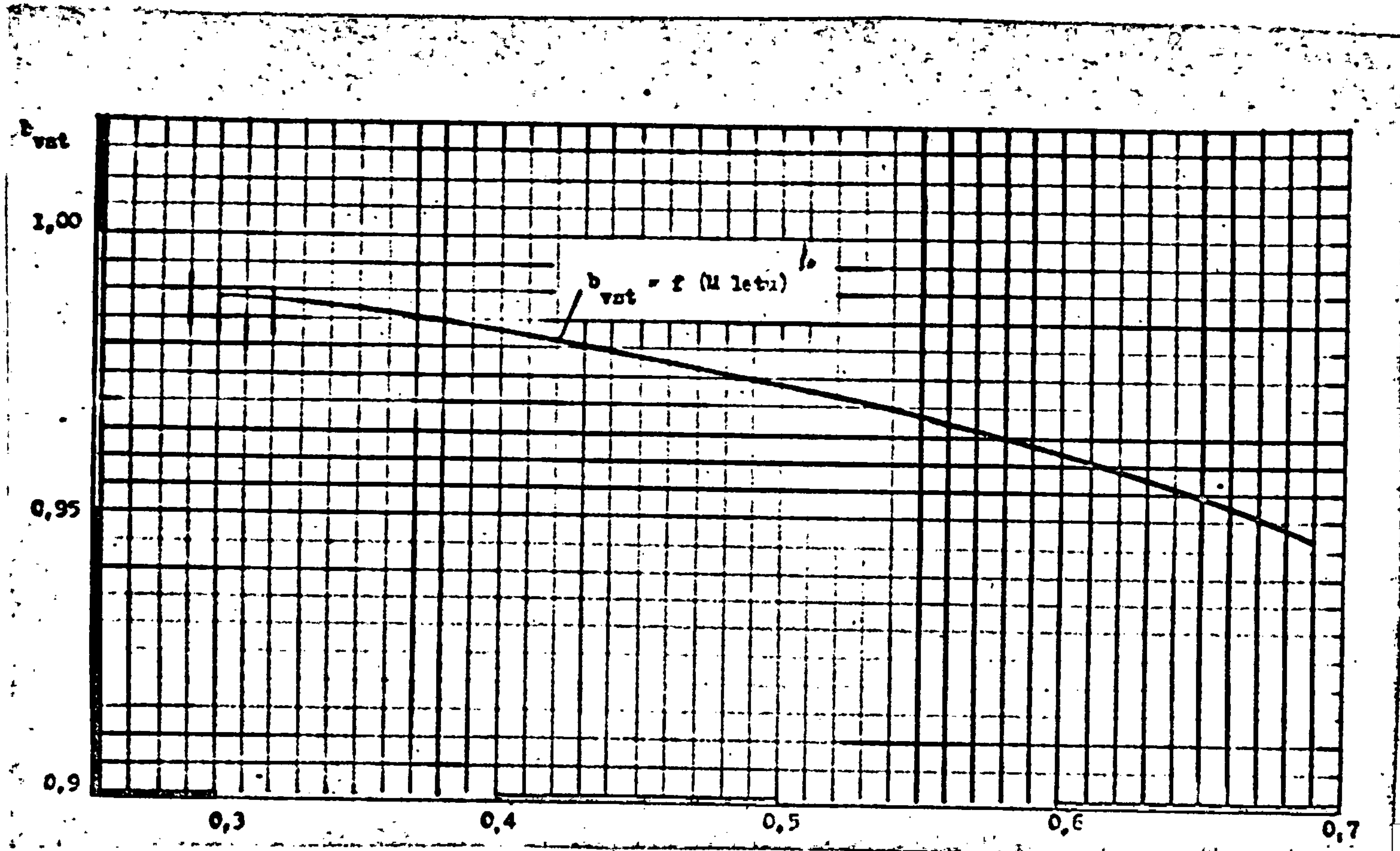

Fig. F. Change of "b_{vst}" coefficient of loss of total pressure at compressor intake for "M" flight

1. b_{vst} = ("M" flight)

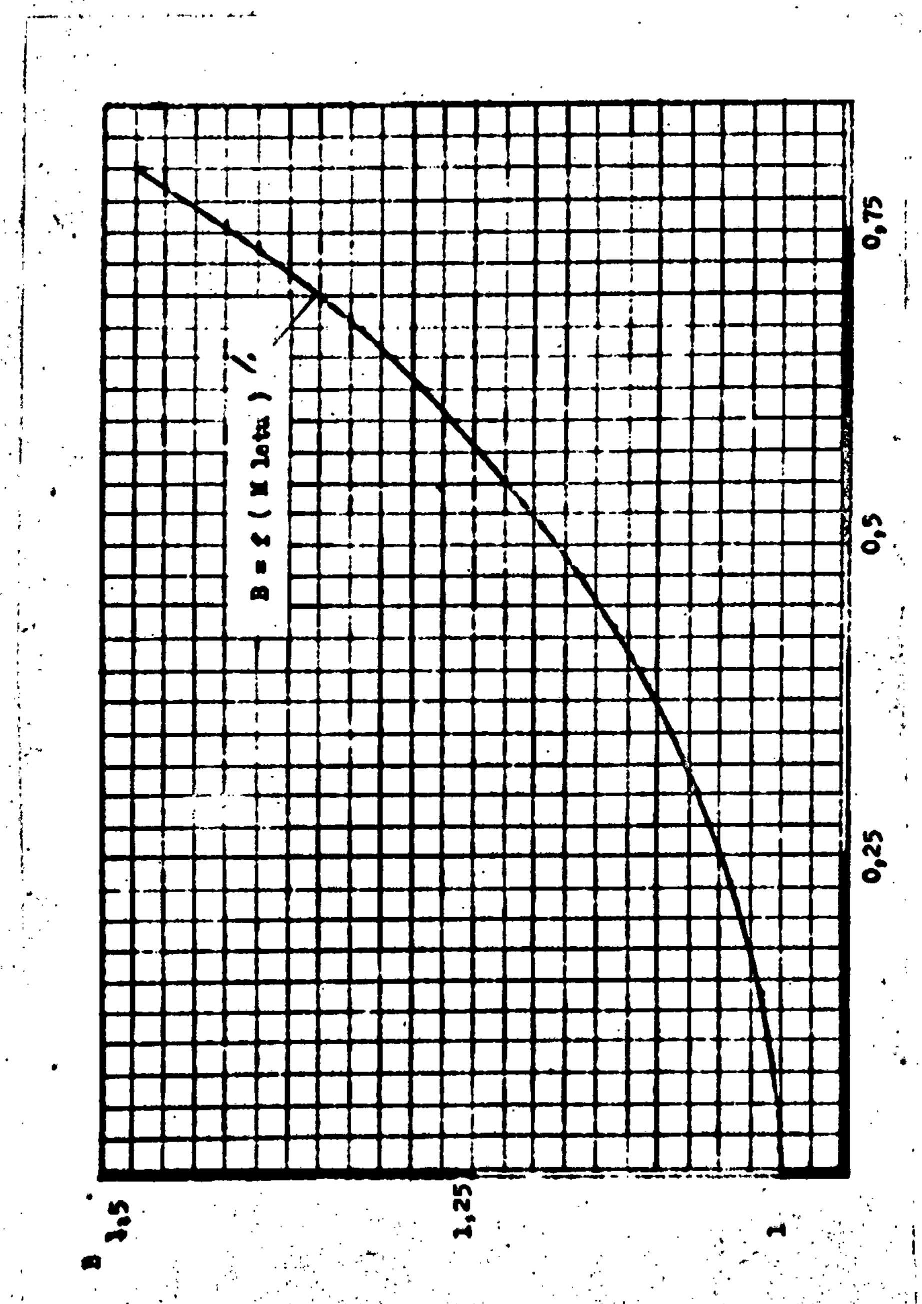

Fig. G. Change of the "B" coefficient according to "M" flight [Mach No?]

1. B = f(M flight)

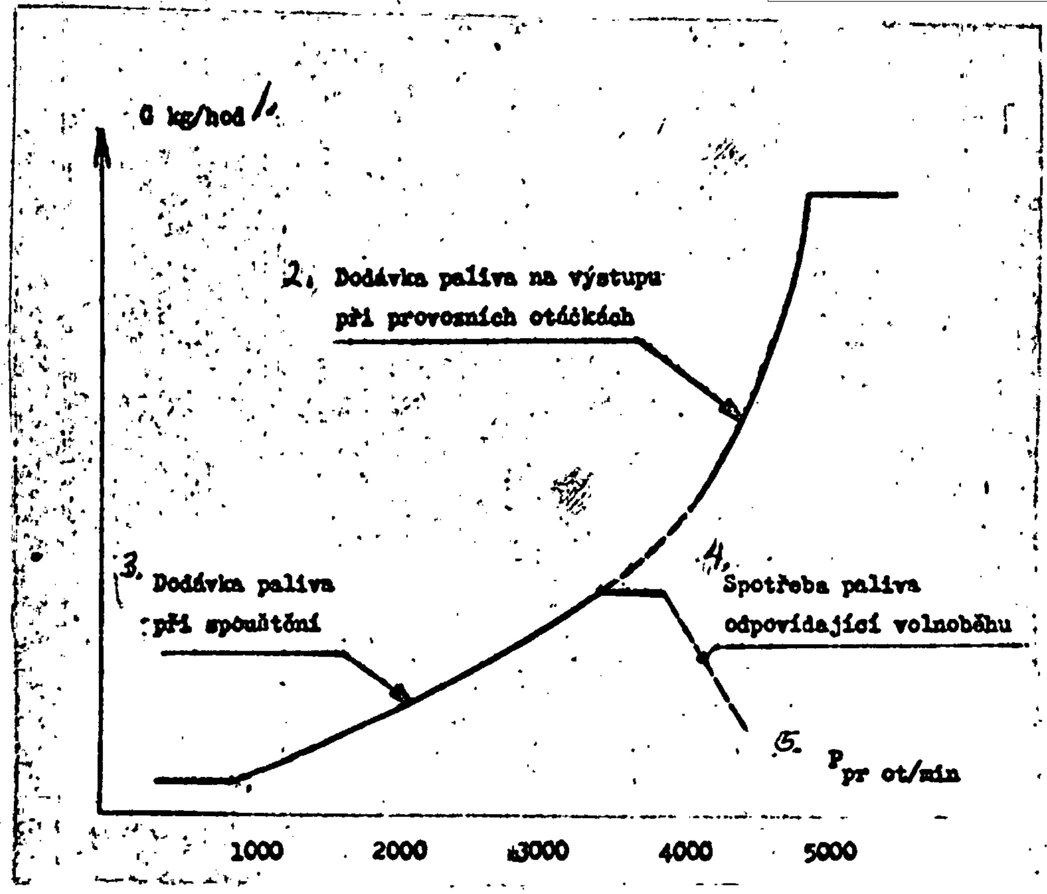

Fig. H. Fuel consumption in relation to KTA-5 F drive rpm

1. G--kilograms per hour
2. Fuel consumption at operating rpm
3. Fuel consumption in starting
4. Fuel consumption in the idle mode
5. P_{pr}--revolutions per minute

[Translator's Note: Figure reproduced on page 68 contains no accompanying legend.]