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RD

РД-3М-500 TURBOJET ENGINE

OPERATING AND MAINTENANCE INSTRUCTIONS

V/K "AVIAEXPORT"

USSR MOSCOW

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Chapter I

ENGINE MAIN SPECIFICATIONS

GENERAL

1. Engine type	turbojet
2. Compressor:	
type	axial-flow
number of stages	8
specific features of design	provided with automatically controlled air blow-off band control mechanism located behind stage III
3. Combustion chamber:	
type	straight-flow with individual flame tubes in common casing
number of flame tubes	14
arrangement of flame tubes	circumferentially with respect to engine axis
numbering	counter-clockwise looking from exhaust unit, taking upper L.H. chamber for chamber No. 1
4. Turbine:	
type	axial-flow
number of stages	2
5. Exhaust unit:	
type	non-adjustable
jet nozzle diameter, *mm*	from 840 to 861
6. Engine rotor sense of rotation	left-hand, if viewed from exhaust unit
7. Attachment of engine to engine frame	according to layout coordinated with Aircraft Manufacturing Plant

MAIN RATINGS

8. "Emergency" rating	may be used at a temperature above —15°C in case of failure of one engine during take-off. After operation at "emergency" rating remove the engine from service and have it overhauled at the Plant
Rotor speed, *r.p.m*	4900^{+15}_{-40}
Temperature of gases after turbine (measured and corrected) at steady-state operating conditions on ground, °C	790 max.
Number of "emergency" rating periods during 500-*hr* life of engine	1 with subsequent removal of engine from aircraft
Duration of continuous operation during one "emergency" rating period, *min*	2 max.

NOTE: After operation at "emergency" rating the engine may be run for 3 hours (if there are no reasons to stop the flight) remove the engine from service and have it overhauled at the Plant.

9. Maximum rating:	
Rotor speed in flight, *r.p.m.*	4700±50 (in summer)
Temperature of gases after turbine (measured and corrected) at maximum rating operating conditions, °C:	
on ground	700 max.
in flight	720 max.
on ground with engine anti-icing system control valve ON	710 max. (not over 720 during 15 *min* after engine starting)
in flight with engine anti-icing system control valve ON	740 max. (to be verified as experience is gained)
Duration of continuous operation, *min*	8 max.

NOTES: 1. At an ambient air temperature below —15°C the maximum engine *r.p.m.* on ground and at altitudes of up to 2000 *m* is limited by the maximum capacity of the fuel pumps, which is regulated by the wobble plate stop (see Fig. 8).
2. As the engine gains speed monthly from IDLING to MAXIMUM rating, a short-term increase of gas temperature after the turbine is allowed up to 720°C with gradual decrease of the temperature within 1—1.5 *min* down to the specified value.
3. In flight the maximum engine speed is allowed to reach 4770 *r.p.m.*
4. Possible variations in gas temperature after the turbine at maximum rating is ±10°C.

10. Nominal rating:	
Rotor speed, *r.p.m.*	4425±25
Temperature of gases after turbine at steady-state operation of engine (measured and corrected), °C:	

on ground	605 max.
in flight	615 max.
while air is bled into aircraft and engine anti-icing system	625 max.
Duration of continuous operation, *hr*:	
on ground	1 max.
in flight	non-restricted

11. 0.8 nominal rating:

Rotor speed, *r.p.m.*	4200±25
Temperature of gases after turbine at engine steady-state operation (measured and corrected), °C	540 max.

12. Idle rating:

Rotor speed, *r.p.m.*	1750+50
Temperature of gases after turbine (measured) during idle rating, °C	520 max.
Duration of continuous operation	non-restricted

13. Acceleration characteristics:

1. from idle rating (1750+50 *r.p.m.*) to maximum rating (4700±50 *r.p.m.*) with engine control lever advanced for 1 or 2 sec.,	17 max.
2. from 1750+50 *r.p.m.* to 3000 *r.p.m.*, *sec.*	7 min.
3. from 3500 to 4700±50 *r.p.m.*, *sec.*	from 12 to 15

At ambient temperature below +15°C the acceleration time is estimated as follows:

1) from IDLING rating to 50 *r.p.m.* below the adjusted MAXIMUM rating, *sec.*	15.5 max.
2) from beginning of automatic control (3500 *r.p.m.*) to a speed 50 *r.p.m.* less than the adjusted MAXIMUM rating speed, *sec.*	from 10.5 to 13.5
3) from MAXIMUM rating (4700±25 *r.p.m.*) to a speed 50 *r.p.m.* less than the adjusted "emergency" rating speed, *sec.*	4 max.

NOTE. In case the MAXIMUM rating speed is decreased because of the limited capacity of the fuel pumps, the adjusted MAXIMUM rating speed is taken for actual *r.p.m.* attained by the engine, with the engine control lever smoothly shifted to MAXIMUM rating stop.

The engine should show satisfactory acceleration characteristics, when its acceleration margin is checked from 1650+50 *r.p.m.* to MAXIMUM rating speed.

NOTE. While checking engine acceleration margin from 1650+50 *r.p.m.*, the time of acceleration is not specified.

14. Maximum permissible engine rotor speed ("overspeed") during acceleration test, *r.p.m.*:

maximum rating	4800 max.
emergency rating	increase of speed to 50 *r.p.m.* from the adjusted speed is allowed

15. Maximum permissible temperature of gases in exhaust unit (measured) during acceleration test from IDLING rating (1750+50 *r.p.m.*) to MAXIMUM rating speed (4700±50 *r.p.m.*), °C: 740 max.

15a. During acceleration from MAXIMUM to EMERGENCY rating allowance is made for momentary increase of gas temperature in exhaust unit (measured) to 800°C max.

16. Engine service life before first overhaul, *hr*: 500 max.

operation at maximum rating, *hr*: 30 max.

operation at nominal rating, *hr*: 150 max.

operation at other ratings: till service life is expired

NOTE. When calculating accumulated engine operating hours, take into account both its operation in flight and on the ground, taxiing included. One hour of engine operation on the ground is considered equal to 12 minutes of engine operation in the air.

16a. Compressor air blow-off band control mechanism actuates at *r.p.m.*: 3800+50

16b. To ensure reliable engine starting at ambient air temperature below —25°C, it is recommended to dilute oil with Б-70 gasoline (non-ethylated), USSR Standard, (ГОСТ 1012-54), within 16—18 per cent of the oil volume in the system

NOTE. Б-70 gasoline may be substituted by starting fuel, i.e. Б-70 gasoline with 1 per cent (by weight) of МК-8 oil or transformer oil.

FUEL SYSTEM

(Fig. 1)

17. Grade of fuel used:

main fuel	ТС-1 fuel, ГОСТ 7149-54, or Т-1 fuel, ГОСТ 4138-49
starting fuel	aviation gasoline Б-70, ГОСТ 1012-54 plus 1% of МК-8 oil, ГОСТ 6457-53, or transformer oil, ГОСТ 982-56, of any grade (with or without ВТИ-1 additive)

18. Starting fuel pump:

type	ПНР10-3М gear pump with electric motor МУ-102А
purpose	independent supply of fuel into starting burners at engine starting
number	1

19. Starting fuel pressure, *kg/sq.cm.*: from 1.4 to 1.75

20. Starting burners:

type	open, centrifugal
purpose	supply of atomized fuel into combustion chamber flame tubes at engine starting
number	4 (in flame tubes Nos. 3, 5, 10 and 12)

21. Fuel booster pump:

type	ЦН-1Д centrifugal
purpose	supply of main fuel to regulating fuel pumps
number	1
transmission ratio	1.765
sense of rotation	clockwise (looking from drive shaft end)

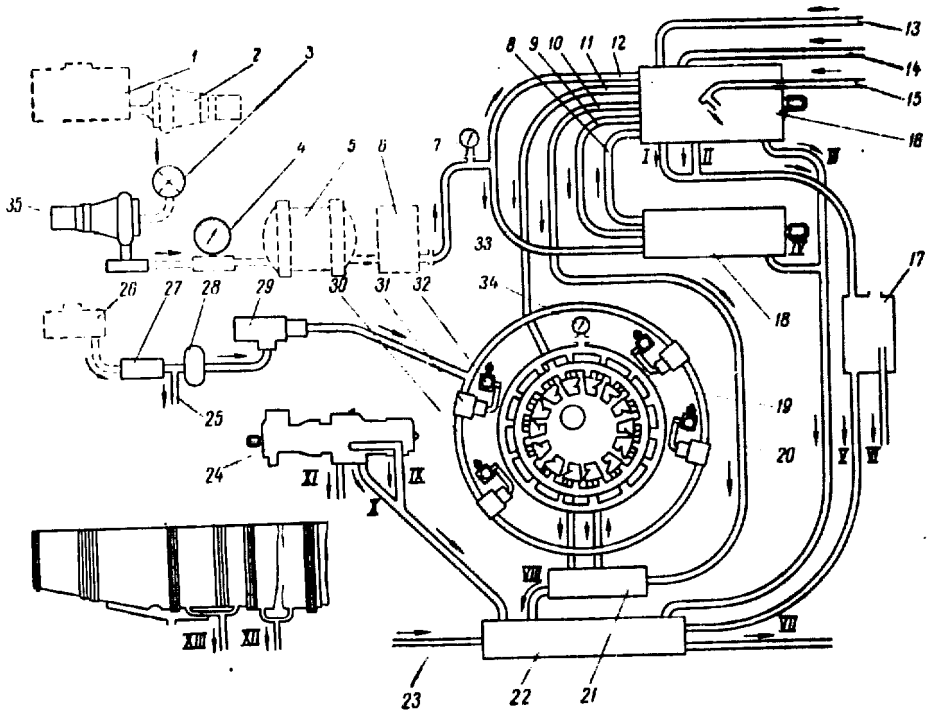

Fig. 1. Engine Fuel Supply System:

1 — main fuel tank; *2* — fuel booster pump; *3* — fuel shut-off valve; *4* — flow meter; *5* — fuel-oil cooler; *6* — screen filter; *7* — fuel pressure gauge installed at fuel pump inlet; *8* — fuel from ПН-28Б fuel pump throttle valve to ПН-15Б fuel pump distributing valve; *9* — fuel supply from ПН-15Б fuel pump to ПН-28Б fuel pump throttle valve; *10* — fuel feed from ПН-15Б fuel pump distributing valve to primary fuel manifold; *11* — fuel feed from ПН-15Б fuel pump distributing valve to main fuel manifold; *12* — fuel supply to ПН-15Б fuel pump; *13* — air from engine compressor to acceleration control unit; *14* — velocity head to barometric fuel control unit; *15* — air from engine compressor to starting fuel control unit; *16* — ПН-15Б fuel pump; *17* — flow-off tank; *18* — ПН-28Б fuel pump; *19* — primary fuel manifold; *20* — main fuel manifold; *21* — flow-of valve; *22* — drain tank; *23* — air from engine compressor to drain tank; *24* — С-300М fuel air combustion starter; *25* — air supply to С-300М starter; *26* — starting fuel tank; *27* — filter; *28* — ПНР10-3М starting fuel pump; *29* — electromagnetic valve; *30* — starting fuel manifold; *31* — filter with return valve; *32* — igniter; *33* — fuel to ПН-28Б fuel pump; *34* — fuel pressure gauge connected to primary fuel manifold; *35* — fuel booster pump

I — barometric fuel control unit drain; *II* — starting fuel control unit drain; *III* — drain from chamber between ПН-15Б fuel pump glands; *IV* — drain from chamber between ПН-28Б fuel pump glands; *V* — fuel drainage from flow-off tank into drain tank; *VI* and *VII* — drain beyond jet nozzle edge; *VIII* — drain from burner fuel manifold; *IX* — fuel drain from С-300М starter fuel system during starter starting; *X* — drain from centrifugal governor of С-300М starter fuel regulating pump; *XI* — fuel drain from combustion chamber casing of С-300М starter; *XII* — fuel drain from engine combustion chamber casing; *XIII* — fuel drain from nozzle diaphragm assemblies and engine turbine

22. Fuel regulating pumps:	
type	ПН-15Б and ПН-28Б
purpose	supply of fuel at starting and service operation of engine; control of engine and regulation of predetermined engine *r.p.m.* at all altitudes and flying speeds (beginning with automatic control speed) when engine control lever is stationary; regulation of fuel supply to engine during acceleration, and maintenance of minimum permissible fuel pressure at all altitudes
Transmission ratio	0.95
Sense of ration	counter-clockwise (looking from drive shaft end)
Automatic control range, (engine), *r.p.m.*	from 3500 to 4900 ± 15
Fuel pressure at inlets of pumps ПН-15Б and ПН-28Б, *kg/sq.cm.*	from 1.8 to 3.2
23. Fuel pressure in primary manifold:	
at maximum rating and different ambient temperatures, *kg/sq.cm.*	66 max.
point of pressure measurement	on primary manifold
minimum permissible fuel pressure at altitude, *kg/sq.cm.*	6
24. Main burners:	
type	centrifugal, two-chamber, two-stage
purpose	supply of atomized main fuel into engine combustion chambers
number	14

OIL SYSTEM

(Fig. 2)

25. Grades of oil used	МК-8, ГОСТ 6457-53, or transformer oil, ГОСТ 982-56, of any grade (with or without ВТИ-1 additive)
26. Oil pump:	
type	gear
purpose	delivery and scavenging of engine oil
number of sections	4 (one delivery and three scavenging sections)
transmission ratio	0.827
delivery section output at nominal rating and 4.5 *kg/sq.cm* counter-pressure, *lit/min*	60
capacity of each scavenging section at engine nominal rating and counter-pressure of 0.8 *kg/sq.cm., lit/min*	60
27. Oil consumption, *kg/hr*	1.5 max.
28. Rate of oil flow through engine at nominal rating and at maximum permissible and recommended temperature of oil at engine inlet, *lit/min*	33^{+5}_{-6}
29. Minimum quantity of oil in tank at which engine operation is still possible	depends upon the type of aircraft oil system and is specified in Aircraft Operating Instructions
30. Oil pressure in main line, *kg/sq.cm.*:	
at "emergency", maximum, nominal and 0.8 nominal ratings	from 3.5 to 4.5
at idling rating	1 min.
31. Oil inlet temperature, °C:	
maximum permissible	80
minimum permissible	minus 40
recommended	from 40 to 60
32. Maximum permissible oil outlet temperature, °C	105
33. Breather:	
type	centrifugal
purpose	separation of oil from engine vent system outlet air
transmission ratio	2.96

STARTING SYSTEM

(Fig. 3)

34. Type of starting system:	independent, automatic, consisting of С-300М starter with accessories, starting relay box and tachometer generator

The engine is equipped with the emergency starting plug connector, ensuring starting when the engine is supplied from generator operating at the autorotation speeds in case the storage batteries fail.

35. Starter:	
type	gas turbine engine
purpose	independent automatic starting of engine
power output at gas temperature in exhaust pipe not over 680°C, *H.P.*	90—100
fuel consumption at starter operating speed, *kg/hr*	from 85 to 100
starter operating conditions:	
operating speed range, *r.p.m.*	31000—33500
maximum temperature of gases in exhaust pipe at operating speed, °C:	
a) at ambient temperature up to +15°C	680 max.
b) at ambient temperature above +15°C	700 max.
maximum permissible speed of starter rotor (overspeed), *r.p.m.*	35000 max.
maximum permissible gas temperature in exhaust pipe during starter motoring, °C	800 max.
duration of starter operating cycle after depressing START button, *sec.*	80 max.
Starter service life (number of full operating cycles)	500 (within the engine service life)

The number of switchings of СА-1895М motor is max. 5 with 4-minute interval between them after that the motor is subjected to cooling during 15 *min.*

NOTE. When calculating starter service life, take into account only those startings which resulted in acceleration of the gas turbine starter to operating speed.

Number of automatic engine startings in succession	not over 4 with 4-minute intervals between startings and a 15-minute cooling interval after the 4th starting
Number of complete engine startings from 12САМ-55 storage battery (without boostcharging)	15 min.
36. Tachometer generator:	
type	ТД-1 generator with independent excitation
purpose	at starting, supplies power to command elements of relay box (signal relay) developing voltage proportionate to engine speed
number	1
37. Relay box:	
type	ПТ-4В
purpose	automatic cut-in and cut-out of starting units
number	1
operating conditions	allowable number of operating cycles 5, with 4-minute intervals and a 15-minute interval after 5 applications. There should be no more than 4 automatic startings out of 5 relay box cycles
38. Total consumption of fuel per one engine starting, *kg*	3 max.
39. Maximum temperature of gases in engine exhaust unit at starting, °C	690 max.
40. Time for gaining idling rating speed (1750^{+50} *r.p.m.*) after depressing START button, *sec.*	120 max.

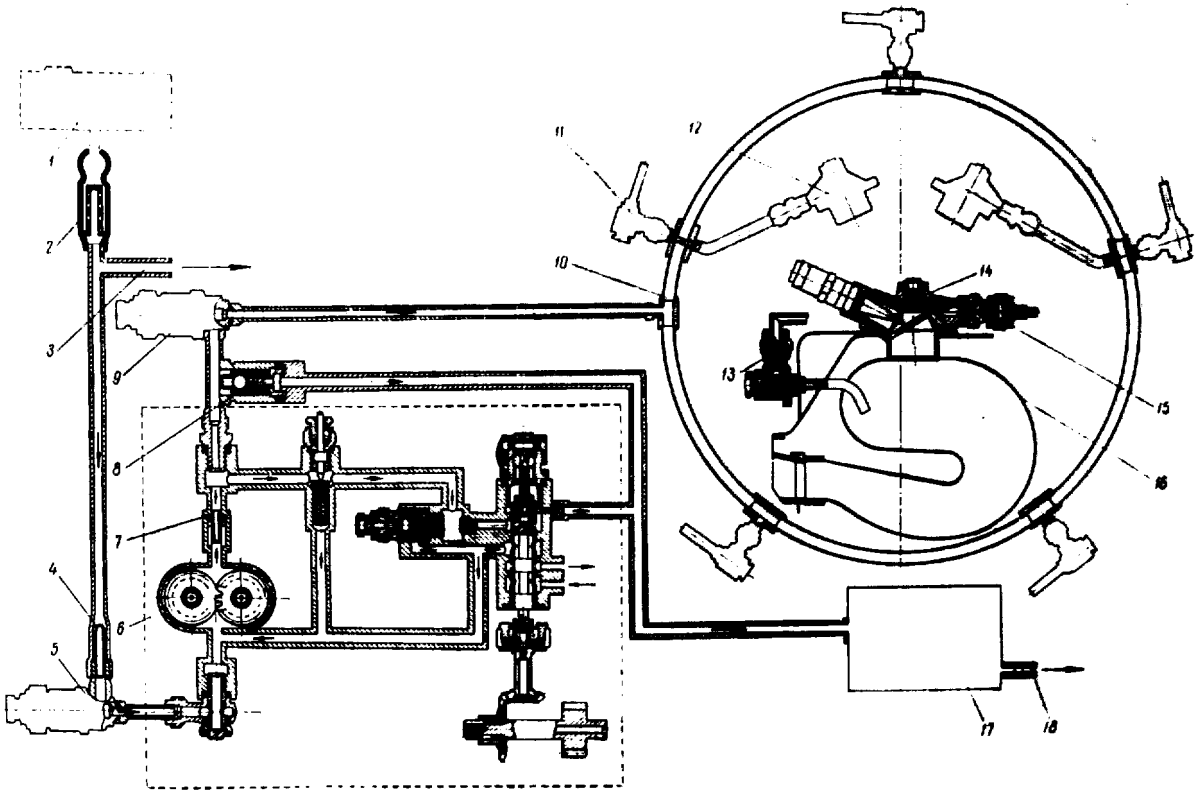

Fig. 3. C-300M Gas Turbine Starter Fuel System:

1 — starting fuel tank; *2* — filter on engine; *3* — fuel discharge to ПНР10-3М pump; *4* — filter on starter; *5* — 1st electromagnetic fuel control valve; *6* — ТНР-3Р fuel regulating pump; *7* — ТНР-3Р pump filter; *8* — valve for automatic elimination of vapor locks; *9* — 2nd electromagnetic fuel control valve; *10* — fuel manifold; *11* — main burner; *12* — igniter; *13* — main burner return valve; *14* — atomizer; *15* — starting burner return valve; *16* — combustion chamber; *17* — engine drain tank; *18* — discharge to jet nozzle edge

COMPRESSOR AIR BLEED SYSTEM

(Fig. 4)

11. Air for engine anti-icing system is bled from the following points:

from chamber behind compressor stage VII to warm up gas turbine starter fairing and inlet duct detachable struts;

from pressure balance chamber of compressor front casing to heat the inlet guide vane edges.

12. Air for aircraft anti-icing system is bled from the chamber behind compressor stage VIII:

number of flanges	1
amount of air bled at engine nominal rating, *kg/hr*	6000 ± 50

13. Air for supercharging pressurized cabins of aircraft is bled from the chamber over compressor stage VII

number of flanges	1
amount of air bled at engine nominal rating, *kg/hr*	620 ± 20

NOTE. Air flow rates indicated under Items 42 and 43 are corrected to standard atmospheric conditions.

IGNITION, ELECTRICAL, CONTROL AND EMERGENCY STARTING SYSTEMS

44. Type of ignition	vibratory sparking
45. Booster coil unit:	
a) for engine	КПН4-2Р1
purpose	supply of H.T. current to engine spark plugs
number	1
supply voltage, *V*	12–28.6
b) for starter	КП-21
purpose	supply of H.T. current to starter spark plugs
number	1
supply voltage, *V*	12–28.6
46. Starting spark plugs:	
a) for engine	СПН-4-3 of electric-erosion surface-discharge type
purpose	ignition of starting fuel at starting engine
number	4 (installed in flame tubes Nos. 3, 5, 10, and 12)
b) for starter	СД-55 АНМ type
purpose	ignition of starting fuel at starting gas turbine starter
number	2

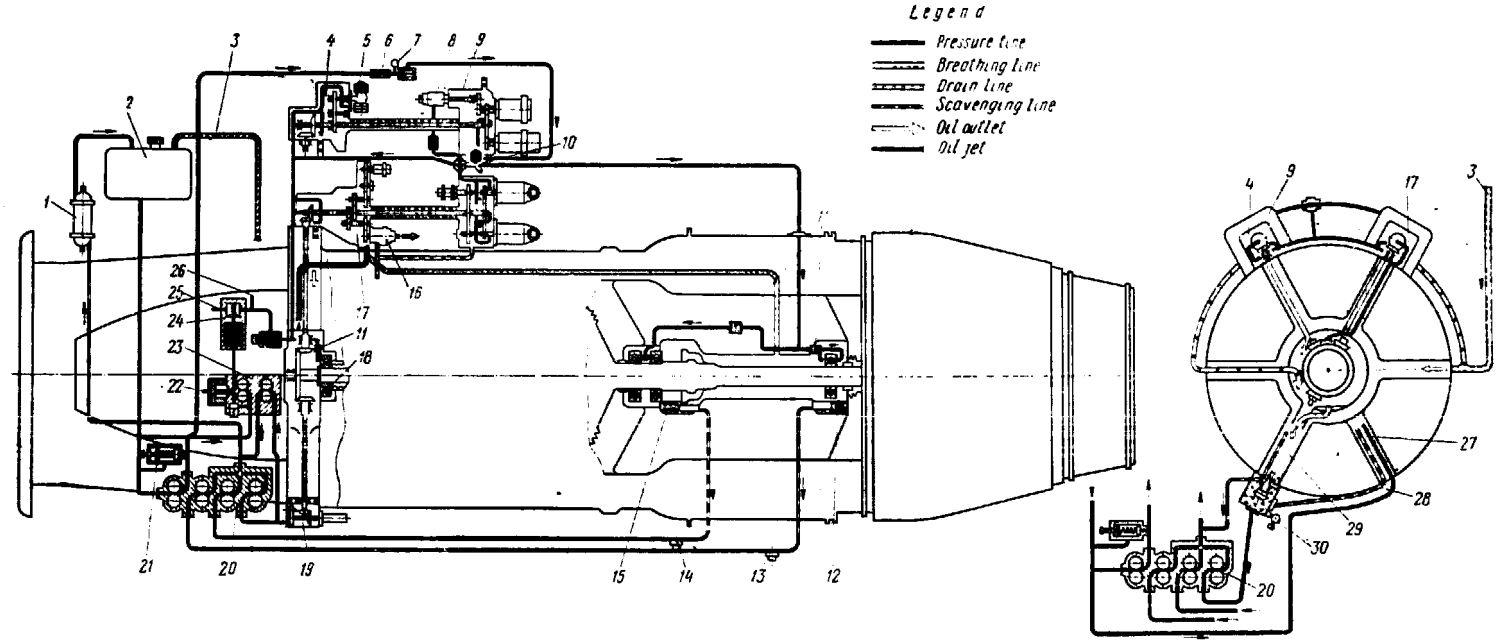

Fig. 2. Engine Lubricating System:

1 – fuel-oil cooler; *2* – oil tank; *3* – oil tank breathing pipe; *4* – right-hand intermediate drive; *5* – air compressor; *6* – oil filter; *7* – pressure gauge; *8* – centrifugal transmitter; *9* – engine wheel case; *10* – oil distributing unit; *11* – filter; *12* – rear support oil collector; *13* – engine rear support oil drain plug; *14* – engine middle support oil drain plug; *15* – engine middle support oil collector; *16* – centrifugal breather; *17* – left-hand intermediate drive; *18* – engine front support bearing; *19* – front casing oil sump; *20* – oil pump unit; *21* – oil pump unit pressure control valve; *22* – oil supply to THP-3P fuel regulating pump; *23* – starter oil pump; *24* – starter oil filter with return valve; *25* – oil supply for lubricating starter bearings; *26* – oil supply to СД-24А oil pressure warning unit; *27* – pipe for feeding oil from oil tank into starter oil pump; *28* – pipe for feeding oil from lower drive into starter oil pump; *29* – pipe for passing oil from starter oil pump into tank; *30* – drain cock

43. Air for supercharging pressurized cabins of aircraft is bled from the chamber over compressor stage VII:	
number of flanges	4
amount of air bled at engine nominal rating, *kg/hr*	620±20

NOTE. Air flow rates indicated under Items 42 and 43 are corrected to standard atmospheric conditions.

purpose	sion surface-discharge type ignition of starting fuel at starting engine
number	4 (installed in flame tubes Nos. 3, 5, 10, and 12)
b) for starter	СД-55 АНМ type
purpose	ignition of starting fuel at starting gas turbine starter
number	2

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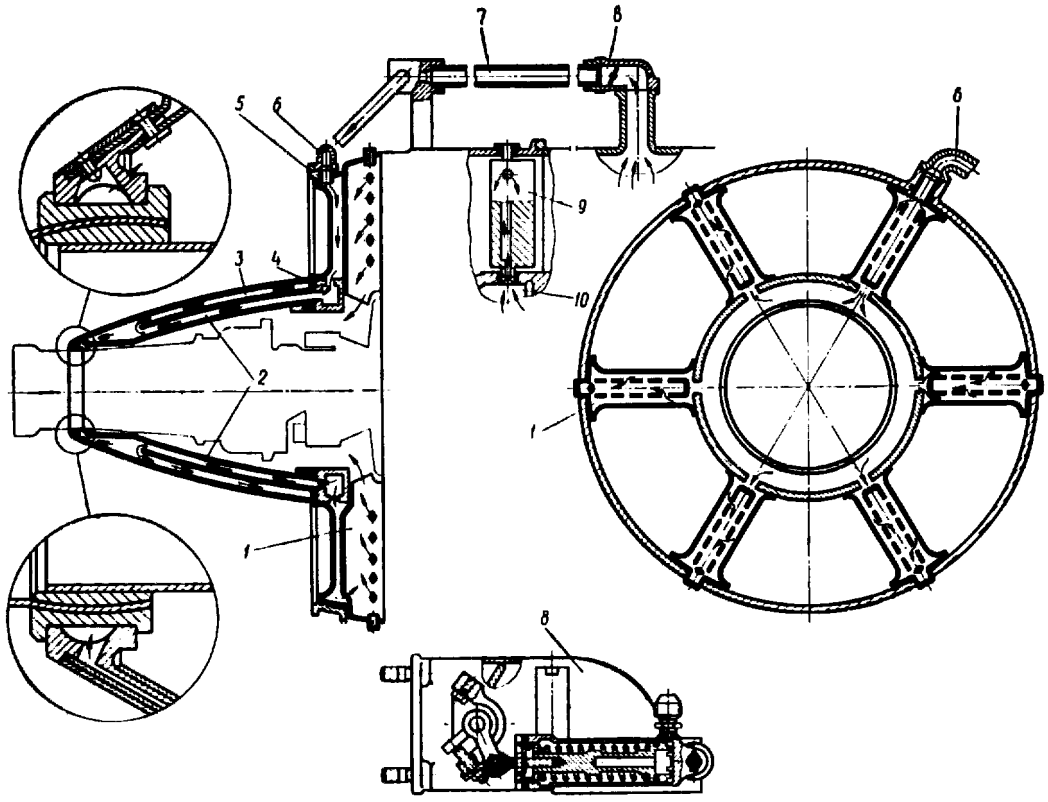

Fig. 4. Diagram of Anti-Icing Device:

1 — front casing struts; *2* — starter fairing channels used for delivering hot air to fairing front section; *3* — fairing channels used for heating entire surface of fairing; *4* — fairing manifold; *5* — diffuser support; *6* — branch pipe for delivery of hot air to front casing; *7* — air inlet pipe; *8* — control valve for bleeding air from compressor; *9* — inlet guide vanes; *10* — front pressure balance chamber

47. Air blow-off band control mechanism for by-passing air from chamber after compressor stage III:
- type ..... air, piston
- air pressure in blow-off band control system, *kg/sq.cm* ..... 40±5
- air reducer 52512700
- number 1
- electromagnetic air valve 25M
- purpose ..... control of air supply to blow-off band mechanism
- number 1

48. Centrifugal transmitter controlling compressor air blow-off band mechanism:
- type ..... ЦД-3, centrifugal, single-duty
- purpose ..... automatic operation at predetermined engine speed of electromagnetic air valve in air blow-off band control mechanism
- transmission ratio 1.33
- number 1

49. Starter exhaust pipe shutter control (not included in engine standard equipment):
- type ..... МЗК-2, electromechanical
- number 1

50. Pneumatic contactor:
- type ..... НК, membrane
- purpose ..... automatic operation of starter exhaust pipe shutter control mechanism

AIRCRAFT ACCESSORIES

51. Generators:
- type ..... ГСР-18000Д, shunt excitation
- purpose ..... power supply of aircraft electrical system
- sense of rotation ..... counter-clockwise
- transmission ratio 1.875
- number 2

52. Air compressor:
- type АК-150Н
- purpose ..... supply of compressed air to aircraft pneumatic system
- sense of rotation ..... clockwise
- transmission ratio 0.428
- number 1

53. Hydraulic pump:
- type ..... 435ВФ, plunger

purpose	building up pressure in aircraft hydraulic system
sense of rotation	clockwise
transmission ratio	0.468
number	1

NOTE. Type AK-150II, 435BΦ units, ГСР-18000М generators are furnished with engines.

54. Time relay box:

type	АЗД-60
purpose	in-flight automatic starting of engine
number	1

NOTE. АЗД-60 time relay box is not furnished with the engine.

Chapter II

ENGINE ELECTRICAL EQUIPMENT

The electrical equipment includes the sources of power supplying the aircraft and engine power consumers, the engine and starter starting units, as well as the units controlling in-flight emergency starting, compressor air blow-off system and emergency rating cutting-in equipment.

POWER SOURCES

The D.C. electrical system of the aircraft is supplied from two ГСР-18000М D.C. generators of 18000 W each. They are mounted on the aircraft gearbox.

Each generator operates in collective with the following units: carbon-pile voltage regulator РУГ-82, reverse current cut-out relay ДМР-600АМ, balast resistor БС-18000, stabilizing transformer ТС-9М. The enumerated equipment is located on the aircraft and used for provision of constant voltage at different engine speeds. The equipment protects the system against reverse current during shut-down and idling rating of the engine (protects the storage batteries from being discharged), ensures parallel operation of the generators, reduces the amplitude and duration of voltage fluctuations at engine transient ratings.

STARTING ELECTRICAL UNITS

The starting system electrical units comprise the following components: engine and starter ignition units (four booster coil units КПП4-2Р1, one booster coil КП-21, four spark plugs СПП-4-3 and two spark plugs СД-55АПМ), engine fuel system units (electric motor МУ-102А driving the starting fuel pump), electromagnetic fuel control valve, units serving the С-300М fuel-air combustion starter (electric unit МЗК-2, pneumatic contactor, starting electric motor СА-189бМ, two electromagnetic fuel control valves), and the units ensuring engine starting control (tachometer generator ТД-1, relay box ПТ-4В).

The КП-21 vibratory booster coil is designed to supply H.T. current to two СД-55АПМ spark plugs of the С-300М starter and consists of an induction coil with a breaker connected to the primary winding. The spark plugs are connected to the induction coil secondary winding.

The vibratory КПП4-2Р1 booster coil units are designed for H.T. current supply to СПП-4-3 spark plugs. They are located at the bottom side of the engine (two booster coils on the right-hand side and two on the left-hand side). Each booster coil unit serves one spark plug СПП-4-3 and comprises two induction coils with breakers and selenium amplifiers.

The primary winding of the КП-21 booster coil and КПП4-2Р1 booster coil unit are supplied with 12 -28.6 V current.

The СД-55АПМ spark plugs are non-detachable, shielded, with ceramic core insulation. They form a component of the С-300М turbo-starter igniters. The spark plugs ensure ignition of starting fuel by means of spark discharging between the spark ping central electrode and igniter discharger.

The СПП-4-3 spark plugs are of the electric-erosion surface discharging type. They are also non-detachable, shielded, with ceramic core insulation. They are designed for ignition of engine starting fuel and form component part of the engine igniters. Starting fuel is ignited by electric sparks jumping between the central and side electrodes. The spark plug gap is formed by the circular surface between the central and side electrodes, which is coated with electrode material, diffused by the electro-erosion method. The coating is renewed during every ground starting of the engine as a result of sparking after starting fuel supply is cut off.

The МУ-102 electric motor with series excitation is of special explosion-proof design and serves to drive the НПР-10-3М starting fuel pump. The electric motor nominal power is 60 W with the current being 6.6 A.

The МЗК-2 electric unit comprises a reversible electric motor with electromagnetic braking device and a five-stage planetary reduction gear. It provides for opening (at the beginning of starting) and closing (after starting) of the shutter

of the C-300M turbo-starter exhaust unit. The M3K-2 electric unit is controlled by means of a pneumatic contactor. The pneumatic contactor is of the membrane type and comprises a contact device (microswitch). The pneumatic contactor switches the M3K-2 electric unit circuit for closing the turbo-starter exhaust unit shutter at a pressure in the membrane chamber within 0.4—0.45 *kg/sq.cm.* (the air is fed from the chamber after the engine compressor), which corresponds to an engine speed of 1850—2050 *r.p.m.* As the pressure fed to the membrane chamber drops below 0.35 *kg/sq.cm.* the pneumatic contactor is switched over to reverse supply of the motor windings.

The CA-189БМ series excitation electric motor is intended for accelerating the turbo-starter during starting. The CA-189БМ electric motor is cut in and out automatically by means of the ПТ-4В relay box. Automatic cutting-out of the CA-189БМ electric motor is effected when the starter has attained 8000—12500 *r.p.m.*

The electromagnetic fuel valves are used to turn on fuel supply to the turbo-starter while the latter is being operated.

ENGINE STARTING CONTROL UNITS

The engine starting control units comprise a tachometer generator and starting relay box ПТ-4В.

These units ensure the required sequence of starting operations.

The ТД-1 tachometer generator is a D.C. generator with independent excitation, designed to energize the signal relays, whose voltage is proportional to engine speed.

The tachometer generator is mounted on the C-300M starter. It starts rotating from the moment of engine acceleration by the starter and is turned off when the starter is disengaged.

The ПТ-4В starting relay box comprises all the engine electrical equipment relays, being the principal commutating device when starting the engine. Housed inside the starting relay box are the following units: РМО-4В maximum speed relay, КМ-200 contactor for CA-189БМ electric motor control; two РЛН-4 signal relays adjusted to certain engine speeds, seven intermediate relays ТКЕ52ПК, automatic starting relay ТКЕ53ПК, КМ-25 contactor for starting fuel control, КМ-100 contactor of engine ignition system, 4 resistors for adjusting the signal relays and one resistor for adjusting РМО-4В relay. The signal relays adjusted with respect to the engine *r.p.m.* operate in certain succession, being supplied from the tachometer generator. The signal relays receive the tachometer generator pulses and make up a respective intermediate relay depending on the engine speed. The intermediate relay, in its turn, cuts in the respective starting unit of the engine. Starting of the engine is effected automatically by pressing the START BUTTON (with the engine electric system preliminarily connected to the aircraft mains and the engine control lever set in the IDLING RATING position).

COMPRESSOR AIR BLOW-OFF SYSTEM CONTROL UNITS

The control units (centrifugal transmitter and electromagnetic air valve) ensure automatic operation of the compressor blow-off band control mechanism, opening or closing the compressor blow-off ports.

At a speed of 3800+50 *r.p.m.* the ЦД-3 centrifugal transmitter actuates the limit switch, thereby cutting in the electromagnetic air valve circuit.

The electromagnetic air valve opens compressed air supply (bled from the aircraft air system via air reducer 52512700) to the pneumatic mechanism of piston type, which operates the blow-off band control mechanism closing the compressor ports.

At an engine speed of below 3800+50 *r.p.m.* the electromagnetic air valve is de-energized, thereby cutting off compressed air supply to the piston pneumatic mechanism. Under the pressure of the spring the mechanism releases the blow-off band and opens the compressor blow-off ports.

On an inoperative engine the electromagnetic air valve may be operated (to close the compressor blow-off ports) through pressing a special button located on the right-hand top side of the engine (near the centrifugal transmitter).

In case of fire the engine is shut down, which is followed by closing the blow-off band and engine nacelle shutters. This prevents the flame-suppressing gas from escaping the engine nacelle space into the atmosphere.

To close the blow-off band concurrently with cutting-off fuel supply and shifting the engine control lever to the stop position in case of fire, provision is made for a limit switch of ВК2-140РТ type which is interlocked with the engine control lever and electrically connected in series with the aircraft thermal warning units.

When one of the thermal units operates, the pilot is aware of the fire by a signal which demands immediate action on the part of the pilot to shut down the engine. When the engine control lever is shifted to the STOP position, the limit switch operates and makes the compressor blow-off band close.

FUNCTIONING OF ELECTRIC EQUIPMENT SYSTEM

All the relays, switches and buttons in the wiring diagram are shown in OFF positions.

The electric equipment system performs the following operations:

1. Automatic starting of the engine on the ground.
2. Cold-cranking of the engine.

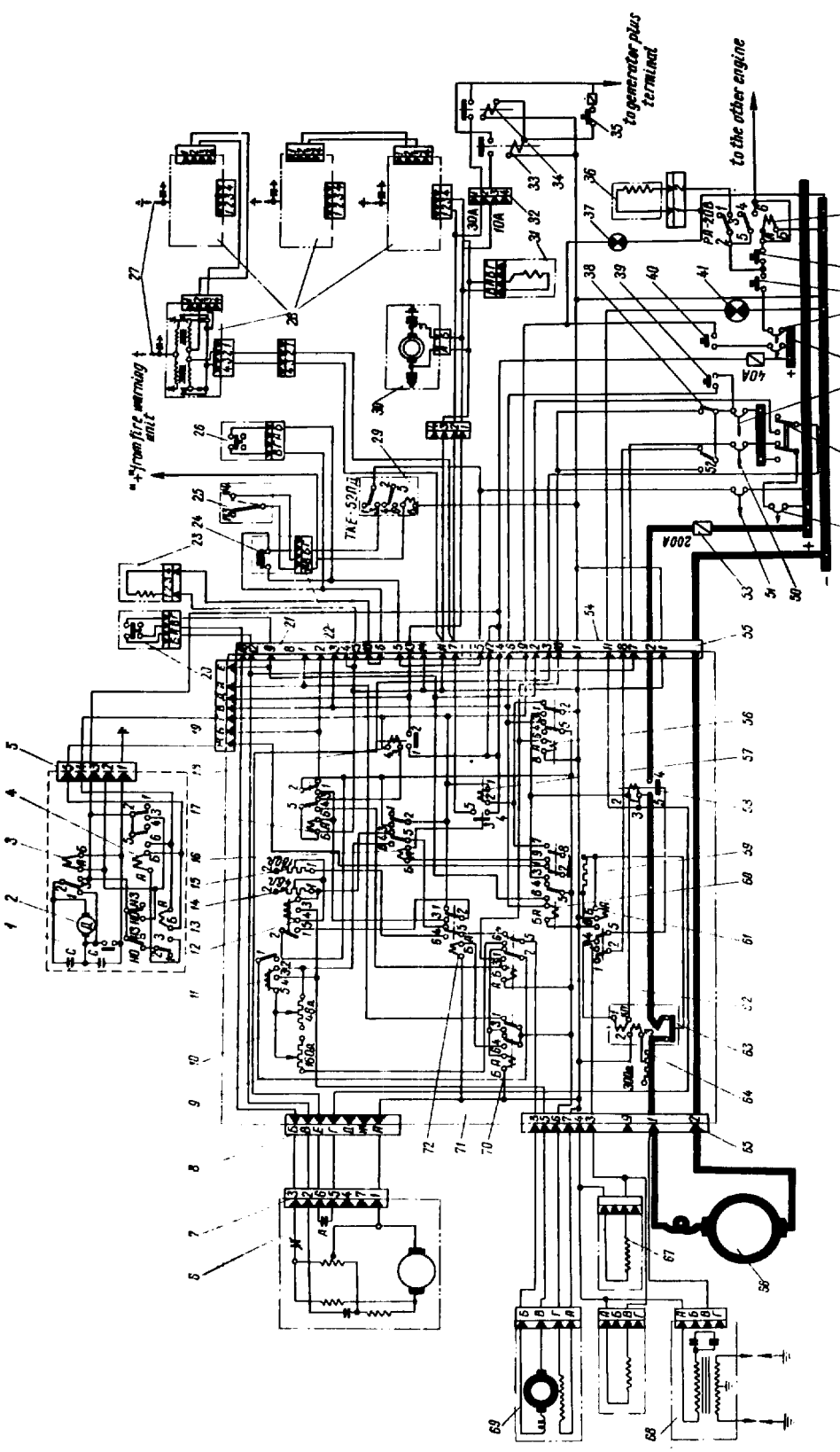

Fig. 5. Wiring Diagram:

1 – АЗЗ 60 time relay; *2* – ДР electric motor; *3* – ТКЕ21ПК electric motor cut-in relay; *4, 16, 17, 62, 70* and *72* – ТКЕ5ПК intermediate relays; *5* – ШР30Г5НШ10 plug connector; *6* – МЗК-2 electric unit (starter exhaust unit shutter control); *7* – ШР28Б7НШ7 plug connector (from МЗК-2 unit); *8* – ВШ 7 (ШУ 7) plug connector; *9, 10, 14* and *15* – adjustable resistor for tuning Р-ЗН-4 relay; *11* and *12* – РЭН-4 signal relay; *13* – ТКЕ21ПК intermediate relay; *18* – КМ-25 contactor (starting fuel supply control); *19* – ВШ 7 (ШП 7) plug connector; *20* – pneumatic contactor; *21* – ШР40П6Ш12 plug connector for engine wiring; *22* – ВШ 4 (ШП-4) fire fighting system plug connector; *23* – electromagnetic air valve; *24* – manual control button of air blow off band electromagnetic air valve; *25* – ВК-2 МРТ limit switch; *26* – ЦД-1 centrifugal transmitter; *27* – СПН 43 spark plug; *28* – КПН 4 spark booster unit; *29* – ТКЕ5ПД1 relay; *30* – ПНР10-3М starting fuel pump; *31* – electromagnetic fuel valve; *32* – ШР20П4Н4Ш8 plug connector (emergency starting); *33* – КМ 25 contactor (starting fuel supply control); *34* – КМ 100 contactor (emergency ignition); *35* – emergency starting in air control button; *36* – emergency raising control electromagnetic valve; *37* – АЗЗ 60 time relay pilot lamp; *38* – engine cold cranking switch; *39* – starting in air button; *40* – starting button; *41* – starter exhaust unit shutter pilot lamp (МЗК unit); *42* – ТКЕ5ПД relay (emergency raising control); *43, 44* – emergency raising control button; *45* and *47* – АЖС 15 circuit breaker; *46* – master switch; *49* – АЖС 25 circuit breaker; *48* – АЖС 5 circuit breaker; *53* – НП-300 fuse; *54* – ШР28П2НШ1 line plug connector; *55* – ШР40П3НШ9 line plug connector; *56* – ТКЕ5ПК relay (ensure system cut-off); *57* – КМ 100 contactor (ignition ON control); *58* – КМ-300 contactor (СА 186БМ motor "ON" control); *59* – ПЭВ 10 10 ohms vitrified resistor; *60* – КЕ5ПК relay (automatic starting); *61* – ТКЕ5ПД relay (gas turbine starter fuel supply control); *63* – РМО 4В maximum speed relay (СА 186 БМ motor cut-out control); *64* – РМО 4В relay tuning resistor for cut-out speed; *65* – ШР44П9Ш1 plug connector for oil starter wiring; *66* – СА 186БМ electric motor; *67* – electromagnetic fuel valves; *68* – КП-21 booster coil; *69* – ТЭ-1 tachometer generator; *71* – ПТ-4В starting relay box

3. Cold-cranking of the starter.
4. In-flight starting of the engine.
5. Cutting-in the emergency rating.
6. Emergency starting of the engine in the air.

ENGINE AUTOMATIC STARTING ON GROUND

For automatic starting of the engine perform the following operations:

1. Open the fuel shut-off valve.
2. Turn on master electric switch *48* (Fig. 5).
3. Switch on A3C-25 circuit breaker *49*.
4. Start the aircraft booster fuel pumps.
5. Shift the engine control lever to the idling rating transitional stop.
6. Press STARTING (ЗАПУСК) button *39* and release it after one or two seconds.

After the above listed operations all the starting units are switched on automatically in proper succession, and the engine should smoothly gain the idling speed in not more than 120 seconds.

When master switch *48* is switched on, with the A3C-25 circuit breaker *49* cut in, the current is supplied to terminals 2, 3 and 8 of plug connector *54* and to the panel with the starting buttons and switches.

Voltage from terminal 2 of plug connector *54* is applied to terminal 6 of relay *60* and, through pneumatic contactor *20*, to motor 6 of the M3K-2 electric unit (via terminals 9 of plug connector *21*, terminal "Г", normally closed contacts and terminal "В" of the pneumatic contactor, terminal 16 of plug connector *21* terminal "Б" of plug connector *8* and terminal 3 of plug connector *7*).

Electric motor *6* of the M3K-2 electric unit starts rotating, thereby opening the C-300M starter exhaust unit shutter. 6 to 10° before complete opening of the shutter the signal contacts "А" of electric unit *6* get closed. In this case current from terminal 3 of plug connector *54*, through terminal "Е" of plug connector *8*, terminal 6 of plug connector *7*, contact "А", and terminal 5 of plug connector *7* flows to terminal "Г" of plug connector *8*, whence the current is directed via terminal 11 of plug connector *54* to pilot lamp *41* (which flashes up) and to winding terminal 1 of contactor *58*, thereby preparing the cutting-in circuit of this contactor. In this way contactor *58* serves as an interlocking device preventing starting of the C-300M starter when the exhaust unit shutter is closed. The winding minus of contactor *58* is connected to the aircraft mains busbar via contacts 2—3 of relay *60* which operates after START button *39* is pressed.

From terminals 4 and 12 of plug connector *54* the voltage is fed to terminal 4 of contactor *57* and terminal 1 of contactor *18*.

From terminal 8 of plug connector *54* the voltage is applied to terminal 2 of relay *61*.

With START button *39* pressed down, the current flows through the button and terminal 6 of plug connector *54* to the winding of relay *60* (terminal "А"); the minus end of the winding is permanently connected to the minus of the aircraft mains.

Relay *60* operates, closing contacts 5—6, 2—3 and 8—9.

After button *39* is released, relay *60* remains in the ON position, since its winding (terminal "А") is supplied with current through another circuit: from terminal 2 of plug connector *54* via closed contacts 6—5 of relay *60* and normally closed contacts 5—4 of relay *56*. Thus, relay *60* is interlocked. Besides, current from terminal 2 of plug connector *54* is supplied via closed contacts 6—5 of relay *60* to the excitation winding of tachometer generator *69* (from terminal 5 of relay *60* via terminal 6 of plug connector *69*, and terminal "Г" of the tachometer generator connector). The minus end of the tachometer generator excitation winding is permanently connected with the aircraft mains through terminal "А" of its plug connector, terminal 7 of plug connector *65* and terminal 1 of plug connector *54*. The voltage is also applied to terminal "А" of relay *62*, terminals 2—5 of relay *70*, terminal 3 of relay *16* and to terminals 2 of relays *11*, *12* and *17*.

The closed contacts of relay *60* make effective the following negative connections with the aircraft mains: the winding negative end of relay *16* (contact "Б") through contacts 8—9; the winding negative end of contactor *58*, the winding negative end of maximum speed relay PMO-4B and terminal 3 of relay *56* through contacts 2—3.

Consequently, with relay *60* cut in (after pressing START button *39*), contactor *58* and then relay PMO-4B are actuated with the help of the shut winding which is fed with current from the power supply circuit (from terminal 3 of contactor *58* via normally closed contacts 5—4 of relay *61*).

After PMO-4B relay *63* has operated, the following units of the C-300M starter are put into operation:

a) CA-189БМ electric motor *66* that begins to spin the C-300M starter. Simultaneously, the series winding of PMO-4B relay *63* is energized; this winding is connected in series with the CA-189БМ electric motor line.

The compensating winding of the PMO-4B relay is also put into action being fed from the power supply mains through tuning resistor *64*. Tuning resistor *64* enables the PMO-4B relay to be adjusted with respect to the CA-189БМ electric motor cut-out speed. The ampere conductors of the compensating winding counteract the ampere conductors of the series winding;

b) the ignition system, since КП-21 starting booster coil *68* is parallel-connected with the CA-189БМ electric motor;

c) electromagnetic fuel valves *67* via relay *61*, whose windings are supplied from terminal 4 of relay *63*.

The electromagnetic fuel valves offer fuel supply to the C-300M starter. These valves are energized from terminal 8 of plug connector *54* via

closed contacts 2—3 of relay *61*, through terminal 3 of plug connector *65*, terminal "B" of their plug connectors. With relay *61* cut in, normally closed contacts 5—4 are broken, thereby de-energizing the shunt winding of relay *63*.

Relay *63* remains engaged until the effort produced by the series winding exceeds the sum of efforts created by the compensating winding and spring, which tend to transfer PMO-4B relay *63* to the OFF position.

With the C-300M starter gaining speed, the turbine power increases, decreasing at the same time the current consumed by the CA-189BM electric motor and hence the current flowing through the series winding of relay *63*.

Therefore, the effort produced by the PMO-4B relay series winding decreases, which owing to the action of the spring and compensating winding will result in an automatic dropping-out of relay *63* and switching off of the CA-189BM electric motor, as soon as the starter is accelerated to 8000—12500 *r.p.m.* By that time relay *61* is still in the ON position (being fed through contacts 5—6), thus ensuring the operation of the electromagnetic fuel valves until the starting automatic control system is entirely de-energized.

When the engine starts rotating (after the hydraulic coupling of the C-300M starter is engaged), tachometer generator *69* also begins to spin, thereby generating voltage in proportion to the engine speed. The tachometer generator voltage is delivered to the windings of signal relays *11* and *12* through terminals "Б" and "В" of the tachometer generator plug connector, terminals 5 and 8 of plug connector *65*. From terminal 8 of plug connector *65* the tachometer generator voltage is applied first to the windings of relay *12* via normally closed contacts 5—4 of relays *62*, *72*, *16* (to terminal 3, if by-passing adjustable resistor *14*, and to terminal 5, if supplied through resistor *14*).

Thus, at the beginning of engine rotation the windings of signal relay *12* are cut into the tachometer generator circuit. As the engine reaches a speed of 220 to 280 *r.p.m.* the voltage built up by the tachometer generator becomes sufficient for operation of relay *12*. Signal relay *12* picks up and supplies current to the windings of contactor *57* (to terminal "A") and contactor *18* (to terminal 4) via signal relay closed contacts 2—1 and normally-closed contacts 2—1 of relay *72*.

Besides, the current is fed to terminal 2 of relay *16* and terminal "Г" of signal relay plug connector *19*. Contactors *57* and *18* operate and switch on the ignition system and the starting fuel pump (current from the aircraft mains is fed via terminals 4 and 12 of plug connector *54*, closed contacts 4—3 and 1—2 of contactor *57*, terminal 7 of plug connector *21* and intermediate plug connectors to booster coil units *28*, which cuts in the ignition system, whereas the closed contacts 1—2 of contactor *18*, terminal 13 of plug connector *21* and the intermediate plug connectors feed current to the electric motor of starting fuel pump *30* and to electromagnetic fuel valve *31*).

Simultaneously, current is supplied to terminal "Д" of plug connector *19*. From terminal 1 of contactor *57* the voltage is applied not only to the ignition system control, but also to the winding of relay *16* (terminal "A"), which picks up. Functioning of relay *16* breaks its contacts 5—4 and makes its contacts 5—6; therefore, the winding of signal relay *12* is cut out of the tachometer generator circuit; instead, the windings of signal relay *11* are cut into the circuit (one winding is cut in through resistor *10*, the other — directly). Closed contacts 3—2 of relay *16* also offer another blocking circuit for current supply to the winding of contactors *57* and *18*.

As the engine speed rises approximately to 300 *r.p.m.* relay *11* picks up to feed the current to the winding of relay *70* (terminal "A") via closed contacts 2—1 of relay *11* and normally closed contacts 2—1 of relay *62*.

Relay *70* operates and gets interlocked through its closed contacts 2—3.

Closed contacts 5—6 of relay *70* bring relay *72* into operation, which results in breaking contacts 4—5 and making contacts 5—6 of relay *72*. Hence, the windings of relay *11* are cut out of the tachometer generator circuit, whereas those of relay *12* are cut in. This time, one winding of relay *12* is connected via resistor *15*, the other winding — through resistors *15* and *14*.

The operation in question (functioning of relay *11*) was used for opening the ПТР valve in the AM-3 engine and is not used in 25M-500 engine.

When the engine speed reaches 740—880 *r.p.m.* relay *12* operates for the second time to deliver current to the winding of relay *17* (terminal "A") via closed contacts 2—1 and contacts 2—3 of relay *72*. Relay *17* picks up and gets blocked through its closed contacts 2—3. Broken contacts 5—4 of relay *17* cut out the minus line of the winding of contactor *18* that drops out and switches off the starter fuel pump. The ignition system still remains cut in to be used for exercising the spark plugs. Closed contacts 5—6 of relay *17* connect the winding minus end of relay *62* (contact "Б") to the minus busbar. Relay *62* operates. As a result of breaking of contacts 5—4 and making of contacts 5—6 of relay *62*, relay *12* is cut out and relay *11* is cut into the tachometer generator circuit via resistors *9* and *10* this time.

When the engine accelerates to 1150—1250 *r.p.m.* relay *11* operates. In this case, the current flows to the winding of relay *56* (terminal "A") through its closed contacts 2—1 and contacts 2—3 of relay *62*. Relay *56* picks up, thereby breaking its normally closed contacts 5—4, which results in cutting out of the winding of automatic starting relay *60* and, hence, in cutting out of the entire automatic starting system; the engine ignition system is de-energized, KM-200 contactor *58* is cut off and then relay *61* drops out, switching off the starter electromagnetic valves. At this, the C-300M starter is switched off and the engine

proceeds with gaining the idling rating speed by itself.

Upon starting the engine, at a speed of 1850–2050 *r.p.m.*, pneumatic contactor *20* actuates (in response to a pressure rise at the compressor outlet), thereby making the supply circuit of M3K-2 electric mechanism *6* to close the C-300M starter exhaust unit shutter. In this case, the current flows from terminal 2 of plug connector *54* through terminal 9 of plug connector *21*, terminal "Г", closed contact and terminal "A" of the pneumatic contactor plug connector *20*, terminal 12 of plug connector *21*, terminal "B" of plug connector *8*, terminal 2 of plug connector *7*, then through the closed contacts of the electric unit to be fed to the electric motor winding. The electric motor of M3K-2 unit *6* closes the C-300M starter exhaust unit shutter, preventing the starter from autorotation in flight. At the same time signal contacts "A" of electric unit *6* are opened by its cam and the supply circuit of contactor *58* is broken. When contactor *58* is switched off, starting of the starter with the engine running at speeds exceeding 1850–2050 *r.p.m.* is rendered impossible. Electric unit *6* also closes the starter exhaust unit shutter in case master switch *48* is turned off. In this case, the current is fed through terminal *7* of plug connector *54* to follow the same way as for operating pneumatic contactor *20*.

As soon as the engine gains a speed of 3800+50 *r.p.m.*, centrifugal transmitter *26* functions. Then current is fed from the aircraft mains (from terminal 5 of plug connector *54*, terminals 5, 6 and 10 of plug connector *21*) through the centrifugal transmitter limit smitch to electromagnetic air valve *23* that admits compressed air to the air blow-off band mechanism.

Button *24*, cut in parallel with the centrifugal transmitter limit switch, serves to close the blow-off band mechanism when the engine is inoperative.

COLD-CRANKING OF ENGINE

Switching on master switch *48* gets the automatic starting system ready for cold-cranking of the engine. Upon switching on of ENGINE COLD-CRANKING SWITCH *38* current is supplied from terminal 10 of plug connector *54* to the winding of relay *56*. Relay *56*, whose contacts 2–3 get closed, operates contactor *58* which, in turn, cuts in the shunt winding of relay *63*.

Upon operation of relay *63* current flows to CA-189ДМ electric motor *66*, booster coil КП-21 and to the winding of relay *61* (from its terminal 4). Relay *61* operates, thereby breaking contacts 5—4 of the РМО-4В relay shunt winding circuit and closing contacts 2—3 to supply current to electromagnetic fuel valves *67*. Through its closed contacts 5–6 relay *61* is blocked. The C-300M starter gets started and begins cranking the engine.

Cold-cranking of the engine is stopped by turning off switch *38* which turns off relay *56*, contactor *58* and relay *61* — fuel supply to the starter is cut off.

COLD-CRANKING OF STARTER

To cold-crank the starter it is necessary to turn on master switch *48* and STARTER COLD-CRANKING switch *52*. The sequence of operating processes in the automatic starting system is the same as after cutting in the ENGINE COLD-CRANKING switch with the sole difference that with the STARTER COLD-CRANKING switch turned on, the starter electromagnetic fuel valve circuit is broken. The starter is not supplied with fuel and is therefore not started.

STARTING ENGINE IN AIR

The engine is started in the air automatically. To start the engine in flight, switch on A3C-5 circuit breaker *46* and keep STARTING IN AIR button *40* pressed for about 2 *sec*. The positive from the aircraft mains is applied through the STARTING IN AIR button to the following units:

a) pilot lamp 37 of АЗД-60 time relay *1*;

b) control winding of ignition system contactors *57* and fuel supply contactor *18* through terminal 9 of plug connector *54*;

c) winding of relay 13 via terminal 9 of plug connector *54*, terminal "Г" of plug connector *19*, and terminal 2 of plug connector *5*. Relay 13 operates and energizes the winding of relay 4 (through its contacts 2—3 and disc switch "A" contacts "О-НО"). Relay *4* picks up delivering current through its contacts 2—3 to energize the winding of relay *3* and through contacts 5—6 to block relay *13*, contactors *57*, *18* and pilot lamp *37*. In this way, delivery of starting fuel and high-tension current for igniting the fuel lasts 56.5 seconds.

Relay *3* operates and starts type Д-2Р electric motor *2* of switch box drive mechanism. Electric motor *2* begins rotating and turning the switch box discs. Two seconds later, relay *3* gets blocked through closed switch contacts "О-НО" of disc switch "О" and is kept in that position for 60 seconds.

EMERGENCY STARTING OF ENGINE IN AIR

Emergency starting of the engine in the air is effected through a simultaneous supply of starting fuel and high-tension igniting current into the inoperative engine in flight. In this case, ПНР10-3М starting fuel pump *30* and КПН4-2Р1 booster coil units *28* are fed from the engine generators rotating at autorotation *r.p.m.*

To supply starting fuel and restore the combustion process in the engine press EMERGENCY ENGINE STARTING IN AIR control button *35*. This will result in cutting in emergency starting contactors *30* and *34* which ensure immediate switching on of the starting fuel pump and ignition system via terminals 2 and 4 of emergency starting system plug connector *32*.

Notes: 1. The EMERGENCY ENGINE STARTING button should be kept depressed throughout the entire starting process but not longer than 60 *sec*.
2. On restarting the engine in the air by means of the emergency starting system exercise the СПН-4-3 spark plugs two times to recondition them as described in Section I of Chapter V (see "Note").

SWITCHING ON EMERGENCY RATING

To switch on the "emergency" rating of the engine, proceed as follows:

1. Turn on A3C-5 circuit breaker *45* if it is cut out.

2. With the engine operating at the maximum rating press the switch of the engine "emergency" rating control mechanism as far as it may go. This will close the contacts of emergency rating control button *43*.

3. Advance the engine control lever to the "emergency" rating stop.

Note: Prior to taking-off be certain that the switch of the engine "emergency" rating control mechanism is in the vertical position corresponding to the emergency rating preliminary state (button *44*).

4. After this is done, current flows from the aircraft mains to terminals 2 and 3 of relay *42* via A3C-5 circuit breaker *45* and button *44*, thereby making the control circuit of electromagnetic valve *36* ready for operation. On pressing button *43* relay *62* picks up, supplying current from the aircraft mains to the windings of electromagnetic valve *36* through terminal 2 of the plug connector. The emergency rating control electromagnetic valve operates allowing for additional displacement of the fuel pump control lever, which in turn results in fuel delivery increase, as well as in an increase of the engine speed above the rated maximum *r.p.m.* (the negative lead of the electromagnet winding is permanently connected to the aircraft mains via terminal 1 of the plug connector).

The "emergency" rating is switched off by throwing over the switch of the engine emergency rating control mechanism to the aircraft fuselage side through 90° from the operating position.

Chapter III

PREPARATION OF ENGINE FOR FLIGHT

PREFLIGHT INSPECTION AND PREPARATION OF ENGINE FOR STARTING

When carrying out preflight inspection of the engine do the following:

1. Examine fastening of the engine, its accessories and piping, and check the fuel and oil lines for leakage (leakage of fuel or oil is not permissible).

2. When the engine is inoperative, switch on the "emergency" rating control mechanism and check the engine control lever for easy movement from the CUT-OFF (СТОП) position to the EMERGENCY RATING SPEED stop on the dial sector of the ПН-28Б pump and back. Check also to see that the ПН-28Б pump lever fits snugly against the EMERGENCY RATING SPEED stop (Fig. 12).

CAUTION! Do not keep the electromagnet of the emergency rating control mechanism energized for more than 6 *min*

3. When the engine control lever is set at the idling rating transitional stop, the lever of the ПН-28Б fuel pump should be located between the end marks on the idling rating sector of the pump dial.

3a. Inspect the aircraft air intake ducts to get certain that no foreign articles have been left there. Examine the inlet guide vanes and accessible rotor blades of the compressor for proper condition.

4. Check fastening of the starter fairing and exhaust unit, paying particular attention to airtightness of the starter fuel and oil lines (there should be no leakage of fuel or oil).

5. Check opening of the air bleed valve gate when air bleed to the engine anti-icing system is turned on from the cockpit. This check is performed visually by watching the position of the air bleed valve lever.

6. Inspect the compressor air blow-off band to see that it is open.

CAUTION! Do not start the engine with the air blow-off band closed.

7. Examine the exhaust unit from the inside to make sure that no foreign articles have been left in the unit. Inspect the turbine blades and the diaphragm assembly vanes for condition. When doing this, check the turbine rotor through the exhaust unit for proper rotation; this is done manually or by using device 1347К-12.

8. Check to see that the drain and vent pipes are not clogged.

9. Check the fuel shut-off valve for proper operation of its control system.

10. Inspect the engine instruments and their condition.

Note 1. To check charging of the aircraft storage battery, aircraft air system and fire extinguishing equipment, as well as filling of the fuel and oil tanks, follow the respective instruction issued by Aircraft Manufacturing Plant.

2. The kerosene tank trucks should be furnished with felt-silk filters.
The tank truck used for filling the oil system must have a screen filter with 8100–10000 meshes per 1 *sq cm*.
For filling the engine with starting fuel, the tank truck should have a filter whose element is made of fabric 848 or 4387.
The dispensing gun of the tank truck should be fitted with a screen filter having 8100–10000 meshes per 1 *sq cm*.

If, for some reason or other, the oil was drained from the engine, then before starting the engine for the first time, fill the oil tank and do the following:

(a) fill the line before the pressure stage of the oil pump unit with oil, checking its filling by draining some oil through the drain valve until the spray of oil discharged from the valve becomes free of air bubbles;

(b) fill the line before the pressure stage of the starter oil pump with oil. To this end, disconnect the pipe, feeding oil to the starting oil pump, and let out the air until a solid spray of oil begins to flow from the open end of the pipe. After filling the line, connect the oil feed pipe to the starter oil pump pipe union;

(c) fill the oil system of the starter with oil. For this purpose disconnect the oil pressure measuring pipe from the pipe union of the СД-24А oil pressure warning unit and cold-crank the starter in the course of 3 to 5 *sec* until a solid spray of oil begins to flow through the open end of the pipe. Having filled the system connect the pressure measuring pipe to the pipe union of the СД-24А pressure warning unit;

Note: If the oil fails to emerge from the pipe within 3 to 5 seconds from the beginning of cold-cranking, stop cranking the starter and find out the cause of absence of oil pressure.

(d) cold-crank the engine in order to fill its oil system with oil.

COLD-CRANKING OF STARTER

Cold-cranking of the starter should be performed in the following sequence:

1. Turn on the master switch.
2. Turn on the STARTER COLD-CRANKING switch (ХОЛОДНАЯ ПРОКРУТКА СТАРТЕРА) and start simultaneously a stopwatch to check the working time of the СА-189БМ electric motor.

CAUTION! 1. Stop cranking and turn off the master switch not later than 20 *sec* after the beginning of starter cranking.
2. To avoid overheating of the СА-189БМ electric motor, it is not allowed to cold-crank the starter more than 5 times running. There should be 1-*min* intervals between the successive cold-cranking operations. Subsequent cranking may be performed only after a 15 *min* interval.
3. Do not start to cold-crank the starter before its rotor has come to a complete standstill after the preceding cranking.

COLD-CRANKING OF ENGINE

Cold-cranking of the engine should be performed in the following sequence:

1. Check the position of the engine control lever (the lever should be in the CUT-OFF position).
2. Open the fuel shut-off valve.
3. Turn on the power supply master switch.
4. Engage the aircraft booster fuel pumps.
5. As soon as the pilot lamp flashes indicating that the starter exhaust unit shutter is open, turn on the ENGINE COLD-CRANKING switch and simultaneously start a stopwatch to check the operating time of the starter and engine.

After the above listed operations the starter should start automatically; then, as soon as its speed reaches 29,000 *r.p.m.* (engagement of the hydraulic coupling) the starter will begin to crank the engine.

ATTENTION! If the starter fails to start and the attempt at starting is accompanied by burning in the combustion chamber, cease cold-cranking of the engine and cold-crank the starter for 10 to 15 *sec*.

The normal process of engine cold-cranking is characterized by the following features:

— in 10 to 12 *sec* after turning on the ENGINE COLD-CRANKING switch, the lamp of the СД-24А oil pressure warning unit should flash up;

— working speed of the starter (31,000—33,500 *r.p.m.*) should be gained within 28 *sec* max.;

— momentary rise of speed during starter cranking should not exceed 35,000 *r.p.m.*;

Notes: 1. Upon engagement of the starter hydraulic coupling which is indicated by the beginning of engine cranking and should take place at not less than 29,000 *r.p.m.*, the starter speed is allowed to drop to 28,000 *r.p.m.* and the lamp of the СД-24А oil pressure warning unit is allowed to fade out for 1 or 2 *sec*.
2. When the starter is running after a speed rise to 35,000 *r.p.m.*, its speed is allowed to fluctuate within 2500 *r.p.m.* in the course of not more than 10 *sec*. The peak speed should not be over 35,000 *r.p.m.*

— the temperature of gases in the starter exhaust unit during cranking should not exceed 800°C;

— the working speed of the starter should be within 31,000 -33,500 *r.p.m.*;

— the temperature of gases in the starter exhaust unit at working speed should not exceed 680°C with the temperature of the ambient air up to +15°C and 700°C at ambient temperature above +15°C;

Note. Before shutting down the starter, the temperature of gases in the starter exhaust unit is allowed to rise up to 710°C in the course of not more than 10 *sec*;

the time for cranking the engine to 400 *r.p.m.* should not exceed 45 *sec*;

— the oil pressure in the engine at a speed of from 400 to 600 *r.p.m.* should be not less than 0.2 *kg/sq.cm*.

If the readings of the instruments registering the operation of the starter and engine during cold-cranking fail to correspond to the above specified data, stop cold-cranking the engine, trace and eliminate all the defects and then start cranking the engine again.

Cold-cranking of the engine may be stopped by turning off the ENGINE COLD-CRANKING switch not later than 80 *sec* after the moment it has been turned on.

After disconnection of the starter the engine rotor should keep rotating smoothly until it stops completely.

CAUTION! 1. Having stopped cold-cranking of the engine be sure to leave the master switch in the ON position to avoid overheating of the starter which may take place when the shutter of its exhaust unit is closed.
2. Do not attempt to cold-crank or start the engine before its rotor has come to a complete

standstill to prevent the ratchet clutch from damage.

3. To avoid overheating of the CA-189БМ electric motor it is allowed to cold-crank the engine not more than 5 times running, with 4-*min* intervals between each cranking. Subsequent cranking is allowed to be started only after a 15-*min* interval for cooling.

STARTING ENGINE

1. During starting and operation of the engine the servicing personnel should keep clear of the air suction zone (not less than 10 *m* from the air intakes) and of the exhaust gas zone (not less than 50 *m* from the exhaust unit).

2. The first starting of a newly installed engine, or of an engine on which maintenance or assembly operations have been performed, must be carried out with opened hatches of the power plant in order to ensure accessibility for inspection of the engine piping, wiring and assemblies.

CAUTION! It is prohibited to start the engine with the compressor air blow-off band in closed position.

3. The engine should be started by observing strictly the following sequence of operations;

(a) open the fuel shut-off valve;

(b) turn on the master power supply switch;

(c) engage the aircraft booster fuel pumps;

(d) shift the engine control lever to the transitional stop of idling rating;

CAUTION! During starting do not set the engine control lever ahead of the idling rating transitional stop.

(e) press the STARTING ON GROUND button (ЗАПУСК НА ЗЕМЛЕ) after flashing up of the pilot lamp which indicates opening of the starter exhaust unit shutter. Simultaneously start the stopwatch to check the starter and engine operating time. After 1 or 2 *sec* release the STARTING ON GROUND button.

After the above-listed operations the engine should smoothly gain the idling speed in not more than 120 seconds.

Note. During starting it may happen that individual short tongues of flame may appear at the exhaust unit outlet; this should not be regarded as a symptom of abnormal performance.

4. Having pressed the STARTING ON GROUND button watch the readings of the instruments to see whether the starter and the engine have reached the working and idling ratings, respectively judging by the following factors:

— within 10 to 12 *sec* after pressing the button, the lamp of the starter oil pressure warning unit must light up;

Note. The warning unit lamp is allowed to fade out for 1 or 2 *sec* when the hydraulic coupling gets engaged.

— the starter should gain working speed within 28 seconds maximum;

— the momentary rise of speed during cranking should not be over 35,000 *r.p.m.* and the temperature of gases in the starter exhaust unit during cranking must not exceed 800°C;

— the working speed of the starter must be within 31,000—33,500 *r.p.m.* and the temperature of gases in the exhaust unit must not exceed 680°C and 700°C at ambient temperatures up to +15°C and above +15°C, respectively;

— the starter operating time from the moment of pressing the button to disengagement of the starter must not exceed 80 *sec*;

— the temperature of gases after the engine turbine must not exceed 690°C;

— the engine should gain idling speed in not more than 120 seconds.

If the readings of the instruments which register operation of the starter and engine at starting fail to correspond to the above specified values, stop the starting cycle by shifting the engine control lever to the CUT-OFF position and turning off the master power supply switch. In 1 or 2 *sec* turn on the master power supply switch again.

Prior to repeating the starting cycle cold-crank the engine, to blow off the fuel remnants. Repeated starting of the engine should be undertaken only after having traced and corrected the defect.

5. While the engine is gaining idling speed check visually whether the fuel is being drained from the upper drain pipe terminating at the edge of the exhaust unit. Absense of fuel draining is an evidence of faulty drain system.

6. If the automatic starting system fails, it is allowed to start the engine non-automatically.

To effect this, proceed as follows:

(a) turn on the master power supply switch;

(b) set the engine control lever at the idling rating transitional stop;

(c) open the fuel shut-off valve and engage the aircraft booster fuel pumps;

(d) 3 to 4 *sec* after turning on the master switch, turn on the ENGINE COLD-CRANKING switch and start simultaneously the stopwatch to control the starter and engine operating time;

(e) as soon as the engine gains a speed of 220—280 *r.p.m.*, press the (STARTING IN AIR) button (ЗАПУСК В ВОЗДУХЕ) and release the button in 1 or 2 *sec* (if the aircraft engine is furnished with an АЗД-60 time relay box). If there is not time relay box, the STARTING IN AIR button should not be held pressed for more than 60 *sec*;

(f) as soon as the engine develops a speed of 1150—1250 *r.p.m.* but not later than 80 *sec* after turning on the ENGINE COLD-CRANKING switch, turn off the latter.

The engine should gain idling speed smoothly without petering out.

The readings of the instrument which register the operation of the starter and engine should be the same as during automatic starting.

WARMING UP AND TESTING ENGINE ON THE GROUND

When warming up and testing the engine on the ground check its performance both by instruments and aurally.

After starting the engine, do the following:

1. Run the engine at idling rating for one *min*.

2. Increase engine speed smoothly to 0.8 of the rated speed (4200±25 *r.p.m.*) and operate it at this rating within one *min*.

While shifting the engine to this rating do as follows:

(a) check the speed at which the shutter of the starter exhaust unit closes (this speed is determined by going out of the pilot lamp; it must be from 1850 to 2050 *r.p.m.*);

(b) check the speed at which the air blow-off band closes the ports (this speed is determined by closing of the aircraft shutters).

3. Smoothly increase engine speed to the maximum rating (in the course of not less than 1 *min*) and keep it at this rating for not less than 8 or 10 *sec* to check engine performance.

CAUTION! 1. When testing the engine do not bring its speed to the maximum rating earlier than 3 *min* after the engine has gained idling rating.

2. When the engine speed is being gradually changed from the idling to the maximum rating, a momentary rise of the gas temperature after the turbine is allowable; the temperature may rise as high as 720° with subsequent gradual dropping to the specified value for a period of 1 to 1.5 *min*.

3. Duration of continuous engine operation at the maximum rating should not be over 8 *min*. Repeated shifting of the engine to the maximum rating is allowed after 10-*min* operation at normal rating, or 5-*min* operation at not more than 0.8 normal rating.

4. When the engine runs at the maximum rating (both on the ground and in the air) it is not allowed to bleed air into the aircraft anti-icing system.

5. It is prohibited to shift the engine under test to the emergency rating.

4. By moving smoothly (in 25 to 30 *sec*) the engine control lever, shift the engine to the idling rating, checking its performance at intermediate ratings and the speed at which the compressor air blow-off band opens the ports (3800+50 *r.p.m.*). At intermediate ratings the engine should run smoothly without shaking and without blowing the flame out of the exhaust unit. The engine speed at which the air blow-off band closes the ports may be higher than the speed of opening the ports by not more than 50 *r.p.m.*

CAUTION! Do not move the engine control lever behind the transitional stop of the idling rating.

5. Check acceleration of the engine having previously worked it at idling rating for not less than 1 *min*. To check the engine acceleration do the following:

(a) advance the engine control lever smoothly (in the course of 1 or 2 *sec*) from the transitional stop of the idling rating to the maximum speed stop. The engine should gain a speed of 4700± ±50 *r.p.m.* in not more than 17 *sec*. At an ambient air temperature below +15°C the engine should be accelerated to a speed by 50 *r.p.m.* less than the adjusted maximum speed, and the acceleration time must last not more than 15.5 seconds.

Note. In case the engine maximum speed is intentionally reduced because of the fuel pump output limitations, the speed actually gained by the engine, when the engine control lever has been smoothly advanced to the maximum rating stop, is considered as the adjusted maximum rating speed.

During acceleration the temperature of the gases is allowed to rise not above 740°C. This may be accompanied by individual short tongues of flame at the exhaust unit outlet; engine speed is allowed to rise not more than 4800 *r.p.m.* after which it must drop to the maximum speed within 5 to 7 *sec*;

(b) after operating the engine at maximum rating (in the case of an ambient air temperature below minus 15°C the engine maximum rating speed will be lower than 4700±50 *r.p.m.*, (see Fig. 8), shift the engine control lever within 1 or 1.5 *sec* to the idling rating transitional stop, thereby reducing the engine speed to 1750±50 *r.p.m.* At intermediate ratings the engine should work smoothly without flameout or smoking;

(c) check the time required for acceleration of the engine from 1750±50 *r.p.m.* to 3000 *r.p.m.* This time should be not less than 7 *sec*;

Note. When checking acceleration of the engine to any of the intermediate ratings, the engine speed is allowed to rise not more than 200 *r.p.m.* above the rated value of the given rating;

(d) check the acceleration time from 3500 to 4700±50 *r.p.m.* The acceleration time within this range should be from 12 to 15 *sec*.

Readings of the instruments which indicate normal performance of the engine being checked on the ground are given in Table 1.

STOPPING ENGINE

When stopping the engine which runs at any rating, reduce at first its speed gradually to 2500—3500 *r.p.m.* and keep it at that speed 1 or 2 *min* to cool it down; then shift the engine control lever all the way to the CUT-OFF position and turn off the master switch.

Note. After taxiing over the airfield it is allowed to stop the engine without letting it cool down at 2500—3500 *r.p.m.*

Table 1

INSTRUMENT READINGS FOR NORMAL ENGINE PERFORMANCE DURING GROUND TESTS

Engine rating	R.P.M.	Fuel pressure before main burners, *kg/sq.cm*	Temperature of gases, °C	Oil		Time of continuous operation, *min*
				pressure, *kg/sq.cm*	inlet temperature, °C	
Emergency	4900^{+15}_{-40}		790 max.	3.5–4.5	from −40° to +80°C	2
Maximum	4700±50		700 max. 710 max. with engine anti-icing system control valve ON (not over 720 during 15 *min* after engine starting)	3.5–4.5	Same	8
Nominal	4425±25	66 max.	605 max. 625 max. when air is bled into aircraft anti-icing system	3.5–4.5	Same	60
0.8 nominal	4200±25		540 max.	3.5–4.5	Same	not restricted
Idling rating	1750+50	26 max.	500 max.	at least 1	Same	not restricted

After shutting off the engine do as follows:

1. With the rotor revolving due to inertia listen to the engine to detect any unusual noises and check for ease of rotation while the rotor is gradually slowing down from 1750±50 *r.p.m.* to a complete standstill. This time should be not less than 2 *min*.

Notes: 1. Ease of rotation should be checked when the engine is warm.
2. After shutting off the engine and during rotation by inertia a clicking noise of the ratchet coupling pawls should be heard.

Should any foreign noises be detected trace their cause by turning the rotor manually or by cold-cranking the engine once or twice up to 100 or 200 *r.p.m.*

It is not allowed to start the engine without first tracing and eliminating the cause of foreign noise.

2. Check to see that there is no smoking from the exhaust unit. Smoking is usually caused by faulty flow-off valve (see Fig. 3a).

3. Switch off the aircraft booster pumps (after stopping all the engines) and close the fuel system shut-off valve.

4. Close the inlet duct and the engine exhaust unit with dummy covers. The exhaust unit should be closed only after the surface of the engine has cooled down to approximately 60 to 80°C as felt by hand.

Emergency stopping of the engine is done by quickly shifting the engine control lever to the CUT-OFF position; this should be resorted in the following cases only:

— at abrupt oil pressure drop at the engine inlet;

— at fire-hazardous fuel or oil leakage;

— when the temperature of the gases after the turbine rises above the permissible level;

— at abnormal flame discharge from the exhaust unit;

— when foreign noises are detected in the running engine;

— when the engine starts shaking;

— at ice formation in the engine inlet duct;

— when the aircraft starts moving suddenly from the parking ground due to failure of the brakes or braking chocks during ground tests.

Chapter IV

OPERATION OF ENGINE IN FLIGHT

1. The aircraft may be allowed to taxi at any engine speed, from idling rating to nominal rating, provided the readings of the instruments are as specified for the given rating.

CAUTION! 1. It is not recommended to operate in the speed range from 3780 to 3920 *r.p.m.* as within this range the engine may run irregularly due to periodical opening and closing of the compressor air blow-off band.
2. Do not shift the engine control lever beyond the transitional stop of the idling rating towards lower speed with subsequent abrupt shifting of the lever towards higher speed since this results in undue rise of the temperature of gases after the turbine. If the engine control lever is shifted beyond the transitional stop of the idling rating and the engine speed is reduced below 1650 *r.p.m.*, it is allowed to smoothly shift the lever to set the engine to idling rating again. The temperature of gases after the turbine should not exceed 690°C.

2. Having warmed up and tested the engine on the parking ground, shift the engine control lever smoothly to increase the engine speed to such a maximum which is permitted by the wheel brakes of the aircraft (see that the latter is held firmly in place), and check promptly the instrument readings to see that the temperature of gases after the turbine, the oil inlet temperature and pressure correspond to the engine speed data specified in Table 1.

CAUTION! Prior to taking-off be certain that the lever switch of the engine "emergency" rating control mechanism is in the vertical position which prepares the engine for application of the emergency rating.

Having ascertained that the engine runs normally, proceed with taking the aircraft into the air.

CAUTION! 1. Taxiing of the aircraft for more than 3 *min* is sufficient for normal warming up of the engine.
2. If the aircraft is to be taken off immediately after starting the engine, the latter should be shifted to the maximum rating not earlier than 3 *min* after setting up of the idling rating.
3. Having taken off and gained altitude, but not later than 8 *min* after reaching the maximum rating, shift the engine to the normal or somewhat lower rating.

If one of the engines has failed during taking-off, it is permissible to resort to switching the engine to the "emergency" rating.

Note. Do not use the "emergency" rating at an ambient air temperature below −15°C, for the engine speed and thrust characteristics at this rating under the above conditions do not differ from those at the maximum rating. This is caused by the limited output of the engine fuel supply equipment at very low temperatures.

To switch the "emergency" rating of the engine, proceed as follows:

(a) press the lever switch of the "emergency" rating control mechanism of the engine, running at the maximum rating, as far as it will go;

(b) shift the engine control lever to the "emergency" rating stop;

(c) when operation at the "emergency" rating is over, but not later than in 2 *min* after switching the engine to the "emergency" rating, set the engine at the nominal rating and throw off the lever switch of the "emergency" rating control mechanism to the aircraft fuselage side through 90° from the operating position, thereby switching off the "emergency" rating control mechanism. The "emergency" rating control mechanism electromagnet should not be kept energized for more than 6 minutes.

Notes: 1. After operation at the "emergency" rating remove the engine from the aircraft and make a record in the engine Service Log of the engine speed, exhaust gas temperature, duration and circumstances concerning operation of the engine at the "emergency" rating.
2. After operation at the "emergency" rating the engine may be run for 20 *min.* at the nominal rating and for 5 *min.* at transient speed.

LEVEL FLIGHT

1. Level flight is allowed at any engine rating except the speed range between 3780—3920 *r.p.m.*

2. The flying time at all the ratings including the normal rating is not restricted. The flying time at the maximum rating should not exceed

8 *min* and the repeated use of the maximum rating may be permitted only after 10 *min* of engine operation at the nominal rating or 5 *min* at a speed not over 0.8 nominal rating.

CAUTION! Under no circumstances should the engine be worked with the air blow-off band opened at ratings exceeding the nominal rating. This may happen as a result of some deficiency in the blow-off band control system. Engine operating time at nominal rating with the blow-off band opened should not exceed 8 *min*. The nominal rating may be used again only after 10 *min* of operation at 0.8 nominal rating.

3. To avoid spontaneous blow-out of both engines in flight because of possible surging, shift the engine control lever of each engine separately.

Note. If surge occurs in the engine at an altitude up to 3000 *m*, shift the engine control lever immediately to the idling rating position, keep it there for 4 or 5 *sec.*, then slowly advance the engine control lever to obtain the required engine rating. When doing this see that the engine accelerates smoothly, without petering-out. Should surging still take place, move the engine control lever to the CUT-OFF position and press the STARTING IN AIR button at once to start the engine anew.
If surge occurs in the engine at altitudes over 3000 *mm*, immediately shift the engine control lever to the CUT-OFF position and restart the engine at once by pressing the STARTING IN AIR button.

4. The readings of the instruments which control engine performance must not be beyond the limits specified in Table 2.

Table 2

INSTRUMENT READINGS FOR NORMAL ENGINE PERFORMANCE IN FLIGHT

Engine rating	R.P.M.	Fuel pressure before main burners, *kg/sq.cm*	Temperature of gases, °C	Oil		Time of continuous operation, *min*
				pressure, *kg/sq.cm*	inlet temperature, °C	
Emergency	4900 $^{+15}_{-40}$		790 max. to be verified in the course of flight tests	3.5—4.5	from −40° to +80°C	2
Maximum	4700±50		720 max. to be verified as experience is gained; 740 max. with engine anti-icing system control valve ON (to be verified as service experience is gained)	3.5—4.5	Same	8
Nominal	4425±25		615 max. 625 max. while air is bled into aircraft anti-icing system	3.5—4.5	Same	not restricted
0.8 nominal	4200±25		540 max.	3.5—4.5	Same	not restricted

CAUTION! If the instrument readings in flight are other than specified in the Table, cut down the engine speed immediately and set up a new rating.

5. Shifting of the engine from any intermediate rating to the maximum rating should be performed in not less than 1 or 2 *sec.*

In this case the limiting conditions with respect to the rise in speed and temperature of gases after the turbine are the same as those prescribed for testing engine acceleration on the ground.

CAUTION! If surge occurs in the engine when the latter is shifted from an intermediate to the maximum rating, turn the engine control lever immediately all the way to the CUT-OFF position, then move it on the transitional idling rating stop and immediately press the STARTING IN AIR button. If the engine speed reduces after this and becomes lower than the speed of the idling rating, and the temperature of gases after the turbine rises up to 690°C, shut off the engine at once. If, however, the engine starts working at idling rating with a reasonable temperature of the gases, move the engine control lever slowly to shift the engine to the required rating. After the flight trace the cause of the trouble and eliminate the defect.

6. In flight, the engine speed is allowed to reach 4770 *r.p.m.*

7. If surge begins when the engine runs at the maximum rating cut down the engine speed by the engine control lever until the surge ceases, trace and eliminate the cause of the trouble after the flight.

SWITCHING OFF AND RESTARTING ENGINE IN FLIGHT

1. To switch off the engine in flight proceed as follows:

(a) throttle down the engine at first to 2500—3500 *r.p.m.* (but not lower than to the altitude idling speed) and allow it to run at this speed for not less than 1 *min* for cooling;

(b) as the engine is cooled down shift the engine control lever all the way to the CUT-OFF position;

(c) turn off the aircraft booster fuel pumps (if this is required by the conditions of the flight);

(d) close the fuel shut-off valve (if it is required by the conditions of the flight).

2. In emergency cases indicated below, shut off the engine by shifting quickly the engine control lever from the initial position to the CUT-OFF position and close the fuel shut-off valve.

The following symptoms should be regarded as emergency situations:

— violent shaking;

— abrupt rise of the temperature of gases after the turbine in excess of the permissible limits;

— abrupt oil pressure drop at the engine inlet below the permissible limit;

— breaking out of fire.

3. Starting of the engine in the air should be performed at altitudes not exceeding 10,000 *m* at indicated flying speeds of at least 400 *km/hr* and at an autorotation speed within 900—1100 *r.p.m.*

When the engine is started in the air, the readings of the instruments measuring the temperature of the gases after the turbine and the oil pressure in the engine should be the same as when starting the engine on the ground.

4. When starting the engine in the air follow the order of operations given below:

(a) open the fuel shut-off valve (if closed);

(b) check the position of the engine control lever (it must be in the CUT-OFF position) and switch on the automatic fuel feed system (if it was OFF);

(c) turn on the master switch, press the STARTING IN AIR button and start the stopwatch simultaneously.

If the aircraft is furnished with an АЗД-60 time relay box, release the STARTING IN AIR button in 1 or 2 *sec*.

Make use of the АЗД-60 relay pilot lamp to see that the relay box is properly operating.

Notes: 1. Prior to pressing the STARTING IN AIR button check to see that the fuel is not thrown out of the engine exhaust unit. If otherwise, force the engine control lever home to the CUT-OFF position and blow off the engine at the autorotation speed.

2. If the aircraft is not equipped with an АЗД-60 time relay box or the engine automatic starting system has failed (the pilot lamp is dead), keep the STARTING IN AIR button depressed throughout the starting process but not longer than 60 *sec*;

(d) 6 or 8 *sec* after pressing the STARTING IN AIR button move the engine control lever to the idling rating stop and watch the engine speed rise.

If the engine speed rises slowly within the speed range from 1300 to 2100 *r.p.m.* move the engine control lever a little back. If the speed increases quickly and steadily, release the STARTING IN AIR button and cut out the master switch;

(e) if the engine speed fails to rise within 60 *sec* after pressing the STARTING IN AIR button, engine starting should be stopped, for which purpose it is necessary to release the STARTING IN AIR button and move the engine control lever to the CUT-OFF position.

Before the next attempt at starting blow the engine at the autorotation speed for not less than 2 or 3 *min* to eliminate throwing-out of fuel from the exhaust unit.

ATTENTION! 1. When starting the engine in the air NEVER press the STARTING ON GROUND button.

2. The maximum speed of the engine should be attained not earlier than 3 *min* after developing the idling speed.

Note. The permissible number of startings in the air should be reckoned on the basis of the specified consumption of the starting fuel per starting which is not over 4 *lit.* on the ground and not over 0.75 *lit.* in the air.

5. Should the engine flame out by itself in flight, shift immediately the engine control lever all the way to the CUT-OFF position and after blowing the engine for 2—3 *min* (due to autorotation of the rotor) start the engine again as described above.

EMERGENCY STARTING

Starting the engine in the air by means of the emergency starting system is resorted to in the case of spontaneous flame-out of both engines in flight if the engines cannot be started from the aircraft mains because of discharge of the storage batteries or malfunctioning of the main starting system.

The sequence of engine starting operations to be observed is the same as that of ordinary starting of the engine in flight with the sole difference that instead of the STARTING IN AIR button the EMERGENCY ENGINE STARTING button is pressed and kept it in that position for the entire process of starting but not longer than 60 *sec*.

ATTENTION! The higher the engine autorotation speed the more reliable starting of the engine in flight.

CAUTION! See that the engine generators are off prior to pressing the EMERGENCY STARTING button. On restarting the engine in the air by means of the emergency starting system, supply H.T. current to the СПН-4-3 spark plugs to recondition them in compliance with Section 1, of Chapter V.

Notes: 1. With the engine operating at a stable rating the engine *r.p.m.* are allowed to fluctuate within the following limits:

(a) at a speed above 3800 *r.p.m.* — not more than ±15 *r.p.m.*;

(b) at a speed below 3800 *r.p.m.* — not more than ±25 *r.p.m.*;

(c) within the speed range from 3300 to 3500 *r.p.m.* (which corresponds to the engine automatic control) — not more than ±50 *r.p.m.*

2. Fuel pressure fluctuations should not exceed ±0.3 *kg/sq.cm* upstream of the fuel pumps and ±3 *kg/sq.cm* in the primary manifold.
3. The emerging rating speed is recorded in the engine Service Log and it must be within 4915 to 4860 *r.p.m.*

PECULIARITIES OF ENGINE SERVICE IN WINTER

1. The anti-icing device (see Fig. 4) should be operating if the engines are run on the ground under conditions of high humidity at an ambient temperature of from +5°C to −5°C or in the case of ice formation at the engine intakes.

If ice formation is probable in the flight, switch on the anti-icing facilities of the engines and aircraft air intake ducts. As soon as the aircraft leaves the dangerous area, cut off the anti-icing system of the engines and aircraft air intake ducts.

2. Do not start the engine if ice is found on the internal surface of the engine intake. In this case make use of a heater to remove the ice before starting the engine.

3. Each time prior to starting the engine make sure the rotor blades are not frozen to the compressor middle casing, for which purpose check the engine rotor for easy rotation, turning the rotor manually or by means of device 134ЖК-12 applied to the turbine rotor blades.

If the compressor rotor blades are frozen warm up the compressor middle casing from the bottom using a heater.

4. Before starting the engine at an air temperature below — 10°C, warm up the starter by 2 or 3 preliminary startings, accelerating the engine to 8000—15000 *r.p.m.* each time.

Note. To preclude starter exhaust gas temperature from further excessive increase during preliminary starts, shut off the starter when the gas temperature in the starter exhaust unit rises to 600°C.

5. To facilitate starting of the engine at ambient temperatures below — 25°C dilute the oil with 16—18 per cent (involume) of non-ethylated gasoline Б-70 (USSR Standard ГОСТ 1012-54). Б-70 gasoline may be substituted by starting fuel which consists of gasoline Б-70 and 1% (by weight) of МК-8 grade or transformer oil.

The above stated oil dilution must be carried out if the engine is supposed to stand idle for a long period of time under conditions which may cause thickening of oil.

The operation should be performed in the following way not later than 20 to 30 *min* after stopping the engine:

(a) measure the oil quantity in the tank using a stick gauge;

(b) referring to Table 3, find out the required quantity of gasoline Б-70, pour the gasoline into the tank and stir the contents thoroughly with the stick gauge.

Table 3

OIL DILUTION TABLE

Amount of oil in oil tank, *lit*	Required amount of gasoline Б-70, *lit*
16	3.6
17	3.7
18	3.9
19	4.1
20	4.3
21	4.4
22	4.6
23	4.8
24	4.9
25	5.1

Notes: 1. The amount of gasoline Б-70 is taken for the entire amount of oil in the engine oil system.
2. The mixture quantity should not exceed the amount of oil usually employed for the oil system in compliance with the aircraft Maintenance Instructions.
3. The gasoline entirely evaporates from the oil within two hours of engine operation at working rating. If the engine is to be run on diluted oil for less than for 2 hours, add gasoline into the oil tank in such amounts as prescribed by the chart in Fig. 6. The chart is to be verified as service experience is gained;

(c) start the engine as outlined in Section 4 of Chapter III and allow it to run for 3 or 4 *min* at a speed from 3000 to 3500 *r.p.m.*;

(d) after stopping the engine, cold-crank it for 50 to 60 *sec* to fill the starter oil system with diluted oil.

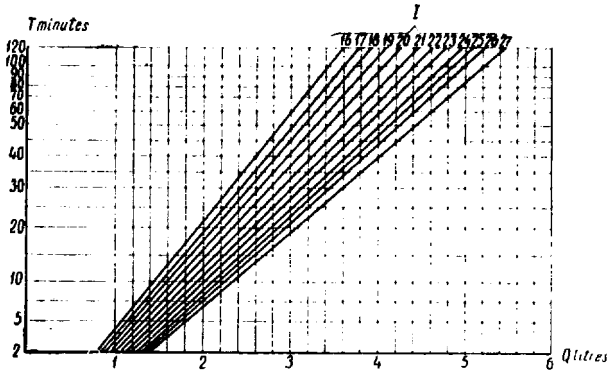

Fig. 6. Chart for Determining Amount of Gasoline Added into Oil Tank Depending on Engine Operating Time with Diluted Oil:
T_{min} — engine operating time, minutes; Q_{lit} — amount of gasoline added into oil tank; I — amount of oil in tank prior to dilution, litres

This operation over, the engine is considered ready for starting at ambient air temperature down to −40°C.

6. If the ambient air temperature is below — 40°C, drain the oil from the engine (see Fig. 7). Under this condition the engine must be filled with oil, heated to 60—80°C, after warming-up the starter and before starting the engine proper.

7. While starting the engine, be certain that the fuel filter is not clogged (not frozen).

Should the fuel filter be frozen up, heat it with warm air, drain off the condensate, heat the filtering elements and dry them up with warm air or replace with new ones.

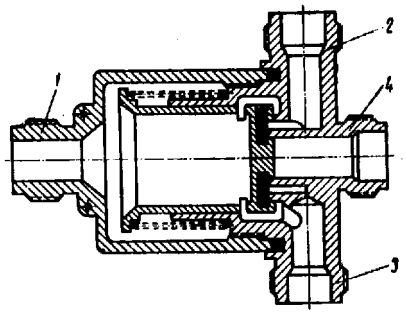

Fig. 7. Flow-Off Valve:
1 — pipe union for fuel pressure supply from chamber before distributing valve; *2* — main manifold flow-off pipe union; *3* — pipe union for draining fuel into drain tank; *4* — pipe union for delivering and draining fuel from primary manifold

8. When starting a cold engine, do not allow the oil pressure to exceed 6 *kg/sq.cm.*

9. With the engine running, take care that the fuel pressure before the burners is not above 66 *kg/sq. cm.* Reduce the engine *r.p.m.* if otherwise.

10. At an ambient air temperature below −15°C the engine maximum speed on the ground and at flight altitudes up to 2000 *m* is limited by the adjustment of the fuel pump maximum output (see "Chart for Limitation of Engine Maximum R.P.M. Depending on Ambient Air Temperature" shown in Fig. 8).

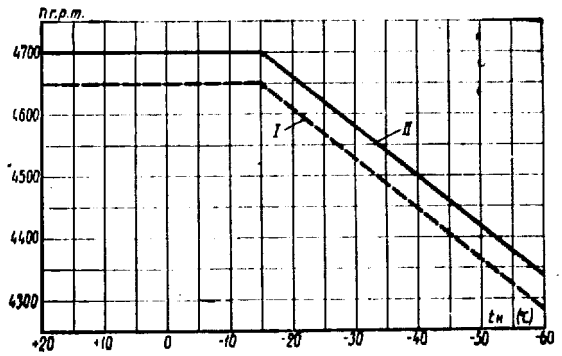

Fig. 8. Chart for Limitation of Engine Maximum R.P.M. Depending on Ambient Air Temperature on Ground:
I — permissible lower limit of maximum R.P.M.; *II* — nominal values of maximum R.P.M. *n r.p.m.*; t_H — temperature of ambient air

11. Prior to stopping the engine let it cool down at a speed of from 2500 to 3500 *r.p.m.* for 1 or 2 *min* to preclude the engine hot parts from distortion.

12. To prevent snow or rain water from getting into the engine after it is shut down, close the engine intake, exhaust unit jet nozzle and starter exhaust unit outlet with dummy covers.

Chapter V

CARE OF ENGINE

Reliable operation of the engine in the course of its service life is guaranteed only under the stipulation that the flying and maintenance personnel adhere to the operating rules outlined in this Manual, efficiently perform the preflight and postflight inspections and carry out the scheduled maintenance operations on the engine in due time.

Before commencing scheduled maintenance operations on the starter, protect the compressor intake with special pads or by means of a canvas cover.

Maintenance operations are performed on the engine at the following specified intervals:

— after the first start of a newly installed engine;

— after the maiden check flight of the aircraft powered by newly installed engine;

— after each twenty five hours of operation;

— after each fifty hours of operation;

— after each one hundred hours of operation.

The maintenance operations after 25, 50, and 100 hours of service may be performed 5 hours before or after the time comes around, simultaneously with the maintenance operations on the aircraft.

The maintenance operations must be carried out only by the use of the tool set furnished with the engine. The date and scope of the maintenance work should be entered in the Engine Service Log.

Before actual maintenance or assembly work being performed on the engine it is necessary to prevent any foreign objects from getting into the compressor by closing the air blow-off band (having previously opened the aircraft shutters), for which purpose press the button, then fix the band mechanism in this position by screwing the wing nut on the stud of the mechanism.

While performing any maintenance or assembly work replace all the removed locks, gaskets and sealing rings by new ones, taking them from the individual set of engine spare parts. The nuts and screws of flange connections should be screwed on and off evenly and in a definite sequence (at first diametrically opposite, then along the perpendicular diameter, etc.).

Upon completion of work examine the engine compartment, remove any foreign articles, and, before closing the aircraft engine nacelle shutter, open the air blow-off band (for this purpose press the button and screw off the wing nut).

After the maintenance and assembly operations on the engine are over, start the engine with the engine nacelle shutters open to offer a possibility of checking the tightness of those fuel and oil system, joints of which were disassembled during maintenance operations.

Note. After starting the engine in the air by means of the emergency starting system exercise the CIIH-4-3 spark plugs two times to recondition them. For this purpose disengage the power supply plug connector of the IIHP-10-3M pump and press the STARTING IN AIR button for 8 or 10 *sec*. After this operation is performed twice join the IIHP-10-3M pump power supply plug connector.

POSTFLIGHT INSPECTION

Postflight inspection of the engine is to be carried out at the end of each flying day, being one of the most principal cares of the engine.

It is well to remember that readiness of the engine for further flights depends entirely on the quality of its postflight inspection.

The postflight inspection should include the following operations:

1. Examine and check:

a) engine-to-aircraft attachment fittings for cracks, proper condition of parts and safety connections;

b) engine intake duct, starter fairing, starter exhaust unit, inlet guide vanes and compressor blades (if accessible for examination). See to it that these parts and assemblies are not damaged, that the engine intake duct is free from dirt, ice or other foreign matter;

c) engine jet nozzle, turbine blades and nozzle diaphragm vanes for proper conditions;

d) compressor rear casing in vicinity of the igniters, the plugs (if installed instead of igniters), and combustion chamber casing (in the bottom section particularly). See to it that these assemblies bear on traces of overheating;

e) all the accessories and piping for secure fastening and locking; tightness of oil, fuel and

compressed air pipelines. All hydraulic system pipeline connections with hydraulic pump should be checked for proper tightness. Replace the rubber rings if leaks are detected in the rubbersealed joints of the pipelines. After replacement and repair of all the faulty joint elements start the engine to make sure that the joints are tight enough.

CAUTION! If fuel was drained from the engine fuel system, it is necessary to slush the system as outlined in Chapter "Engine Slushing and Deslushing",

f) engine drain system for leaking oil and fuel pipe connections. See that the pipelines carrying fuel from the combustion chamber casing, nozzle diaphragm assembly and fuel pump housings are not clogged or damaged.

2. Measure fuel consumption. Bear in mind that it should not exceed 1.5 *kg/hr*. The measurement must be taken after the engine has operated at a speed of 2200 to 3000 *r.p.m.*

3. Follow the respective Instructions of the Aircraft Manufacturing Plant when filling the fuel and oil tanks or when checking the storage batteries.

After the postflight inspection is over, open the compressor air blow-off band before closing the aircraft shutters.

MAINTENANCE OPERATIONS AFTER FIRST START OF NEWLY INSTALLED ENGINE

After the first start of a newly installed engine and its run-up test at all the ratings, proceed as follows:

1. Carry out the operations listed in Item 1 of the preceding section.

2. Remove and examine the engine inlet oil filter (Fig. 9).

For this purpose, unscrew the wing nut securing the cover to the oil filter casing.

If metal dust or chips are detected on the filter element or casing interior, clean the filter, and after giving the engine another run-up test check it for the second time. If the filter is clean, the engine is admitted for further service.

MAINTENANCE OPERATIONS AFTER MAIDEN CHECK FLIGHT OF AIRCRAFT POWERED BY NEWLY INSTALLED ENGINE

1. Perform the operations described in Section "Engine Postflight Inspection" of this Chapter.

2. Remove, examine and clean the engine inlet fuel filter as it is specified by the Aircraft Manufacturing Plant Instructions.

Note. The aircraft fuel filter installed at the engine inlet (Ref. No. 6 in Fig. 1) should separate particles up to 20—25 μC in size.

3. Remove, examine and wash in case of necessity the external surface of the oil filter in the following way:

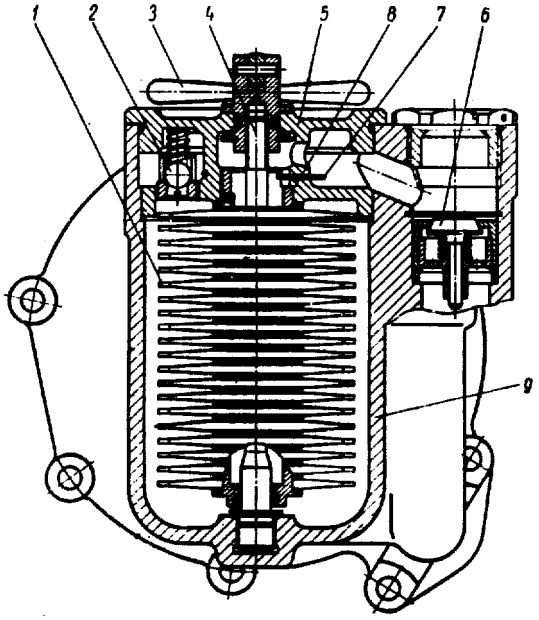

Fig. 9. Oil Filter:
1 — filter element; *2* — safety ball valve; *3* — handle; *4* — central tie rod; *5* — filter cover; *6* — return valve; *7* — locking ring; *8* — filter frame; *9* — filter casing

a) rinse the filtering elements along with the cover in a bath filled with gasoline, having closed the oil outlet hole with a rubber plug;

b) blow dry the filter with compressed air at a pressure not over 3 *kg/sq.cm*. Prior to airblasting the filter bleed some air from the compressed air bottle to expel dirt and moisture from the bottle and pipeline;

c) thoroughly wash the oil filter well with clean gasoline.

ROUTINE MAINTENANCE AFTER EVERY 25 HOURS OF OPERATION

1. Carry out the maintenance operations prescribed in Section 3, with the exception of Item 3.

2. Check the pipeline connections of the distributing valve and acceleration control unit of the ПН-15Б pump for tightness.

3. Inspect and check the entire engine control system linkage for excessive play in the joints. When required, lubricate the engine control linkage.

4. Inspect the inlet filters of the ПН-15Б and ПН-28Б pumps.

ROUTINE MAINTENANCE AFTER EVERY 50 HOURS OF OPERATION

1. Perform the 25-hour maintenance Operations listed above.

2. Examine and wash, if necessary, the ПН-28Б fuel pump central fine filter.

3. Check tightness of the pipe line connections and examine the inlet filters of the ПН-15Б and ПН-28Б fuel pumps.

4. Flush with gasoline and airblast the pipeline which delivers air to the acceleration and starting control units.

5. Dismount and clean the oil filter proceeding as follows:

a) wash the filter in clean gasoline;

b) remove locking ring *7* (Fig. 9), unscrew filter frame *8* from filter cover *5* and take off the sets of filtering elements *1*;

c) close the central holes of the filtering elements with rubber plugs;

d) clean each filtering element from both sides by means of a coarse hair brush soaked in gasoline;

e) blow out the filtering elements with compressed air at a pressure not over 3 *kg/sq. cm* (bleed some air from the bottle before airblasting);

f) wash in clean gasoline and airblast the frame, cover and other parts of the filter.

Note. If the oil filter is but slightly contaminated, it is allowed to wash it without stripping into parts.

6. Clean and wash with gasoline the air bleeding jet of the starting control unit.

7. Inspect the C-300M starter externally to make sure that its inlet and outlet fuel and oil lines are tight enough, that it is not damaged, that the starter accessories and wires, gasoline, oil and air lines are securely attached and locked.

8. Wash the fuel filter of the ТНР-3Р fuel regulating pump with gasoline and blow it with compressed air at a pressure of not over 3 *kg/sq.cm.*

9. Check the compressor air blow-off band control mechanism for proper operation as advised in Chapter VI under Section "Adjusting Speed at Which Compressor Air Blow-Off Band Centrifugal Transmitter Operates".

ROUTINE MAINTENANCE AFTER EVERY 100 HOURS OF OPERATION

1. Carry out the 50-hour operations.

2. Change the oil.

3. Inspect the lines feeding fuel to the primary manifold igniters to be sure that they are free from cracks and signs of damage.

4. Examine the rubberized fabric hoses feeding fuel to the main and primary fuel manifolds. In the course of storage and service the rubberized fabric hoses are exposed to sun light, heat, and ozone, and this results in a lattice-shaped crack formation on the external rubber layer. The cracks extend and grow deeper with time penetrating through the outer rubber layer.

Since the above described defect does not affect the hose strength significantly, it is permissible to use such hoses till its service life expires.

5. Wash and blow out the air suppiy line to the pneumatic contactor.

6. Inspect and wash the starting fuel system filter.

7. Inspect the starter turbine blades to make sure that they are not nicked or otherwise damaged.

8. Examine the starter strainers installed in the lines feeding oil to the hydraulic coupling and starter bearings. Wash the strainers in clean gasoline, if necessary.

9. Engine accessories should be subjected to maintenance work within the scope specified by the respective manuals and at the time intervals prescribed for the engine.

AFTER EXPIRATION OF SERVICE LIFE

1. Carry out engine internal slushing.

2. Dismount the engine from the aircraft, slush it from the outside and forward to a repair agency for overhaul.

Prior to checking the engine maximum speed warm up the engine for 2 *min* at different ratings, from the idling rating speed up to 4200±25 *r.p.m*

To attain maximum rating speed after warming up the engine, smoothly advance the engine control lever to the MAXIMUM RATING stop within one minute.

Note. When checking the engine maximum speed, keep it at the maximum *r.p.m.* for 8 to 10 *sec*.

If maximum rating speed does not comply with the specified value (4700±50 *r.p.m.*) and has dropped by more than 50 *r.p.m.* with respect to the speed originally adjusted (see para. 9 of the ПН-28Б Pump Certificate), proceed as follows:

1. With the engine stopped, shift the engine control lever to the MAXIMUM RATING stop and check the position of the throttle valve control lever indicating pointer in terms of degrees on the dial.

If the pointer position does not correspond to that prescribed in the ПН-28Б Pump Certificate (paras. 3 or 9), check whether the maximum speed stop screw ball makes a tight fit with the cam (Fig. 11).

If the fit is tight, make use of the maximum speed adjusting screw to set the indicating pointer in the position specified by the Certificate.

2. Should a further check-up show that the maximum rating speed differs by less than

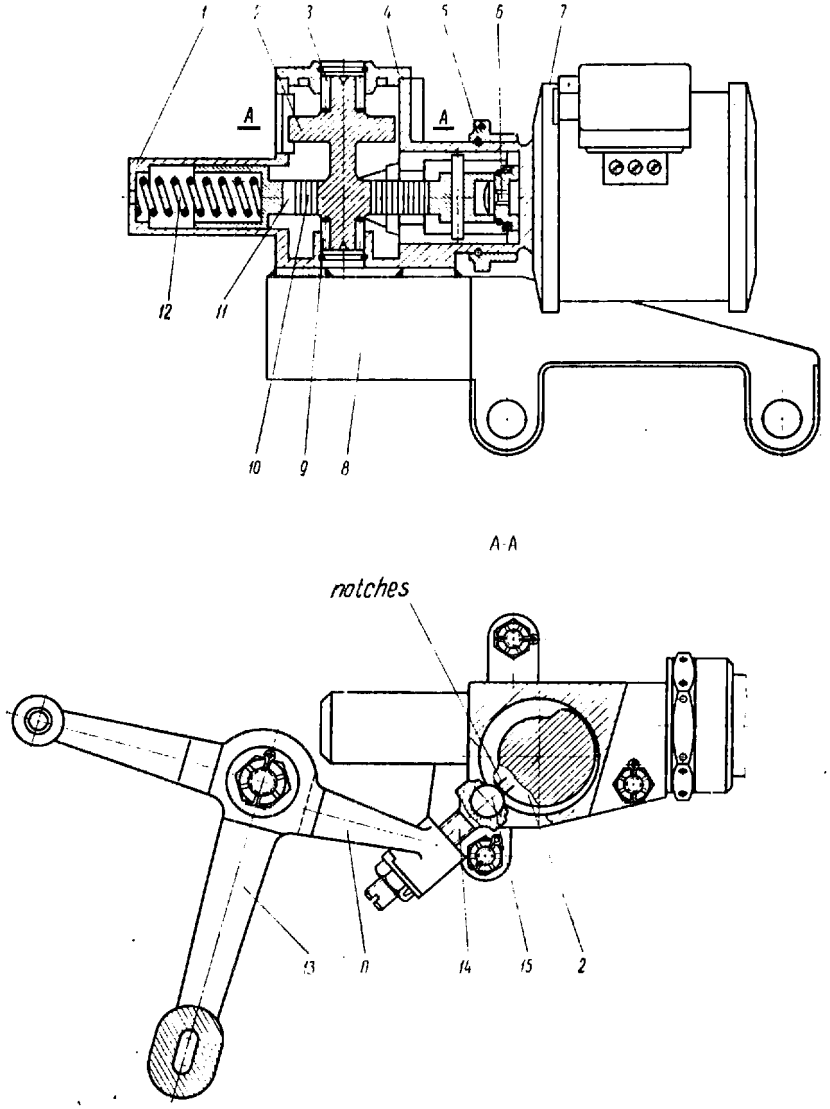

Fig. 11. Emergency Rating Control Mechanism:
1 — housing; *2* — cam; *3* and *9* — needle bearing; *4* — cover; *5* — nut; *6* — electromagnet rod; *7* — ЭМТ-25 electromagnet; *8* — bracket; *10* — gear; *11* — rack; *12* — spring; *13* — lever; *14* — adjusting screw; *15* — ball

50 *r.p.m.* from the formerly adjusted value and is within the specified limits (4700±50 *r.p.m.*), there is no need of adjusting the maximum rating speed or emergency rating speed.

3. If the maximum speed differs by more than 50 *r.p.m.* from the initially adjusted speed or does not comply with the specified limits (4700±50 *r.p.m.*), proceed as follows:

a) calibrate or change the ТЭ5-2 tachometer measuring the engine speed (if the instrument was not checked just before the job);

b) check to see that the acceleration control unit of the ПН-15Б pump does not by-pass fuel. For this purpose drive a blind air bleeding jet in the unit housing.

Should the defect be detected, eliminate it in compliance with the instructions given in Chapter VIII of this manual.

4. Check and note the maximum rating speed. If the maximum rating speed does not alter after the above check over according to Item 3, proceed with the adjustment of the maximum rating speed.

CAUTION! It is prohibited to adjust the maximum rating speed by the use of the ПН-28Б fuel pump hydraulic decelerator stop screw and FUEL THROTTLE stop screw on the ПН-28Б fuel pump dial, because both of the adjusting elements have been positioned with respect to the emergency rating speed setting.

It is permitted to adjust the speed up to 4750 *r.p.m.* by the ТЭ5-2 electric tachometer taking into account the actual error of the instrument.

The adjustment of the maximum rating speed is carried out in the following manner.

If the engine maximum speed is below 4650 *r.p.m.* after the engine control lever is shifted forward, with adjusting screw 14 (see Fig. 11) being in contact with cam *2* of the emergency rating control mechanism, slow down the engine speed to the idling rating and back out maximum speed stop screw *14*. Afterwards, check the maximum speed by advancing slowly the engine control lever, taking care not to overspeed the engine beyond 4750 *r.p.m.* If the engine maximum speed is over 4750 *r.p.m.*, turn in stop screw *14*; it should be known that one revolution of the stop screw changes the engine speed by 40 *r.p.m.* approximately.

In all the cases of adjustment be certain that ball *15* of adjusting screw *14* is located between the notches on cam *2*. The throttle valve control lever indicating pointer of the ПН-28Б fuel pump must not be displaced from the maximum rating notch on the ПН-28Б pump dial in excess of ±5° with respect to the normal maximum speed setting which is recorded in para. 3 of the ПН-28Б fuel pump Certificate.

Note. When checking the maximum rating speed finally keep the engine at this rating for 1 or 2 *min.*

Recheck the engine maximum speed twice: at first by slow movement of the engine control lever, then by a swift motion as during the acceleration check.

Upon completion of adjustments lock maximum speed stop screw *14* with safety wire and seal it.

The new position of the throttle valve indicating pointer at the maximum speed setting and the value of maximum *r.p.m.* should be recorded in para. 9 of the ПН-28Б fuel pump Certificate. Make also a record to that effect in Section XII of the Engine Service Log.

At ambient air temperatures below −15°C the engine maximum speed may be less than 4700± ±50 *r.p.m.* because of limited fuel pump output (see chart in Fig. 8).

In that case check the maximum speed setting in flight at an altitude of above 3000 *m.* The maximum speed should be 4700±50 *r.p.m.* Do not overspeed the engine in flight. If the engine maximum speed obtained is equal to 4750 *r.p.m.* land the aircraft and turn in stop screw *14* (Fig. 11) by 1/2 of a revolution. Recheck the adjustment during the next flight.

ADJUSTING EMERGENCY RATING SPEED

Adjustment of the emergency rating speed consists in setting the hydraulic decelerator stop screw to a corresponding position. This is carried out in the following two cases:

a) after adjustment of the maximum rating speed, if it has dropped in the course of service life;

b) after replacement of the ПН-28Б fuel pump (if a fuel pump with a calibrated dial is used).

A. Adjusting Emergency Rating Speed After Adjustment of Maximum Speed If the Latter Have Dropped in Service

1. Adjust the maximum rating speed as it is recommended in Section "Adjusting Maximum Engine Speed".

2. Determine the emergency rating speed drop value which corresponds to the maximum speed drop value and is found as the difference between the maximum *r.p.m.* recorded in para. 9 of the fuel pump Certificate and the maximum *r.p.m.* obtained during the check of the maximum speed under para. 4 of the previous section.

3. Determine the value of one revolution of the hydraulic decelerator adjusting screw in terms of engine rotor *r.p.m.* The corresponding value in terms of fuel pump *r.p.m.* is given in para. 3 of the fuel pump Certificate, the engine-to-fuel pump transmission ratio equals 0.95.

4. Divide the value of the emergency rating speed drop by the *r.p.m.* value corresponding to one turn of the hydraulic decelerator screw and find out the number of turns required for restoring the emergency rating speed of the engine. It is well to remember that the hydraulic decelerator screw must be adjusted so that engine speed does not exceed 4900 *r.p.m.* This limit is set on purpose to preclude the engine from overspeeding at the emergency rating, which may be possible due to an erroneous adjustment in service.

[illegible] by the value determined under para 4. Then turn out twice as much the FULL THROTTLE stop screw located on the IHI 28L fuel pump dial.

Example. Assume that the maximum rating speed has dropped in service from 4700 *r.p.m.* to 4650 *r.p.m.* i.e. the maximum speed and therefore the emergency rating *r.p.m.* have been decreased by 50 *r.p.m.* If the emergency rating speed recorded in the Engine Service Log does not exceed 4900 *r.p.m.* the hydraulic decelerator screw should be turned off as much as to increase the engine emergency rating speed by 50 *r.p.m.*

If the emergency rating speed recorded in the Service Log is equal to 4910 *r.p.m.* i.e. exceeds the specified limit by 10 *r.p.m.*, turn off the hydraulic decelerator screw as much as to increase the engine emergency rating speed only by 50 − 10 = 40 *r.p.m.*

Supposing one revolution of the hydraulic decelerator screw with respect to the fuel pump rotor speed corresponds to 71 *r.p.m.*, which is equal to 74 · 0.95 = 78 *r.p.m.* with respect to the engine rotor speed, the engine emergency rating speed may be restored if the hydraulic decelerator screw is turned off by 50 : 78 = ⅔ of a turn for the first case and by 40 : 78 = ½ of a turn for the second case.

6. Upon completion of adjustments lock and seal the adjusting elements (the hydraulic decelerator screw and FULL THROTTLE stop screw on the IHI-28B fuel pump dial) and make a record of the accomplished adjustments in Section XII of the Engine Service Log. Enter also the corrected number of turns of the hydraulic decelerator screw in para. 9 of the fuel pump Certificate.

B. Adjusting Maximum and Emergency Rating Speeds After Replacement of Fuel Pump

After replacing the IHI-28B fuel pump the engine maximum speed is adjusted in compliance with Section "Adjusting Maximum Engine Speed" of this chapter.

The emergency rating speed is to be adjusted after replacing the fuel pump only in such cases when the emergency rating preset speed of the newly installed pump as reduced to the engine rotor *r.p.m.* is not within 4860 to 4900 *r.p.m.* or differs by more than plus or minus 25 *r.p.m.* from the engine emergency rating speed recorded in the Service Log.

If the emergency rating speed of the newly installed fuel pump as taken from the Certificate and recalculated with respect to engine rotor speed differs by not more than plus or minus 25 *r.p.m.* from the normal emergency rating speed and is within 4860—4900 *r.p.m.* adjustment is unnecessary.

Prior to adjusting the emergency rating speed determine the engine rotor speed change which corresponds to one revolution of the hydraulic decelerator screw. With this purpose divide the [illegible] IHI-28B [illegible] Certificate by 0.95. Then turn in or out the hydraulic decelerator screw to attain a normal emergency rating speed [illegible] (i.e. 4900 *r.p.m.*).

The new position of the hydraulic decelerator screw should be entered in para. 9 of the IHI-28B fuel pump Certificate. Make also respective records in the Engine Service Log: in Section VI on fuel pump replacement, and in Section XII on adjustment of the engine emergency rating speed.

ADJUSTING ENGINE SYNCHRONISM

Since the maximum rating speed is adjusted by means of screw *11* abutting against cam *2* of the emergency rating control mechanism (see Fig. 11), any displacement of the throttle valve control lever of the IHI-28B fuel pump relative to the shaft splines with the aim of engine adjustment for synchronous operation will result in misadjustment of the maximum rating speed.

Therefore, it is prohibited to adjust synchronous operation of the engines by shifting the throttle valve control lever of the IHI-28B fuel pump with respect to the hub teeth or to shift the hub relative to the shaft splines.

Synchronism of engine operation is adjusted by changing the effective length of the serrated arm of IHI-28B pump control lever *13* (see Fig. 11) and by means of certain aircraft control system adjusting elements.

ADJUSTING IDLING SPEED

Prior to checking and adjusting the idling *r.p.m.*, the engine must be warmed up (with the power plant compartment hatches closed) in the course of 3 *min* at speeds from idling *r.p.m.* up to 1200 *r.p.m.* (with the exception of 3800—3900 *r.p.m.*).

The idling speed should be adjusted with the throttle control lever in one and the same position on the transitional stop of the idling rating in the aircraft cabin. The control lever of the IHI-28B fuel pump must rest on the idling rating sector of the pump dial.

The idling speed of the engine is adjusted by the idling rating needle of the IHI-28B fuel pump (idling rating adjusting screw *4* in Fig. 12).

If the idling rating needle is backed out, the engine idling speed increases and on the contrary, if the needle is screwed in the engine idling speed decreases; it must be borne in mind that one click of the screw changes the engine speed by 30 to 50 *r.p.m.* approximately.

It is not allowed to give the screw more than 2.5 revolutions out and one revolution in with respect to the position set at the pump Manufacturing Plant.

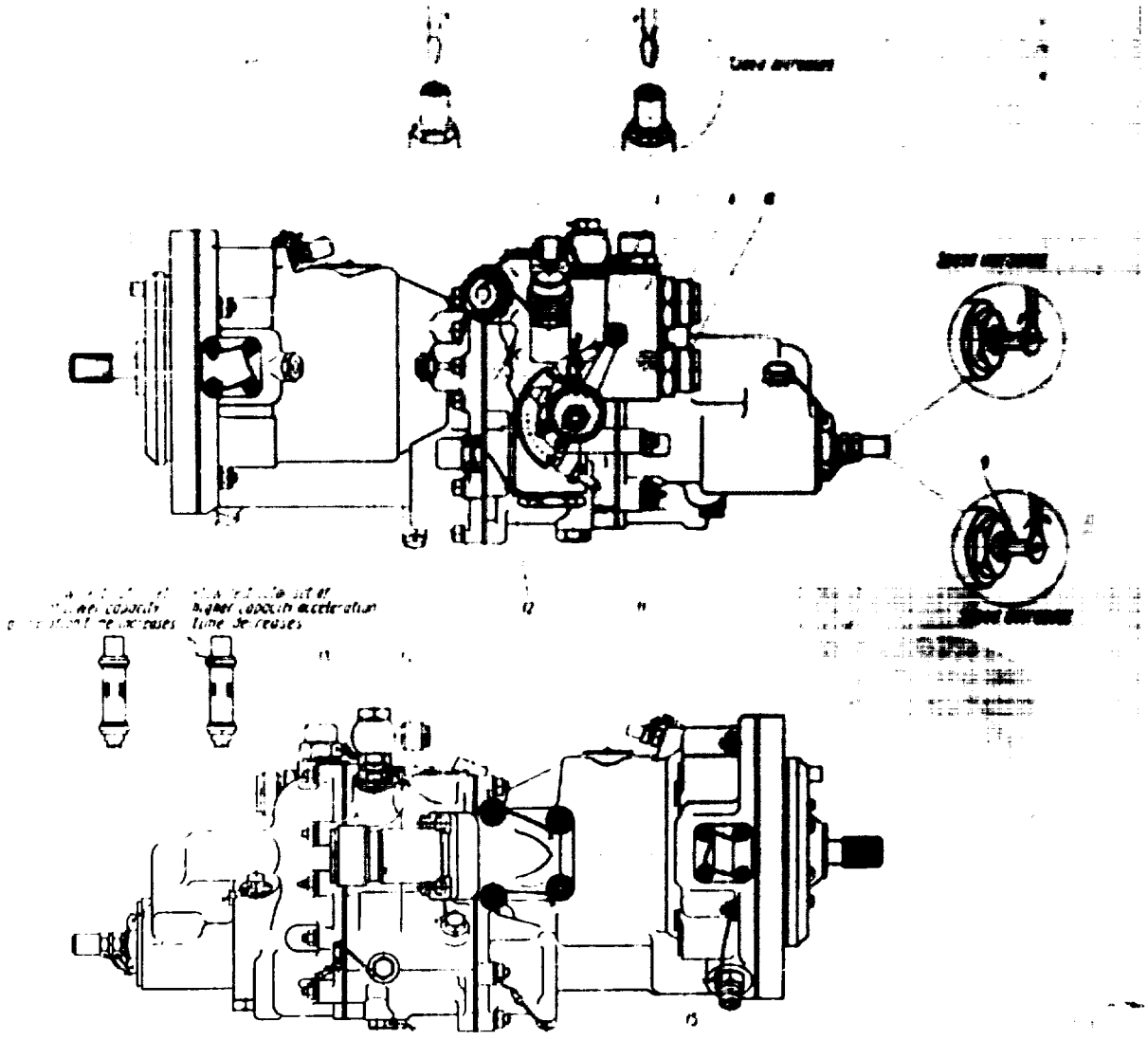

Fig. 12 ПН-28Б Fuel Pump:

1 — minimum fuel output adjusting stop screw; *2* — maximum fuel output adjusting stop screw (covered with cap); *3* — control fine filter (plugged); *4* — idling rating adjusting screw; *5* — nipple for supply of fuel to acceleration control unit of ПН-15Б fuel pump; *6* — CUT-OFF stop; *7* — throttle valve control lever; *8* — pipe union for fuel supply to distributing valve of ПН-15Б fuel pump; *9* — hydraulic decelerator stop; *10* — fuel inlet pipe union from ПН-15Б pump; *11* — emergency rating speed adjusting screw; *12* — throttle valve stop; *13* — hydraulic decelerator flow restrictor; *14* — fuel inlet pipe union; *15* — pump drive gland drain pipe union

ADJUSTING SPEED AT WHICH PNEUMATIC CONTACTOR OPERATES

The speed (1850—2050 *r.p.m.*) at which the pneumatic contactor operates for closing the shutter of the C-300M starter exhaust unit, is adjusted by means of screw *1* of the pneumatic contactor (Fig. 15).

Turning pneumatic contactor screw *1* clockwise increases the shutter closing speed and vice versa.

ADJUSTING ENGINE ACCELERATION

Acceleration of the engine is controlled by the acceleration control unit, distributing valve of the ПН-15Б fuel pump and by proper selection of the hydraulic decelerator throttling assembly of the ПН-28Б fuel pump.

Acceleration of the engine is adjusted as follows:

1. By screw *4* tensioning the spring of the acceleration control unit (Fig. 16).

Turning the screw clockwise, diminishes the pressure on the membrane of the unit air chamber and increases the acceleration time; turning the screw counter-clockwise diminishes the acceleration time.

While adjusting the engine acceleration it is allowed to give the aneroid spring tensioning screw not more than one revolution in the clockwise direction from the position set by the pump Manufacturing Plant; the number of turns for backing out the screw is not limited.

2. By screw *15* which adjusts tension of the distributing valve spring.

Engine acceleration is adjusted by this screw only in case it could not be adjusted by the spring tensioning screw.

Backing out screw *15* diminishes the acceleration time and increases the temperature of gases after the turbine.

Turning in the screw increases the acceleration time. Adjustments are allowed to be performed by turning the screw through not more than $^3/_4$ of a revolution to either direction from the position set by the Manufacturing Plant.

3. By jet *14* used for bleeding air from the membrane chamber of the acceleration control unit.

Increasing the jet diameter diminishes the pressure upon the membrane from the side of the air chamber and increases the acceleration time; decreasing the jet diameter diminishes the engine acceleration time.

For adjusting the engine acceleration time, the individual set of spare parts for the ПН-15Б fuel pump incorporates a set of jets from 2.9 to 3.7 *mm* in diameter at intervals of 0.1 *mm*. Changing the jet diameter by 0.1 *mm* changes the engine acceleration time by 2 or 3 *sec*.

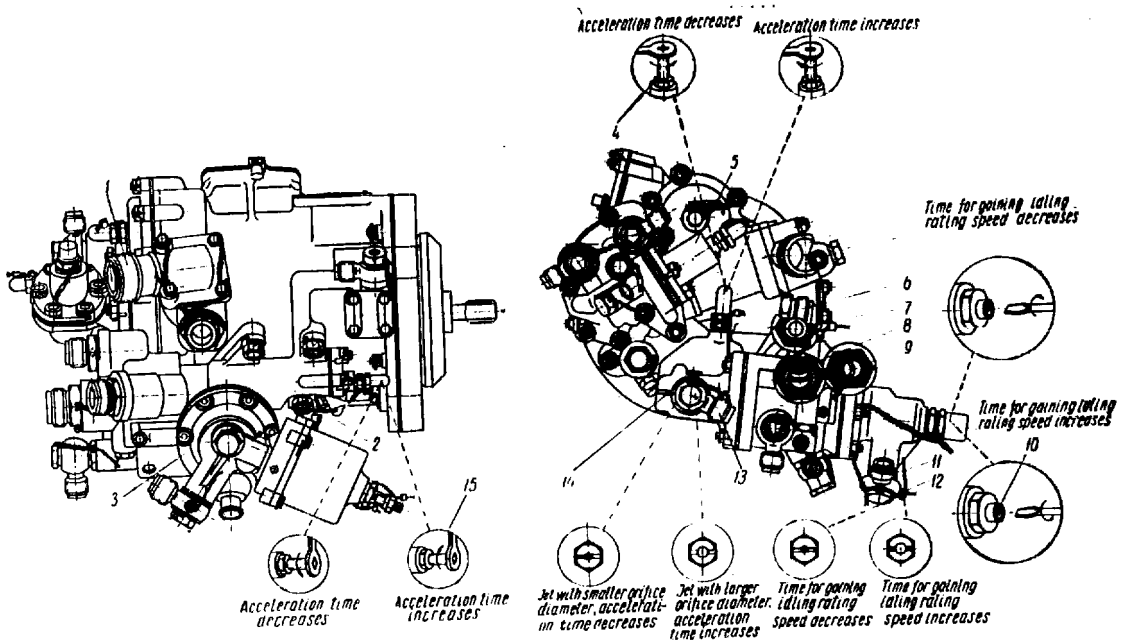

Fig. 16. ПН-15Б Fuel Pump:

1 — fuel inlet pipe union; *2* — fuel distributing valve; *3* — starting control unit; *4* — acceleration control unit spring adjusting screw; *5* — minimum pressure valve; *6* — pipe union feeding fuel to ПН-28Б pump; *7* — fuel feed pipe union to primary manifold; *8* — fuel inlet pipe union from ПН-28Б pump; *9* — fuel feed pipe union to main fuel manifold; *10* — starting control unit adjusting screw; *11* — adjustable nipple for feeding air to acceleration control unit from compressor stage VIII; *12* — air bleeding jet; *13* — adjustable nipple for feeding air to acceleration control unit from compressor stage VIII; *14* — acceleration control unit jet; *15* — distributing valve spring adjusting screw

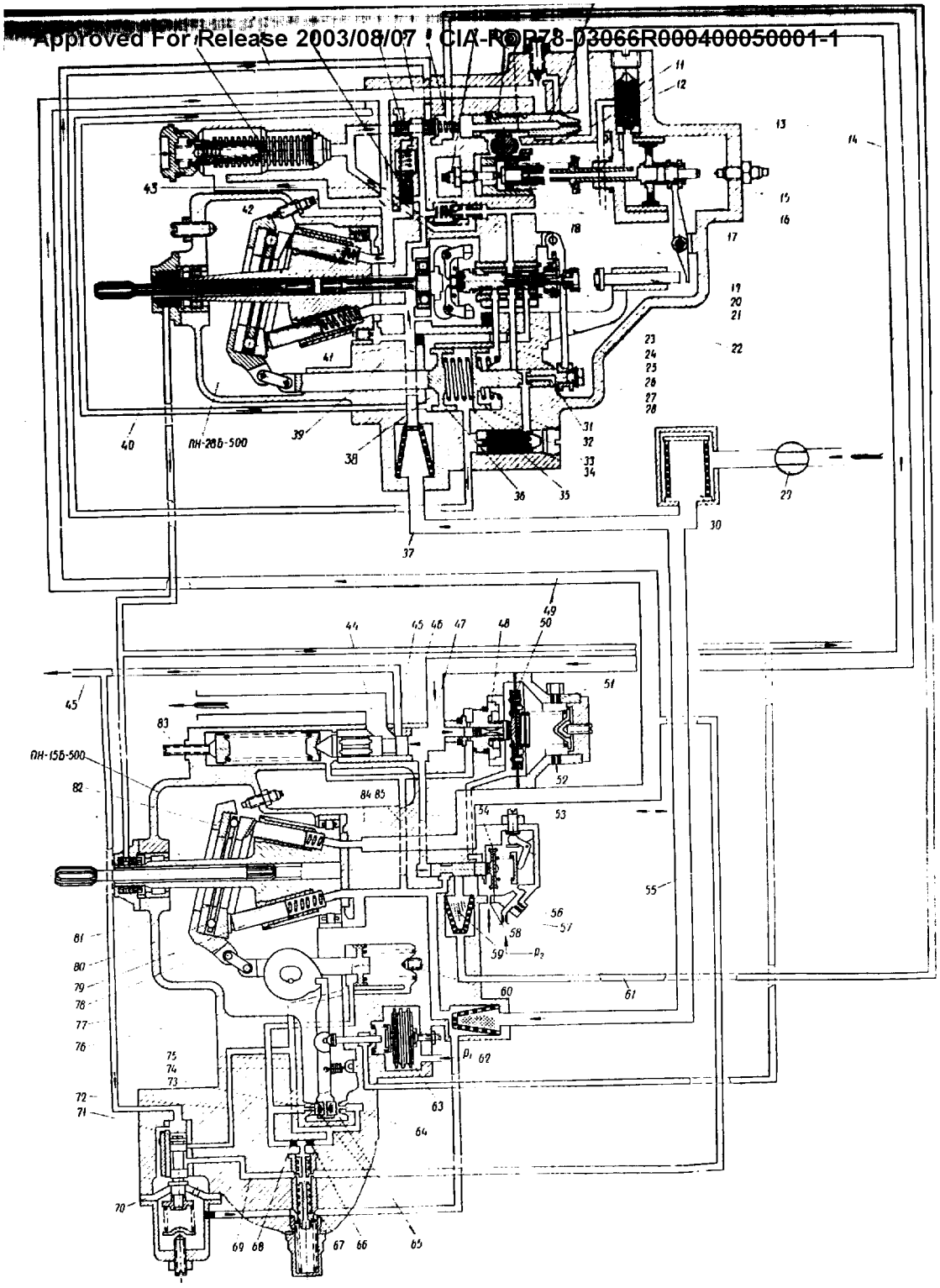

Fig. 49. Fuel Equipment System

1 – central fuel filter, 2 – inter-piston chamber, 3 – fuel return channel, 4 – relief valve, 4 – constant pressure drop valve, 5 – high pressure fuel inlet channels, 6 – constant pressure drop valve chamber, 7 – automatic operation setting screw, 8 – ПН-28Б fuel pump control lever, 9 – idling speed adjusting screw, 10 – throttle valve, 11 and 12 – flow restrictor, 13 – plate of spring 14, 13 – low pressure fuel chamber, 14 – distributing valve (DK) fuel feed channel, 15 – hydraulic decelerator piston rod, 16 – hydraulic decelerator piston, 17 – lever connecting hydraulic decelerator with rod 20, 18 – fuel constant pressure valve of ПН-28Б pump, 19 – hydraulic decelerator slide valve spring, 20 – spring rod of speed governor transmitter, 21 – speed governor transmitter slide valve supporting needle, 22 – speed governor transmitter slide thrust bearing, 23 – speed governor transmitter slide valve, 24 – feedback lever, 25 – wobble plate piston chamber, 26 – fuel inlet channel, 26 – feedback servo piston chamber, 32 fuel inlet channel, 27 – inter-piston chamber, 28 fuel inlet channel, 29 – feedback slide, 29 – fuel shut-off cock, 30 – fine fuel filter, 31 – fuel discharge channel from cleaner, 35, 32 – feedback servo piston, 33 – interpiston chamber, 36 – wobble plate piston of ПН-28Б pump, 37 and 38 – fuel suction channels, 38 – wobble plate servo piston chamber, 39 – speed governor centrifugal transmitter, 40 – fuel high pressure feed channel to chamber 38, 41 – fuel by-pass jet from wobble plate servo piston chamber, 42 – fuel pump maximum output limiting screw, 43 – constant pressure valve fuel feed channel, 44 – main manifold fuel feed channel, 45 – primary manifold fuel feed channel, 46 – fuel distributing valve PK (flow divider), 47 – channel feeding fuel to acceleration control unit slide, 48, 49 – starting control unit slide valve seat, 49 – channel for feeding fuel from ПН-15Б pump to ПН-28Б pump throttle valve, 50 – starting control unit valve plunger, 51 – air pressure supply jet of starting control unit chamber, 52 – starting control unit membrane, 53 – acceleration control unit spring tensioning screw, 54 – acceleration control unit membrane, 56 – acceleration control unit chamber, 57 – acceleration control unit air pressure P_2 inlet jet, 58 – air balance channel of chamber behind membrane, 59 – inlet (nutromesh), 60 – minimum output limiting screw, 61 – fuel pressure relief channel from chamber 6 of constant pressure drop valve, 62 – barometric unit control aneroid chamber, 63 – barometric unit control aneroid, 64 and 65 – barometric unit fuel control variable area jets, 66 – valves of jets 64 and 65, 66 and 65 – barometric unit fuel control constant area jets, 67 – constant pressure valve of ПН-15Б pump, 68 and 69 – by-pass of spassuyu, 70 – pressure fuel to wobble plate servo piston, 70 – minimum pressure valve membrane, 71 – minimum pressure valve slide, 72 – spring of lever 73, 73 – feedback lever of barometric control unit, 74 – barometric unit cam, 75 – wobble plate piston of ПН-28Б pump, 76 – inlet ported member auxiliary part, 76 – plunger with step bearing, 80 – plunger thrust bearing, 81 – holder, 82 – wobbler (bearing holder), 83, 83 – fuel distributor spring adjusting screw, 84 – acceleration control unit slide valve.

and install jet *12* of a smaller orifice diameter, and vice versa.

The operational speed of the automatic starting devices is adjusted by means of additional adjustable resistors connected in series into the winding circuits of the signal relays and shunt winding of the РМО-4 maximum speed relay.

Adjustments are carried out in case the engine speed (or starter speed) at which the unit or element of the automatic starting system must operate is beyond the limits specified below:

1. Speed at which the engine ignition system and starting fuel pump switch on should be within 250±30 *r.p.m.* (adjustment is effected by screw 3Д on the port lid of the ПТ-4В relay box).

2. Speed at which the engine starting fuel pump switches off must be within 810±70 *r.p.m.* (adjusted by screw II).

3. Speed at which the СА-189БМ starter electric motor is switched off should be from 8000 to 12500 *r.p.m.* (to be adjusted by means of screw "Р").

4. Speed at which the starter and entire automatic starting system are switched off should be equal to 1200±50 *r.p.m.* of the engine (adjusted by screw III).

Turning the screws clockwise, reduces the speed at which a certain automatic system unit or element operates; and on the contrary, turning the screws counter-clockwise, increases this speed. While making adjustments give the screws *2* or *3* revolutions after which check the results by starting the engine.

The fuel system diagram is shown in Fig. 19.

Chapter VII

REPLACEMENT OF ENGINE ACCESSORIES AND ASSEMBLIES

If it is impossible to eliminate defects detected on the engine accessories and assemblies, replace the faulty units and accessories. When doing this, be sure to observe the following rules:

1. Before work close the air blow-off band; before disassembling any units of the fuel and oil systems drain the system in question.

2. All the holes exposed during disassembly of engine accessories and units must be plugged immediately to prevent dirt and foreign matter from getting inside the engine.

3. Accessories and assemblies removed from the engine must be slushed. If a removed accessory is delivered to the Manufacturing Plant not later than 48 hours after removal from the engine, external slushing may be avoided.

4. Before installing a new accessory or assembly on the engine it should be deslushed and checked for conformity with its Certificate.

5. While installing new accessories and assemblies on the engine it is by no means allowed to use old locks or washers. The nuts and screws of flanged connections must be turned in and out evenly and in a definite order (in a cross-wise sequence).

6. When assembling hose and pipe joints provided with rubber sealing rings, tighten the union nuts of the joints turning them through a certain angle counted from the position of the nut screwed in by hand to contact the pipe union mating shoulder. These angles are as follows:

a) for union nuts with thread size under $22\times1.5-60\pm10°$;

b) for union nuts with thread size over $24\times1.5-40\pm10°$.

Such tightening of the union nuts in the rubber-sealed joints will ensure the necessary tightness at fuel, oil, or air pressures of up to 250 *atm*.

Further tightening of the nuts with the purpose of eliminating leaks is not allowed. Replace the faulty rubber ring with a new one to eliminate the trouble.

7. After assembly of the fuel or oil system accessories be sure to check their connections for leakage on the running engine.

8. All the operations performed on the engine should be entered in the accessory Certificates and the Engine Service Log.

Described below are the operations related to replacement of some of the engine accessories and units.

Replacement of the remaining units and accessories listed below does not require any preliminary fitting operations, or any special assembly instructions.

While assembling any accessory or unit, be sure to use only fastening and cottering parts (clamps, nuts, bolts, locks, etc.) indicated in the specifications of the Manufacturing Plant.

The fastening parts of the hoses and pipes should be installed in exactly the same places they occupied before replacement of the accessory or unit.

Before installing the pipes and hoses, wash them thoroughly with clean gasoline and blow out with compressed air.

LIST OF ACCESSORIES AND ASSEMBLIES WHICH MAY BE REPLACED IN THE COURSE ON ENGINE OPERATION

Name of Accessory and Assembly	Quantity
Engine Accessories	
Oil pump unit	1
Centrifugal transmitter	1
ПН-28Б fuel pump	1
ПН-15Б fuel pump	1
Electromagnetic air valve	1
Flow-off valve	1
ЭМТ-25 emergency rating control mechanism	1
ПНРІО-3М starting fuel pump	1
Centrifugal breather	1
ЦН-1Д booster fuel pump	1
КПН4-2Р1 booster coil unit	1
Air pressure reducer	1
Anti-icing system air bleed valve	1
Air blow-off band control mechanism	1
Oil filter	1
С-300М starter	1
СД-24А oil pressure warning unit	1
СА-189БМ electric motor	1
Starting electromagnetic fuel valve	2

Name of Accessory and Assembly	Quantity
Starter oil pump	1
ТНР-3Р fuel regulating pump	1
ТЭ-45 tachometer generator	1
КП-21 booster coil	1
ТД-1 tachometer generator	1
Т-9 thermocouple	1
ПТ-4В relay box	1
ПК pneumatic contactor	1
Engine electromagnetic fuel valve	1
АК-150П air compressor	1
СПН-4-3 spark plug	4
Engine Assemblies	
Aircraft accessory drive gear box	1
Engine wheelcase	1
R. H. intermediate drive	1
L. H. intermediate drive	1
Lower drive box	1
Aircraft accessory drive gear box coupling shafts	2
Starting fuel manifold on engine	1
Main and primary fuel manifolds with burners (to be replaced jointly)	1
Starter fuel manifold with burners (to be replaced jointly)	1
Starter igniter	2
Engine igniter	4
Engine flame tube	14
Exhaust unit with shroud	1
Jet nozzle (to be replaced by one of the same diameter)	1
Starter exhaust unit	1
Starter fairing	1
Drain tank	1
Flow-off tank	1
Air blow-off band	1
Engine-to-aircraft attachment fittings	
Fire extinguishing manifold	2
All external oil, fuel and air pipes, instrument pipes, as well as electric wires and their attachment parts	

REPLACEMENT OF OIL PUMP UNIT

1. Drain oil from the oil tank and compressor front casing sump.

2. Disconnect the oil inlet and outlet pipes from the pipe unions of the oil pump unit.

3. Remove the starter oil inlet pipe.

4. Disconnect the pipe passing oil from the oil pump unit into the engine.

5. Disconnect the pipes scavenging oil from the oil collectors of the engine middle and rear supports.

6. Remove the pipe returning oil from the starter into the oil tank.

7. Unlock and unscrew the nuts with a wrench and remove the oil pump unit from the engine.

8. To install the oil pump unit, reverse the removal operations.

REPLACEMENT OF ЦД-3 CENTRIFUGAL TRANSMITTER

To replace the centrifugal transmitter:

1. Disconnect the oil inlet pipe and the wire of the automatic starting system bunched conductor.

2. Remove the centrifugal transmitter having previously undone the locks and unscrewed its attachment nuts.

3. When installing a new transmitter see that the square extension of the driving gear is free to enter the square hole in the centrifugal transmitter.

4. Having installed the transmitter, start the engine and switch it from the idling rating to 0.8 normal rating and back to check the speed at which the air blow-off band is closed and opened. (It should open at 3800+50 *r.p.m.*).

If the band closing and opening speeds are other than required, adjust the centrifugal transmitter operating speed in accordance with the recommendations given in Chapter VI.

REPLACEMENT OF ПН-28Б AND ПН-15Б FUEL PUMPS

The fuel pumps should be replaced in the following order (Fig. 20):

1. Drain fuel through pipe union *3* on the pump suction line by the use of С170-54 device, having previously closed the fuel shut-off valve.

2. Unlock all the union nuts of the fuel supply, air and drain pipes, and adapter connected to the ПН-15Б and ПН-28Б pumps.

CAUTION! The free ends of the fuel and air lines should be plugged immediately after the pipes have been disconnected.

3. Disconnect fuel low pressure measuring pipe *15* from adapter *14*.

4. Remove adapter *14* with the branch pipe.

5. Remove pipe *6* feeding fuel from the ПН-15Б pump distributing valve to the flow-off valve.

6. Dismount pipe *10*, feeding fuel from ПН-15Б pump to the throttle valve of the ПН-28Б pump, and pipe *9* feeding fuel from ПН-28Б pump throttle valve to the distributing valve of ПН-15Б pump.

7. Remove pipe *13* which passes fuel from the ПН-15Б pump acceleration and starting control units to the flow-off tank.

8. Disconnect hose *8* delivering fuel from the ПН-15Б pump to the main fuel manifold.

9. Disconnect pipe *7* delivering air pressure P_2 to the starting unit and acceleration control unit *10* of the ПН-15Б pump.

10. Disconnect pipe *4* which feeds the velocity head to the ПН-15Б barometric control unit.

11. Remove pipe *2* which feeds fuel from the

2. Disconnect the pipe, taking air after the 8th stage of the compressor, from the pneumatic contactor.

3. Undo and unscrew one of the nuts which connect the front and middle casings of the compressor and remove the pneumatic contactor from the engine.

4. Enter the total working time and the probable cause of removal into the pneumatic contactor Certificate.

5. Install the pneumatic contactor by reversing the removal operations.

REPLACEMENT OF FLOW-OFF VALVE

To replace the flow-off valve with a new one:

1. Disconnect the inlet and outlet pipes from the flow-off valve.

2. Remove the flow-off valve having undone the locks and unscrewed the bolts fastening the flow-off valve to the bracket.

3. Install a new valve by reversing the removal operations.

4. Check functioning of the flow-off valve on the engine working at idling rating.

REPLACEMENT OF AIR REDUCER 52512700

The air reducer should be replaced in the following order:

1. Disconnect the air inlet and outlet pipes from the air reducer pipe unions.

2. Unscrew the nuts, remove the shackle and take the air reducer off the support.

3. To install the reducer reverse the removal operations.

REPLACEMENT OF СД-24А OIL PRESSURE WARNING UNIT

The oil pressure warning unit of the starter is replaced as follows:

1. Disconnect the oil pressure measuring pipe from the warning unit as well as the wire leading to the unit lamp.

2. Undo and unscrew the attachment nut and remove the СД-24А warning unit complete with its bracket.

3. To install a new СД-24А warning unit, first attach it to the bracket and then proceed in the order reverse to the removal operations.

Prior to installing the new warning unit check its error of functioning with the oil pressure dropping (it should operate at a pressure of 3.5 ± 0.3 *kg/sq.cm*). The oil pressure during the check must be changed within 0 to 5 *kg/sq.cm*.

REPLACEMENT OF С-300М STARTER

To replace a faulty starter with a new one proceed as follows:

1. Drain oil from the oil tank.

2. Remove the fairing and plug up the compressor screen at the starter air inlet. Remove the support of the compressor front frame.

3. Disconnect the following starter lines from the engine lines:

— the pipe feeding fuel from the electromagnetic fuel valve pipe union;

— the lower drive oil scavenging line from the oil pump pipe union;

— the pipe conducting oil into the oil tank from the pipe union of the oil pump;

— the pipe feeding oil from the oil pump;

— the pipe which feeds oil from the inner nose section of the compressor front casing and serves for measuring the oil pressure fed from the pipe union of the oil filter;

— the pipe feeding compressed air from the engine air distributor valve;

— the combustion chamber drain pipe;

— the ТНР-3Р fuel regulating pump drain pipe.

4. Unscrew the union nut from the oil flow-off pipe located on the bottom part of the reducer.

5. Disconnect the wires from the tachometer generator, fuel valve, electric motor СА-189БМ, booster coil КП-21 and ТЭ-45 tachometer generator. Insulate reliably the ends of the removed electric wires. Disconnect the thermocouple.

6. Fix the lifting device to the starter, remove the parts (locks, washers, nuts and bolts) attaching the starter to the flange of the compressor front casing inner nose section, then remove the starter and place it on the support.

7. Protect the removed starter with a cover, put seals on it and forward the unit to a repair shop having indicated in its Certificate the number of startings and the probable cause of detect.

8. Before installing a new starter, clean, wipe, dry and examine carefully the engine-to-starter fitting surfaces and the splines of the drive coupling.

If a new starter is to be installed not immediately after the removal of the defective one, close the hole in the inner nose section of the compressor front casing with a metal plug or thick paper.

9. Check the play of the drive coupling shaft, i. e. the axial clearance between the butt end of the shaft and locking ring *2* (Fig. 21).

For this purpose, measure distances А and Б with a depth gauge and determine the clearance В = А − Б which should be within 1—5 *mm*.

10. Deslush the starter in compliance with the procedure outlined in Chapter X.

When doing this, fill the starter oil system with oil, for which purpose disconnect the oil pressure measuring pipe from the СД-24А warning unit pipe union and keep it open while cold-cranking the starter. Connect the pipe to the

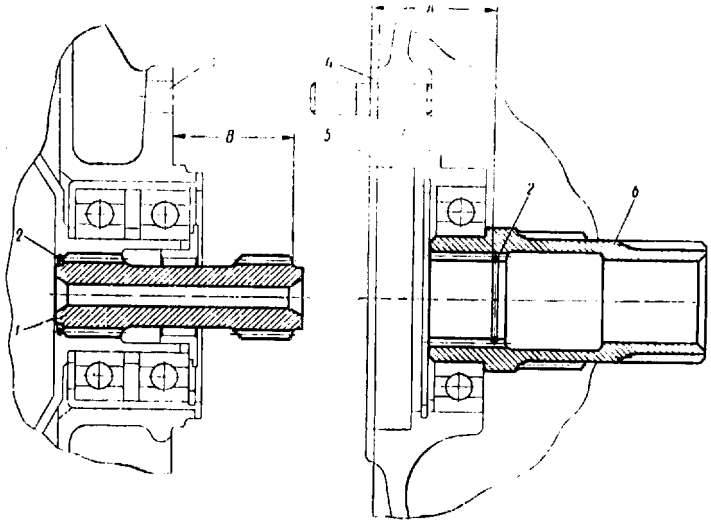

Fig. 21. Starter Replacement Diagram:
1 — coupling shaft; *2* — locking ring; *3* — starter reduction gear casing flange; *4* — gasket; *5* — engine front casing liner section flange; *6* — engine front casing inner section drive shaft

СД-24А warning unit pipe union as soon as a solid spray of oil appears from the open end of the pipe.

Cold-crank the engine.

Before cold-cranking the engine start the starter 2 or 3 times bringing its speed to 8000—15,000 *r.p.m.* to burn out any oil that may have remained as a result of incomplete deslushing of the starter.

If during cold-cranking of the engine the performance data of the starter are other than specified (see Chapter III), take the measures advised in Chapter VIII.

REPLACEMENT OF CA-189БМ ELECTRIC MOTOR

To replace the CA-189БМ electric motor observe the following order of operations:

1. Remove the starter fairing and the support of the compressor front casing.
2. Disconnect and insulate the power supply wires.
3. Undo and unscrew the nuts attaching the electric motor to the starter reduction gear body and remove the motor.
4. Unscrew the nut and remove the driving gear of the electric motor, bushing and sealing ring.

Note. As the driving gear and bushing are furnished together with the starter assembly, they should be mounted on the newly installed CA-189БМ electric motor in case of its replacement.

5. On the removed motor measure distance A between the gasket and the face of the inner race of the ball bearing, using a depth gauge. Then set up this distance on the newly installed motor by selecting calibrated gaskets *2* of necessary thickness (Fig. 22).

6. Having selected the calibrated gaskets install the bushing and driving gear on the motor shaft, fix and lock them; place the selected gasket and mount the motor in its seat in the reduction gear casing. Tighten and lock the motor attachment nuts and fix the power cables on the terminals.

7. Check whether the electric motor has been properly installed, for which purpose cold-crank the C-300M starter and engine.

REPLACEMENT OF THP-3P FUEL REGULATING PUMP

To replace the THP-3P fuel regulating pump perform the following operations:

1. Remove the fairing and protect the screen at the starter air inlet.
2. Remove the starter oil drain hoses.
3. Disconnect the fuel and oil inlet and outlet pipes and disconnect the drain pipe.
4. A new pump is installed in the reversed order.
5. Having installed the new pump disconnect the fuel inlet pipe from the starter fuel manifold and turn on the ENGINE COLD-CRANKING switch in order to prime the starter fuel system for 15 to 20 *sec* several times until a solid spray of fuel without air bubbles appears from the free end of the pipe.
6. Connect the fuel inlet pipe to the starter fuel manifold and depending on the temperature of the gases in the starter exhaust unit perform

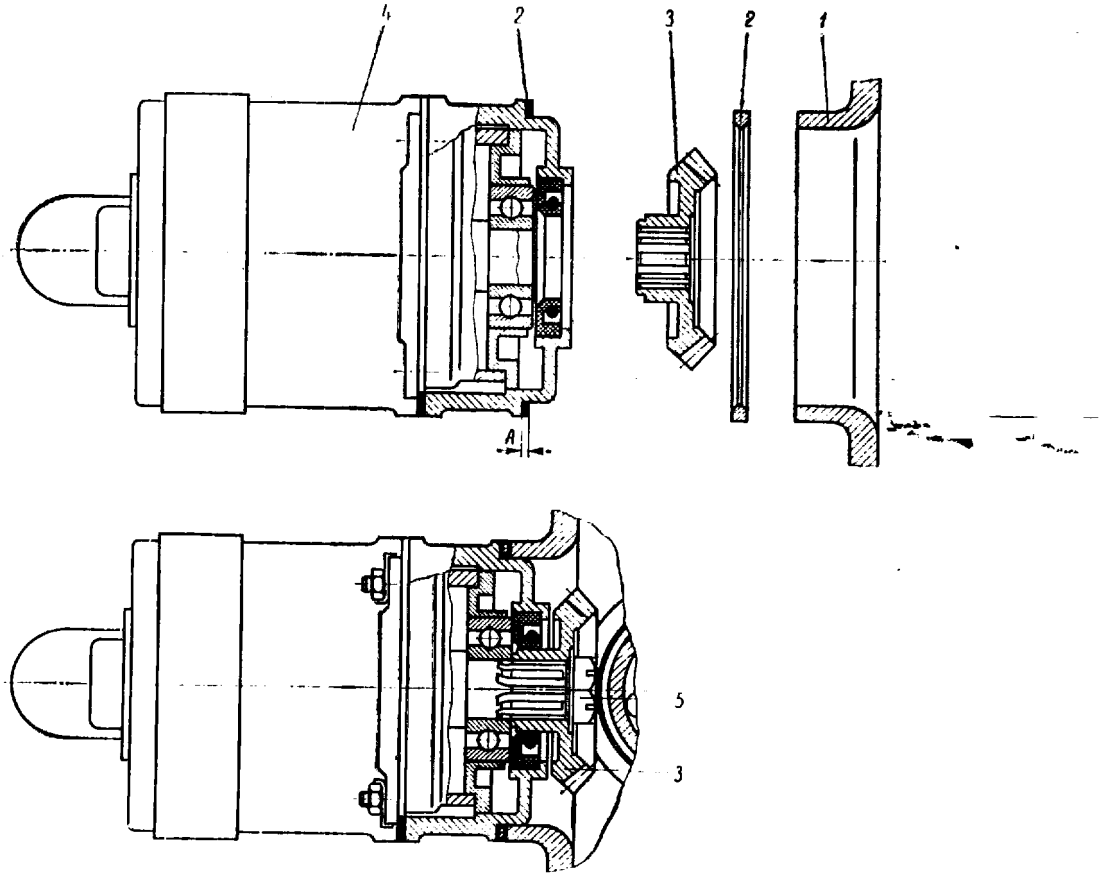

Fig. 22. CA-189BM Electric Motor Replacement Diagram:
1 — reduction gear casing flange; *2* — calibrated gasket; *3* — electric motor driving gear; *4* — CA-189BM electric motor; *5* — driving gear attachment nut

one or two preliminary startings of the starter bringing its speed to 10,000—15,000 *r.p.m.*

7. Cold-crank the engine.

If the starter performance factors fail to conform with the specified values, adjust the fuel regulating pump and recheck operation of the starter during cold-cranking of the engine.

8. Having finished cold-cranking of the engine check the lines leading to the pump for leakage.

REPLACEMENT OF КП-21 BOOSTER COIL

Replace the КП-21 booster coil in the following sequence:

1. Remove the starter fairing from the engine.
2. Disconnect the plug connector and detach the power supply wire from the coil.
3. Disconnect the wires leading from the coil to the spark plugs.
4. Unlock and unscrew the bolts and remove the booster coil complete with the bracket.
5. Inspect visually the new coil and assemble it with the bracket.
6. Installation of the coil is the reverse of its removal.

REPLACEMENT OF ENGINE IGNITER AND SPARK PLUG

In replacing the igniters it is well to bear in mind that the igniter of No. 3 flame tube is interchangeable with that of No. 10 flame tube and the igniter of No. 5 flame tube is interchangeable with that of No. 12 flame tube.

To replace the igniters do the following:

1. Disconnect the fuel feed pipe from the starting fuel manifold filter.
2. Disconnect the screened H.T. cable from the spark plug.
3. Remove the bolts with the igniter fastening locks and remove the igniter with the gasket from the compressor rear casing.
4. To install the igniter reverse the removal operations.

Upon completion of work, check carefully the attachment parts for reliability of locking and start the engine two or three times.

To replace the spark plug proceed as follows:

1. Disconnect the H.T. cable from the CIIH-4-3 spark plug.
2. Remove the spark plug from the igniter.
3. Put a new gasket on the new spark plug.

To install the new spark plug reverse the removal operations. Using a torque wrench tighten the spark plug with an effort of not over 6 *kgm*.

REPLACEMENT OF JET NOZZLE

Replace the jet nozzle as follows:

1. Disconnect the clamps fastening the drain pipes located on the nozzle surface.
2. Undo and unlock the union nut, then remove the pipe which carries fuel from the drain tank away to the edge of the jet nozzle.
3. Undo and unscrew *56* bolts with locks and levelling bracket and remove the jet nozzle from the exhaust unit of the engine.

It is allowed to replace the jet nozzle with a new one whose outlet diameter differs by not more than ±1 *mm* from the outlet diameter of the nozzle being removed.

The figures denoting the outlet diameter of the jet nozzle are stamped on the outlet face of the nozzle and registered in the Engine Service Log.

To install the nozzle on the engine reverse the removal operations.

Having installed the jet nozzle and tightened the bolts, use a feeler gauge to check the clearance between the nozzle and the exhaust unit; this clearance must not exceed 0.05 *mm* along the entire circumference.

REPLACEMENT OF COMBUSTION CHAMBER FLAME TUBES

To replace the combustion chamber flame tubes remove the engine from the aircraft.

When replacing the tubes it should be remembered that the tubes are divided into two groups according to their interchangeability; one group includes Nos. 3, 5, 10 and 12 tubes with flame igniters, while the other group includes tubes Nos. 1, 2, 4, 6, 7, 8, 9, 11, 13, and 14 which are fitted with retainers.

The tubes within each group are interchangeable, but they are not interchangeable between the groups.

The combustion chamber flame tubes should be replaced in the following order:

1. Remove the exhaust unit shroud and the shroud attachment brackets from the engine.
2. Disconnect the attachment parts and remove the drain pipes from the drain and flow-off tanks and from the nozzle diaphragm assembly chamber.
3. Remove the branch pipe connections of the pressure-balance chamber.
4. Remove the oil pipe attachment parts.
5. Remove the combustion chamber casing attachment parts, shift the casing towards the exhaust unit and remove it from the engine.

The casing must be removed by means of two wire ropes protected by rubber on the outside, and by a lifting device.

6. Remove the igniter or retainer of the flame tube to be removed and take off the igniters or retainers of two adjacent flame tubes.
7. Remove the main burner of the flame tube to be removed.
8. Undo and remove the attachment parts of two main burners that are adjacent to the one removed.
9. Force apart the flame tubes adjacent to that being removed and free the flame tube from the flame interconnecting tube bushings of the adjacent flame tubes.
10. Shift the flame tube to position III (Fig. 23) and move its shell out of the nozzle diaphragm assembly frame; then, moving the tube to position IV take it off the engine.

Note. If removal of the faulty flame tube proves to be difficult, remove some of the adjacent tubes located above or below and, working the faulty tube up or down in the space thus formed, pull it out of the engine.

11. To install the flame tubes reverse the order of the removal operations. Before installation, inspect the inner spaces of the tubes and have them cleaned.

Upon completion of work examine thoroughly the attachment parts for reliability of locking and start the engine two or three times.

Chapter VIII

ENGINE TROUBLESHOOTING AND REMEDIES

CAUTION! Prior to adjusting the engine make sure that the measuring instruments show correct readings.

Probable cause	Troubleshooting and Remedy
I. C-300M Starter Fails to Start	
1. Insufficient supply of fuel to burners	1. Check for presence of gasoline in the tank 2. Check the fuel lines for leakage. Tighten the nuts and replace the gaskets or pipes, if necessary 3. Check condition of the gasoline filter and wash it, if necessary 4. Disconnect the end of the pipe feeding starting fuel to the starter manifold, then turn on the master switch and the ENGINE COLD-CRANKING switch to prime the starting system unit a solid spray of fuel flows from the open end of the pipe
2. Ignition system faulty	1. Check the igniter for sparking by turning on the STARTER COLD-CRANKING switch for 10 or 15 *sec.* In case of heavy carbon deposits on the electrodes, or if the electrodes are found to be oily, wash the spark plug in clean gasoline and check for sparking again 2 If the washed spark plugs are still missing, check condition of the storage battery, resistance of the wires in the ignition system and in the connections 3 If the remedies mentioned in Items 1 and 2 fail to produce the desired results replace consecutively the spark plugs and the ignition coil NOTE. Having checked the ignition system, cold-crank the starter once or twice to expel the remaining fuel from the combustion chamber
3. CA-189BM electric motor fails to bring the speed of the C-300M starter to 4500—5000 *r. p. m.*	1. Check condition of the electric motor. Replace the motor, if it overheats 2 Check condition of the storage battery and recharge or replace it, if necessary 3. Check the voltage on the electric motor terminals at the beginning of engine cold-cranking. This voltage must not be below 10 *V* 4. Check the connections and the resistance in the entire circuit between the storage battery and the electric motor terminals (the resistance must not exceed 0.0133 *ohm*)
II. Starter Speed at Which CA-189BM Motor Switches Off Does Not Correspond to the Specified Data (8000—12,500 *r. p. m.*) (the moment the motor is switched off is determined by a sharp deflection of the ammeter pointer)	
1. Motor switching-off speed is too high	Turn in the adjusting screw of the PMO-4B relay (the screw is marked "P" on the cover of the ПТ-4В box) checking the results of adjustment after every 2 or 3 revolutions of the screw
2. Motor switching-off speed is too low	1. Check condition of the storage battery 2. Turn out the adjusting screw of the PMO-4B relay and check the results of adjustment after every 2 or 3 revolutions of the screw

Probable cause	Troubleshooting and Remedy
III. Starter Gains Operating Speed Too Slowly	
The time required by the starter for gaining operating speed exceeds 28 *sec* (at an excessively low temperature of gases in the starter exhaust unit)	Turn in starting screw *2* (Fig. 10), check the results of adjustment by starting the starter after every 1/8 of a revolution of the screw
IV. Engine Gains Speed of 400 *r. p. m.* in More Than 45 *sec*	
Starter fuel consumption at operating speed too low	Turn in screw *1* of the pressure control valve of the THP-3P fuel regulating pump (Fig. 10) checking the results of adjustments by starting the starter after every two revolutions of the screw Notes: 1. Screw *1* of the THP-3P pump must be turned in for an even number of revolutions only. 2. If turning in screw *1* fails to increase the fuel consumption, restore the initial position of the screw and turn in starting screw *2* through 1/8 of a revolution
V. Starter Operating Speed is Other than Specified	
1. Operating speed too high (more than 33,500 *r. p. m.*)	Back out screw *3* (Fig. 10) of the centrifugal governor by 1/8 of a revolution and check the results of adjustment by starting the starter
2. Operating speed too low (less than 31,000 *r. p. m.*)	Turn screw *3* of the centrifugal governor through 1/8 of a revolution clockwise and check the results of adjustment by starting the starter.
VI. Temperature of Gases in Starter Exhaust Unit (Exceeds 700°C at Operating Speeds)	
Fuel consumption too high	Back out screw *1* (Fig. 10) of the pressure control valve and check the results of adjustment by starting the starter after each revolution of the screw
VII. Main Fuel Fails to Ignite in Engine	
1. No feed of starting fuel into engine to burners	1. Check for presence of gasoline in the tank 2 Check the pipes for leakage and tighten the nuts, replace the gaskets or pipes, if necessary 3 Check condition of the gasoline filter and wash it, if necessary 4. Disconnect the starting fuel supply line from the engine and wash out the aircraft system line 5. Check operation of the ПНР-10-3М starting fuel pump by disconnecting the end of the pipe feeding fuel to the starting manifold If the pump functions properly gasoline must flow out in a continuous spray
2. Faulty supply of main fuel (pressure gauge registers no fuel pressure in primary manifold)	1. Check whether the fuel shut-off valve is open 2. Check functioning of the control system 3. Expel any air from the fuel system by feeding fuel through the system. Be certain that the aircraft booster pumps function properly, this is evidenced by fuel pressure registered before the engine fuel pumps Note. If the above measures fail to detect and eliminate the defect replace the ПН-28Б and ПН-15Б fuel pumps
3. Engine ignition system faulty	1. Check functioning of the starting booster coil units aurally having switched off the ПНР-10-3М pump by means of STARTING IN AIR button kept depressed for 10 to 15 *sec* 2. Unscrew the spark plugs and check sparking having previously turned off the ПНР-10-3М fuel pump. If the ignition system fires irregularly replace the faulty spark plugs and carry out the check-up again. 3. If spark plug operation is not perfect yet, check the storage battery for charge and the resistance of the ignition system wires and connections. 4. If after the above operations the ignition system is still misfiring, replace the igniters and the starting booster coil unit in succession
VIII. Engine Starting Time Exceeds 2 *min*	
1. Cranking of engine by starter not sufficiently intensive	Check the time during which the engine gains speed at cold-cranking (a speed of 400 *r. p. m.* should be reached in not more than 45 *sec*); should this time prove to be too long, adjust the output of the THP-3P fuel regulating pump in accordance with Section IV of this Chapter
2. Insufficient fuel feed during starting	If the engine does not gain speed adjust the starting control unit in conformity with Chapter VI

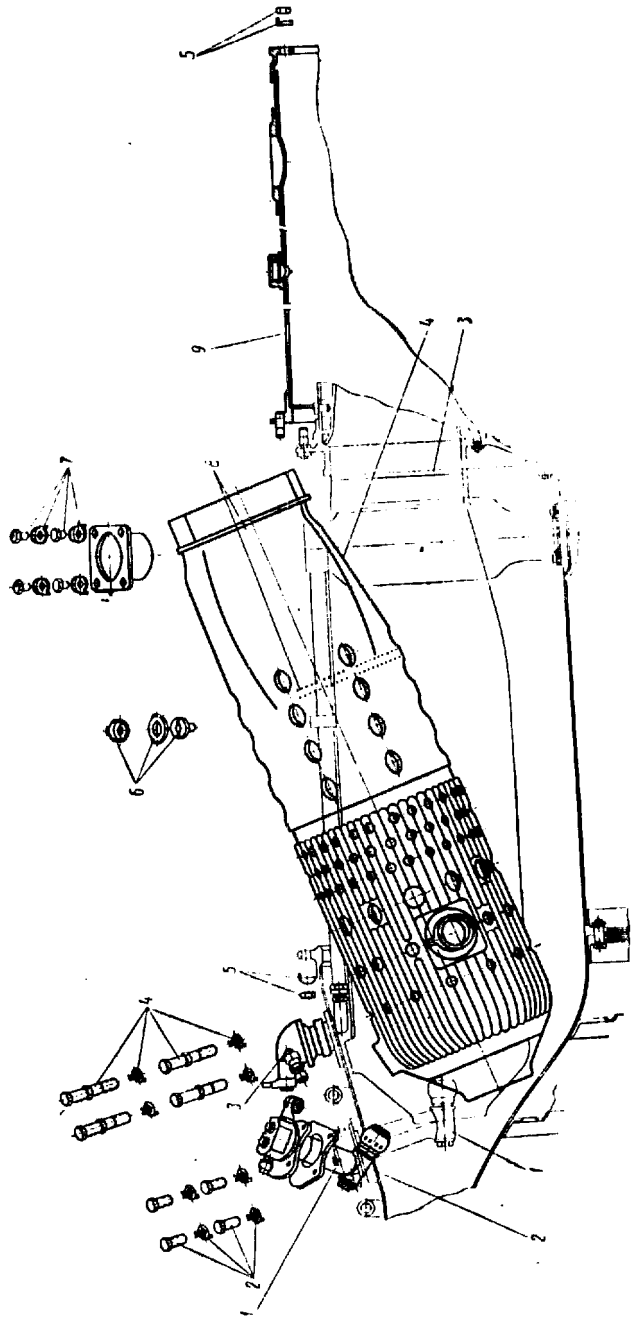

Fig. 23. Replacement Diagram of Igniters, Burners and Combustion Chamber Flame Tubes:
1 — main burner; *2* — burner attachment parts; *3* — igniter; *4* — igniter attachment parts; *5* — combustion chamber casing attachment parts; *6* — oil pipe attachment parts; *7* — pressure balance chamber outlet branch pipe attachment parts; *8* — combustion chamber flame tube; *9* — combustion chamber casing

Probable cause	Troubleshooting and Remedy
IX. Engine Fails to Reach Idling Speed	
1. Engine control is disturbed (with the engine control lever on the transitional stop of the idling rating, the lever of the ПН-28Б pump is below the idling rating sector)	Adjust the engine control system on the aircraft so that, with the engine control lever on the transitional stop of the idling rating, the lever of the ПН-28Б pump is between the end marks of the idling rating sector
2. Starting control unit out of adjustment	Adjust the starting control unit as advised in Chapter VI
X. Engine Starting Accompanied by Surge an Excessive Rise of Gas Temperature after Turbine	
1. Compressor air blow-off band closed	Open the air blow-off band. Do this by pressing the button, taking off the wing nut and fixing it on the stud located on the blow-off mechanism casing
2. Engine control is disturbed (with the engine control lever on the transitional stop of the idling rating, the lever of the ПН-28Б pump is above the idling rating sector)	Adjust the engine control system on the aircraft so that, with the engine control lever on the transitional stop of the idling rating, the lever of the ПН-28Б pump is between the end marks of the idling rating sector
3. Fuel feed during engine starting exceeds the necessary limit	Adjust the starting control unit as instructed in Chapter VI of this Manual
4. Air blow-off band manual control button jammed	Check functioning of air blow-off band control mechanism by pressing the manual control button. In case of malfunctioning, check the manual control button contacts for condition
XI. Idling Speed is Other than Specified	
The quantity of the fuel supplied by the pumps is too low or too high	Adjust idling speed as instructed in Chapter VI
XII. Air Blow-Off Band Fails to Close	
No supply of compressed air to blow-off band control mechanism	1. Check pressure of compressed air in the aircraft air system 2. Check functioning of the electromagnetic valve. For this purpose, disconnect the plug of the centrifugal transmitter plug connector, turn on the master switch and close sockets Б and В of the plug connector. Upon closing the sockets the valve must operate. (This check should be performed aurally). If the valve fails to operate examine the electric wiring and, if it is intact, replace the valve. 3. Replace the centrifugal transmitter if the band closes during the check described in Item 2 4. If during the check described in Item 2 the band fails to close, replace air reducer 52518700 Note. If the ambient temperature is low, warm up the air reducer and check its operation prior to replacing it
XIII. Air Blow-Off Band Opening and Closing Speeds Other than Prescribed	
1. Centrifugal transmitter out of adjustment	Adjust centrifugal transmitter as prescribed in Chapter VI
2. The difference in band opening and closing speeds exceeds 50 *r. p. m.*	Replace the centrifugal transmitter
XIV. With Reduced Temperature of Gases after Turbine the Maximum Rating Speed is Lower than Specified	
1. Insufficient fuel supply to engine (fuel pressure before ПН-28Б and ПН-15Б pumps too low)	1. Check whether the fuel shut-off valve is open 2. Inspect the fuel filters and wash them, if necessary 3. Check functioning of the aircraft booster pumps 4. If the aircraft pumps operate normally, replace the ПН-1Г1 pump 5. If the above measures fail to correct the fault replace in succession the fuel-oil cooler and the flowmeter
2. Maximum speed stop out of adjustment	Adjust the maximum speed stop as instructed in Chapter VI
XV. With Normal Temperature of Gases after Turbine the Maximum Speed is Lower than Specified	
Engine speed indicator faulty or improperly calibrated	Replace the engine speed indicator
XVI. Maximum Rating Speed is Higher than Specified	
1. Engine speed indicator faulty or improperly calibrated	Replace the engine speed indicator
2. Maximum speed stop out of adjustment	Adjust the maximum speed stop as advised in Chapter VI
XVII. Temperature of Gases after Turbine at Maximum Rating to High	
Air is bled from compressor (air blow-off band or aircraft anti-icing system control valve opened)	Check the air blow-off band control system and aircraft anti-icing system control valve

Probable cause	Troubleshooting and Remedy
XVIII. Temperature of Gases after Turbine at Maximum Rating Too Low	
1. Short-circuiting of one or more thermocouples 2. Heating of wires leading from thermocouples to indicator 3. Faulty conductors in thermocouples. Poor contacts in connections	Replace the set of thermocouples Check to see that the wires do not touch hot parts of the engine Check wire connections at the sensing elements, in the terminal box, plug connector and indicator
XIX. Acceleration Time Exceeds 17 *sec*	
1. Insufficient fuel feed (fuel pressure before ПН-28Б and ПН-15Б pumps too low)	1. Inspect the fuel filters and wash them, if necessary 2. Check functioning of the aircraft booster pumps 3. If the aircraft booster pumps operate normally, replace the ЦН-1Д pump 4. If the above measures fail to correct the fault, replace in succession the fuel-oil cooler and flowmeter
2. Acceleration control unit out of adjustment.	Adjust engine acceleration as instructed in Chapter VI
XX. Engine Acceleration Check is Accompanied by Flaming-Out and Surging	
1. Acceleration control unit out of adjusment.	Adjust the acceleration control unit as instructed in Chapter VI
XXI. Oil Pressure Too Low	
1. Insufficient oil in tank 2. Wrong pressure gauge readings. 3. Oil pump pressure control valve out of adjustment 4. Heavy oil leaks in oil system 5. Oil filter clogged	Check the oil level Check calibration of the pressure gauge Adjust the pressure control valve as instructed in Chapter VI Check the engine oil system for leakage through the joints and replace the defective pipes or gaskets Inspect the filter and wash it, if necessary
XXII. Oil Pressure Too High	
1. Oil pump pressure control valve out adjustment	Adjust the oil pump pressure control valve as instructed in Chapter VI
XXIII. Oil Consumption Exceeds 1.5 *kg/hr*	
1. Leaky oil pipes 2. Excessive quantities of oil thrown out through breather 3. Breather pipe clamped	Check the oil pipes for leakage Replace the centrifugal breather Check the cross-section of the pipe and eliminate the defect, if necessary (the pipe should be ø 28 *mm*)
XXIV. Oil Flows from Tank into Engine with Aircraft at Parking Ground	
1. Poor tightness of oil system return valves	1. Drain oil from the compressor front casing before starting 2. Replace the starter oil filter and starter oil pump in succession
XXV. R. H. Engine Maximum Rating Speed Too Low at Subzero Temperatures	
Fuel feed effected by barometric control unit	Disconnect the pipe supplying air to the ПН-15Б pump barometric control unit. If the engine maximum rating speed is restored, the trouble is not considered to be a fault
XXVI. Oil Fumes Contaminate Air Bled from Compressor for Cockpit Pressurization	
1. Breathing pipe squeezed 2. Oil leaking into engine intake duct	Check the clear cross-section of the breather pipe and eliminate the defect, if necessary Check the starter oil system for tightness
XXVII. Fuel Penetrates into Oil System	
1. Poor tightness of fuel-oil cooler 2. Poor tightness of fuel and booster pump glands 3. Poor tightness of gas turbine starter electromagnetic valve (Fig. 3).	Remove the cooler and check it for tightness. Replace the cooler, if necessary Replace the fuel units in succession Check the electromagnetic valve for tightness

If the above methods prove to be ineffective in eliminating the engine operating troubles, it is necessary to invite a representative of the Supplier.

Chapter IX

REPLACEMENT OF ENGINE

REMOVING ENGINE FROM AIRCRAFT

After the engine which is to be replaced is stopped slush immediately its internal surfaces and close the compressor intake, the aircraft air blow off holes, and the jet nozzle with lids.

The operations for removal of the engine from the aircraft should be performed in the sequence contrary to that followed during installation (see below).

When removing the engine from the aircraft be sure to close the oil, fuel and air pipes of the engine and aircraft systems with plugs immediately after disconnecting them.

TRANSPORTING ENGINE

For transportation purposes the engine is to be packed into a special wooden box along with the following items:

- set of spare parts;
- set of parts and units necessary for assembling and mounting the engine in aircraft.

The dimensions of the wooden box are 5700×2040×2040 *mm*.

The box consists of an upper detachable cover and bottom part. Bolted to the bottom is a metal support for the engine. The engine is fastened to the support in two planes:

in the plane of the compressor middle casing rear section by the two diametrically opposite attachment fittings set into the holes located in line with the horizontal split joint;

in the plane of the front flange of the 1st stage nozzle diaphragm assembly casing by three supporting brackets provided with rubber pads.

To ensure better fastening of the engine to the support, it is lashed to the latter with a wire rope in a rubber cover. The rope is run through the combustion chamber casing in the plane of the front flange of the 1st stage nozzle diaphragm assembly. Tension of the rope is adjusted by means of the bolts fixed in the inclined braces in the rear uprights of the support.

The box may be hoisted with a crane whose load-lifting capacity is not less than 6 tons.

CAUTION! It is strictly prohibited to turn over or tilt the box with the engine.

The box is suspended from the crane by means of wire ropes run through four rings in the upper part of the cover (two rings at each side).

CAUTION! When hoisting the box with the aid of a crane from a truck or railway car check whether the upper cover of the box is reliably fastened to the bottom.

UNPACKING NEW ENGINE

Prior to unpacking, examine the box on the outside. If the box or the seals are damaged draw up a special statement. Unpack the engine as follows:

1. Remove the four bolts holding the cover to the bottom.
2. Secure the wire ropes to the box cover rings, lift the cover avoiding any distortion and lower it on the ground at some distance.
3. Remove the set of engine mountings and spare parts. Check the condition of the seals on the packing.
4. Slacken and remove the wire rope holding the engine to the support in the rear attachment plane.

PREPARING ENGINE FOR INSTALLATION ON AIRCRAFT

Before installing the engine on the aircraft remove the external slushing compound. Attach the engine-to-aircraft mountings. A set of slushed aircraft mountings and rods is furnished and transported in the box complete with the engine. If the aircraft is equipped with two engines, the aircraft mountings are installed after the engines are classified into left-hand and right-hand engines.

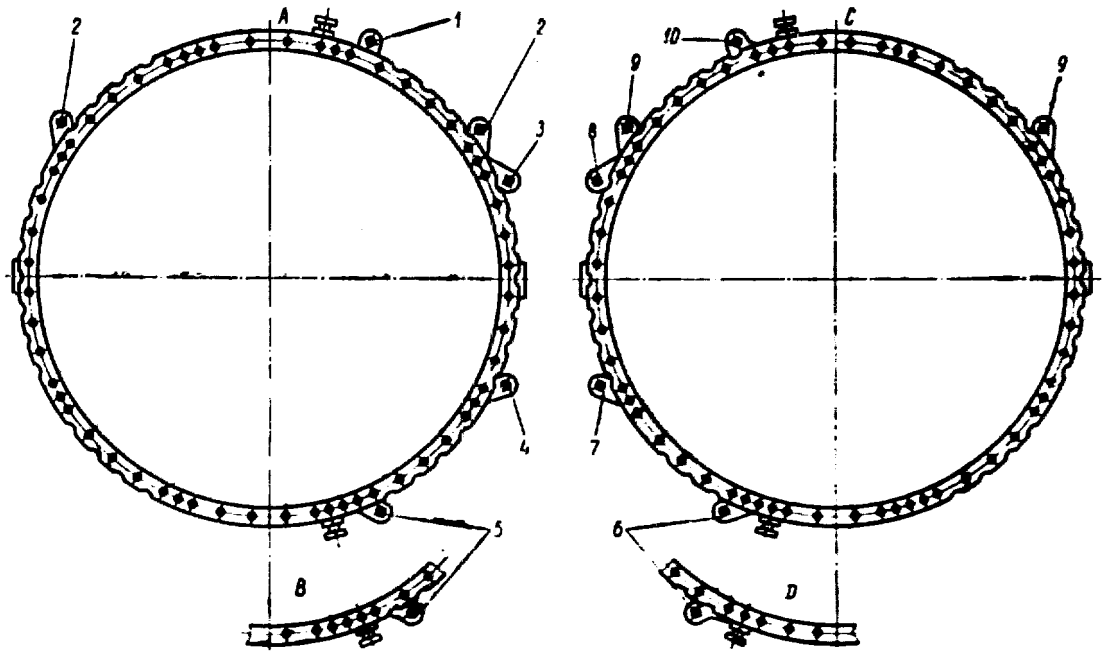

Fig. 24. Rear Casing Ring with Engine Attachment Fittings (Viewed from Exhaust Unit):
from *1* to *10* — engine mounting bracket, *A*, *B* - frame ring of L.H. engine rear casing, *C*, *D* - frame ring of R.H. engine rear casing

To convert a L.H. engine into a R.H. one it is necessary to rearrange the following parts and assemblies:

1. Mounting brackets *1*, *3*, *4*, *5* (Fig. 24) and *9* (Fig. 25) — from the right-hand side of the compressor rear casing to the left-hand side.

2. Five clamps which fasten the thermocouple wires — from the right-hand side of the exhaust unit shroud to the left-hand side.

3. The pipe which conveys oil from the starter into the oil tank-from the left-hand side of the oil pump unit to the right-hand side.

To convert a R.H. engine into a L.H. one the corresponding parts and assemblies must be rearranged in the reverse order.

When mounting R.H. and L.H. engines on TУ-104 aircraft see to it that the lower central mounting brackets are installed in accordance with views B and Г in Fig. 24.

The mounting parts should be attached to the engine in compliance with Fig. 25.

The mounting brackets should be arranged on the engine in two planes:

— in the plane of the guide vanes of compressor stage VIII (mounting brackets *1*, *4*, *6*, *7*, *8*);

— in the plane of the 1st stage nozzle diaphragm assembly flange (mounting brackets *2* and *3*).

The attachment fitting must be installed on the engine which is fastened to the support of the shipping box after external deslushing. The attachment fittings and rods should be deslushed with clean gasoline by the use of a brush. The lower attachment fittings may be installed after removing the engine from the support. The engine that has been provided with attachment fittings and inspected on the outside is considered ready for installation on the aircraft.

Prior to installing the engine on the aircraft check the condition of the engine compartment. The compartment is considered ready for accommodation of the engine if it has been cleaned of dust, dirt, traces of oil or fuel and of any foreign articles such as nuts, bolts, tools, etc.

INSTALLING ENGINE ON AIRCRAFT

Secure the lifting device to the engine fittings, separate the engine from the metal support, lift it and move carefully into its compartment in the aircraft.

When lifting and mounting the engine take care not to damage the outer hoses and piping. See to it that the lifting device wire ropes or aircraft engine compartment parts do not touch the engine units and assemblies.

The attachment rods are mounted and secured, and the engine is levelled out in accordance with the instructions of the aircraft Manufacturing Plant. When levelling the engine take for reference points two flats on the jet nozzle and the holes in the lower part of the compressor front casing support.

Having fastened the engine, connect the throttle valve control rod to the ПН-28Б fuel pump lever.

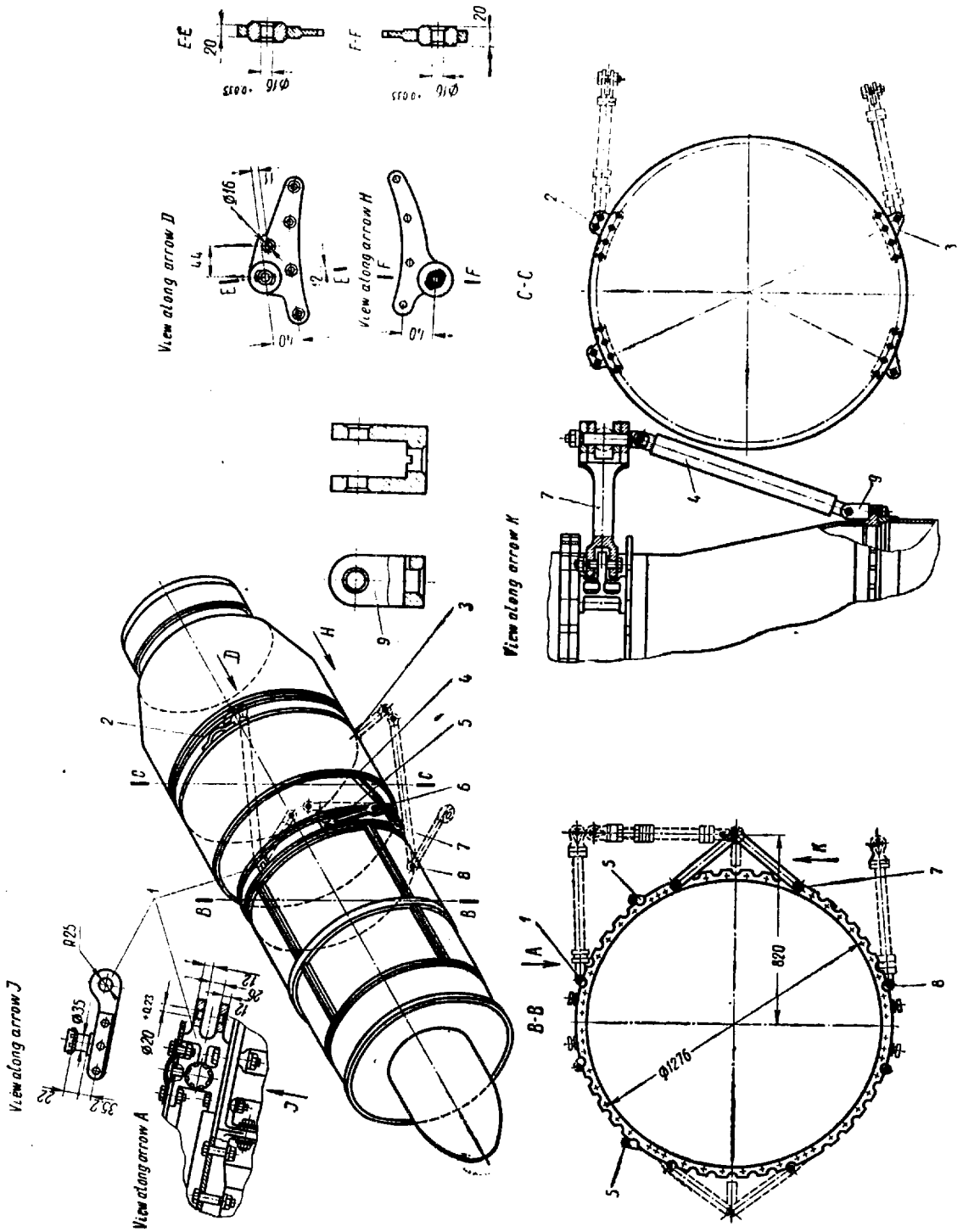

Fig. 25. Mounting Engine in Aircraft:

1 — upper front mounting bracket; *2* — upper rear mounting bracket; *3* — lower rear mounting bracket; *4*, *6* and *7* — load-carrying aircraft braces; *5* — front mounting for handling engine; *8* — lower front mounting bracket; *9* — mounting assembly attached to rear flange of compressor rear casing

CONNECTING AIRCRAFT PIPELINES TO ENGINE

Before connecting the aircraft fuel and oil system pipelines to the engine make sure they are clean and not clogged by foreign matter or dirt. The plugs of the engine and aircraft pipes must be removed just before their connection.

Having connected the pipes, wipe the engine surfaces with pieces of cloth to clean the engine of any fuel and oil stains.

CAUTION! It is neither allowed to fit the engine with parts, assemblies or units which do not belong to it, nor to remove parts, assemblies or units, from the engine without consulting the Supplier.

LIST OF AIRCRAFT PIPELINES AND WIRES CONNECTED TO ENGINE

Description	Type of joint
Oil System	
Oil inlet line	Rubberized fabric hose
Oil outlet line	Rubberized fabric hose
Engine breathing line	Same
Oil tank breathing lines	Same
Pipes for measuring oil pressure	Nipple joint
Oil temperature measurement connection	Treaded joint
Drain pipe from ГСР-18000М generator adapter	Nipple joint
Main and Starting Fuel System	
Pipes feeding main fuel to booster pump	Rubberized fabric hose
Pipes carrying fuel from booster pump	Same
Pipes feeding main fuel to high pressure fuel pumps	Same
Connection for measuring fuel pressure at ПН-28Б inlet	Nipple joint
Connection for measuring fuel pressure in primary fuel manifold	Same
Starting fuel supply connection	Rubberized fabric hose
High-Pressure Air System	
Pipes feeding air to reducer	Nipple joint
Pipes feeding air to mechanism which controls the engine compartment air discharging shutter	Same
Engine Air Bleed System	
Pipes feeding air to aircraft cabins (from compressor stage VII)	Flanged joint
Pipes feeding aircraft anti-icing system (air bleed from after compressor stage VIII)	Flanged joint
Hydraulic System	
Pipes feeding hydraulic fluid to 435ВФ hydraulic pump	Nipple joint
Pipes carrying hydraulic fluid from 435ВФ hydraulic pump	Same
435ВФ hydraulic pump drain pipes	Same
Generators	
Connection of wires to generators	Bolted joint
Hose feeding air for cooling generators	Rubberized fabric hose
Engine Electric System	
Connection of four-pin plug connectors	
Connection of bonding strips	Bolted joint
Drain System	
Pipes for draining fuel from combustion chamber casing	Nipple joint
Pipes for draining fuel from nozzle diaphragm assemblies	Same
Pipes for draining fuel from С-300М starter combustion chamber	Same
Fire Fighting System	
Pipes feeding carbon dioxide to discharge rings	Nipple joint

Note. The pipe ends in the nipple joint are expanded

INSTALLING AND CONNECTING ENGINE GAUGES AND INSTRUMENTS

To check the engine performance it is necessary to install and connect the following gauges and instruments (Fig. 26):

1. ТЭ-45 tachometer indicator showing the starter speed; this instrument is joined to plug connector *142*.

2. ТСТ-29 thermocouple indicator registering the temperature of gases in the starter exhaust unit; this instrument is connected to wires *143*.

3. ТЭ5-2 tachometer generator for measuring engine speed, the generator is installed on flange *141*.

4. ЭДМУ-3 electric remote-reading pressure gauge (standard) for measuring fuel pressure before ПН-28Б and ПН-15Б fuel pumps; the pressure gauge is connected to pipe *146*.

5. Pick-up unit for measuring fuel pressure in the primary manifold (belongs to the ЭМИ-3Р gauge unit); the pick-up unit is attached to the engine panel and connected to pipe *145*.

6. Engine oil main line pressure pick-up unit (belongs to the ЭМИ-3Р gauge unit); the pick-up unit is fastened to the engine panel and connected to pipe *144* through the damper mounted on the pick-up unit.

7. Sensing element for measuring oil temperature in the engine oil main (belongs to the ЭМИ-3Р gauge unit); the sensing element is installed in branch pipe *147*.

8. Pick-up for measuring oil pressure in started inlet pipe *149*.

9. Having installed the transmitters in compliance with Items 5, 6, and 7, connect them to

the plug connectors of the ЭМИ-3Р gauge unit indicator.

10. T-64-4 thermocouples for measuring the temperature of gases in the engine exhaust unit; the thermocouples should be installed in bosses *148*.

GROUND AND AIR TESTS OF NEWLY INSTALLED ENGINE

1. Having installed the engine on the aircraft, pay particular attention to proper mounting of the engine and make sure that no foreign matter has been left on the engine (tools, bolts, nuts, washers, etc.).

2. Prior to the first starting of the engine installed in the aircraft prime its fuel and oil lines and deslush the engine fuel system as described in Chapter X.

Note. If engine ground tests are accompanied by fluctuations of engine speed or fuel pressure, prime the fuel lines once more.

3. Preparation of the engine for starting, warming up and stopping the engine should be carried out in conformity with Chapter "Preparation of Engine for Flight".

4. The first start of the engine should be carried out with the hatches of the engine compartment in the aircraft opened to facilitate inspection of the engine and checking of its adjustment.

5. With the engine running, check pressure tightness of the pipe and unit connections of the fuel, oil and drain systems (the check should be carried out only at idling rating).

6. If the results of the engine ground tests prove to be satisfactory, proceed with testing the engine in the air.

Chapter X

ENGINE SLUSHING AND DESLUSHING

GENERAL

The engine treatment with anti-corrosion compound is the basic process which ensures proper protection of the engine parts against corrosion during storage and transportation. Therefore, engines which are temporarily placed out of service should be properly and timely treated with anti-corrosion compounds meeting the respective specifications with regard to their physical and chemical properties.

Engines may be subjected to either partial or complete anti-corrosion treatment.

Partial (or internal) processing consists in slushing the engine fuel lines with compound to coat them from inside with a film protecting the lines against corrosion. Internal slushing of the engine should be carried out when the aircraft is kept (or the engine is placed in storage) in a hangar or some other closed location protecting the engine against atmospheric precipitation and sudden changes of the temperature. Engines so treated may be stored for up to 30 days.

Engines which are removed from the aircraft and placed in storage for up to 3 months should be subjected to complete slushing in accordance with the procedure set forth in the present chapter. Complete slushing of the engine will guarantee protection against corrosion in the course of not more than 3 months in case the engine is being kept at a depot. If the engine is expected to be stored in excess of 3 months it should be slushed in compliance with the Instructions on Engine Slushing supplied with the engine.

If the aircraft is not to be flown (with the engines installed in the aircraft) for a period of up to 30 days it is allowed to keep the engines deslushed in case the engines are started regularly (once a week) and warmed up for 4 or 5 *min* at 0.8 nominal rating. Periodical startings of the engine are required for washing the engine fuel system units with circulating fuel.

If the engines (the aircraft) are placed out of service for a long period of time without fuel in the fuel system, the fuel system accessories should be temporarily treated within three hours after the fuel has been drained. This operation may be carried out with the fuel system units installed on the engine or removed from it.

Surfaces attacked by corrosion should be dressed with fine-grade abrasive cloth soaked in oil, then polished with ГОИ paste, washed in clean gasoline and coated with slushing compound.

It is not allowed to carry out corrosion removal operations during rains or snow-falls. Anti-corrosion compound must be applied only to clean and dry surfaces of the engine parts.

ANTI-CORROSION COMPOUNDS

To perform internal processing of the fuel and oil systems make use of МК-8 oil (USSR Standard ГОСТ 6457-53) or transformer oil (USSR Standard ГОСТ 982-56).

All external unpainted metal parts (with the exception of those made from stainless steel) are slushed with neutral petrolatum (USSR Standard ГОСТ 782-53).

Notes: 1. Petrolatum may be substituted by aviation oil МС-20 (USSR Standard ГОСТ 1013-49) mixed with 4 to 6% of ceresine (USSR Standard ГОСТ 2488-47). The mixture of oil and ceresine should be heated to a temperature of from 60 to 70°C before being applied.

2. Anti-corrosion compound should not contain any water. If moisture is detected in the anti-corrosion compound intended for slushing, remove the moisture by heating the compound to 110 - 120°C until it stops foaming at that temperature.
3. Prior to slushing the engine check whether the anti-corrosion compound meets the requirements set forth in the Specifications.
4. It is not allowed to use reclaimed or used oils for slushing.

INTERNAL SLUSHING

Internal slushing of the engine consists in filling its fuel system with oil.

The operation is carried out by means of an outfit (furnished with a felt filter at the outlet) in the following sequence:

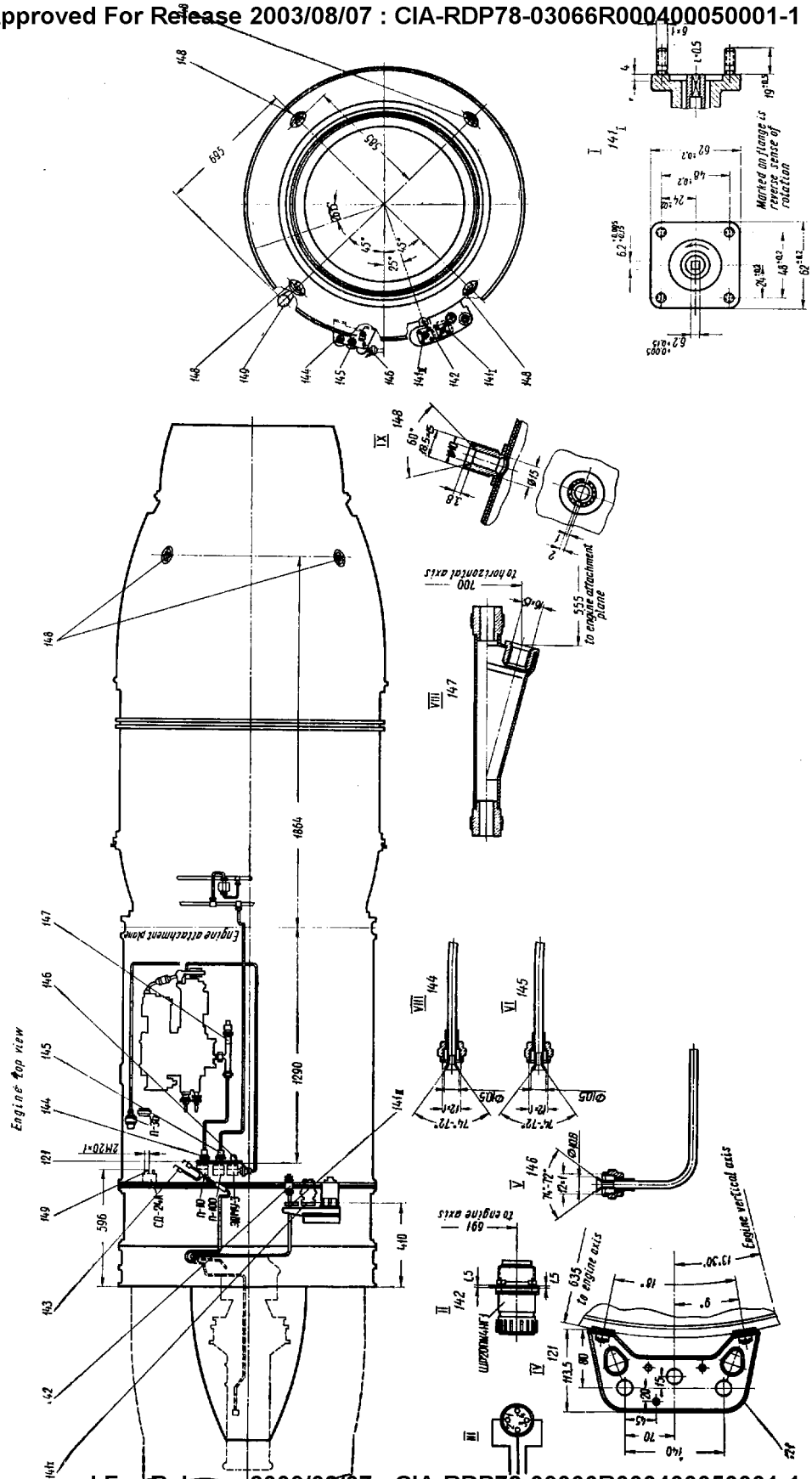

Fig. 26. Measuring Instrument Connection Diagram:

141 — engine speed pick-up unit; *142* — C-300A starter speed pick-up unit; *143* — TCT-29 thermocouple set, oddleads used for measuring exhaust gas temperature in starter exhaust unit; *144* — engine oil main pressure pick-up unit; *145* — pick-up unit for measuring fuel pressure before burners; *146* — pick-up unit for measuring oil pressure before ПН-10Б and ПН-10В pumps; *147* — sensing element for measuring oil temperature in engine oil main line; *148* — installation place of thermocouples for measuring exhaust unit gas temperature; *149* — СП-30А oil pressure warning unit plug connector from starter; *121* — panel for pick-up units and transmitters; *I* — engine tachometer generator attachment flanges; *II* — starter tachometer generator plug connector; *III* — socket wire connection diagram; *IV* — instrument panel; *V* — pipe for measuring fuel pressure before ПН-10 pump; *VI* — pipe for measuring fuel pressure in primary manifold of burners; *VII* — pipe for measuring oil pressure in engine oil main line; *VIII* — pipe connection for measuring oil temperature; *IX* — bosses for thermocouples measuring exhaust unit gas temperature

Note. Pressure transmitters П-10 and П-100, as well as sensing element П-1 for measurements under item "K" belong to the ЭМИ-3Р gauge unit set. Thermocouple Т-9 from the ТСТ-29 set and tachometer generator Т9-45 are mounted on the engine and supplied along with the latter

1. Disconnect the fuel pipes from the ЦН-1Д booster pump and connect by means of a nozzle, the hose from the internal processing outfit.

2. Using hoses connect the pipe unions for measuring the fuel pressure on the main and primary manifolds.

3. Pour 70 *lit* of oil compound into the oil tank of the outfit. The oil should be strained through a silk filter.

4. Disconnect the plug connectors feeding current to two КПП4-2Р1 booster coil units.

5. Drain kerosene from the drain tank (through the drain plug), from the filter and fuel-oil cooler (through the drain cocks).

6. Shift the engine control lever to the idling rating position and switch on the oil pump of the outfit to build up a pressure of from 0.4 to 1.5 *kg/sq.cm*. Cold-crank the engine 2 or 3 times within 60 -65 *sec* each time; while cold-cranking the engine feed 45 to 50 *lit* of oil into the fuel system. During cold-cranking of the engine move the engine control lever from the idling rating position to the maximum speed stop and back a few times.

After cold-cranking the engine two times the oil compound should flow from the drain pipes of the nozzle diaphragm assemblies, combustion chamber casing and exhaust unit. Upon completion of cold-cranking the engine, set the control lever to the CUT-OFF position.

7. Switch off the pump of the outfit.

8. Disconnect the plug connector of the wire feeding current to the КП-21 booster coil.

9. Drain gasoline from the starting fuel tank through the drain cock and disconnect the starting fuel inlet pipe from the starting fuel filter.

10. Disconnect the hose of the outfit from the ЦН-1Д booster pump and take the nozzle off the hose. Connect the hose to the starting fuel filter. Switch on the pump of the outfit for internal slushing of the engine starting system and starter fuel system.

11. Depress the STARTING IN AIR button and prime the engine starting system with oil. Repeat this operation 2 or 3 times. The ПНР10-3М pump should not operate for more than 15—20 *sec* with intervals between startings of not less than 1 *min*.

12. Prime the starter fuel system with oil, cranking the starter 2 or 3 times. The starter should be cranked by pressing the STARTING button. It should be operated not longer than 20 *sec* at a time and brought up to a speed of at least 4500 *r.p.m*. Stop the starter by turning off the master switch. At the end of the second or third cranking the oil should flow from the drain pipes of the combustion chamber casing.

13. Restore the proper connection of the fuel and electric systems of the engine.

14. Drain completely the engine oil system.

COMPLETE SLUSHING

Engines which are removed from aircraft and prepared for storage or shipping must be subjected to complete slushing.

Internal slushing of the engine is carried out with the engine installed on the aircraft in compliance with the previously outlined procedure.

External slushing of the engine should be performed not later than 20 hours after its removal from the aircraft.

All the engine slushing operations must follow one another without interruption.

External slushing of the engine should be carried out in the following sequence:

1. Put special plugs into all the holes which communicate with the internal chambers of the engine.

Caution! Use of paper or wooden plugs is not allowed.

2. Clean the engine outside of dust, dirt and condensate with pieces of cloth soaked in clean gasoline.

The cleaned surfaces (in particular those which are to be painted) should be dried up and blown with compressed air.

CAUTION! The compressed air used for air blasting must be cleaned of water, dust and oil. Protect electric fittings and wires against contact with gasoline.

3. After cleaning with gasoline and blowing with air all the unpainted external metal parts of the engine, as well as the internal surface of the engine exhaust unit should be coated with a layer of neutral petrolatum or compound consisting of MC-20 or MK-22 oil mixed with 4 to 6 per cent of ceresine. The compound is applied by means of a brush. To thin out the slushing compound heat the petrolatum to 80—90°C and the mixture of aviation oil with ceresine from 60 to 70°C.

4. Upon expiration of the three months' period the engine should be deslushed and retreated with anti-corrosion compound according to the above procedure.

CAUTION! 1. It is prohibited to slush the engine during rain or snow-fall.
2. Apply anti-corrosion compound only to clean and dry parts of the engine.

Having completed the external slushing, pack the engine. All the protruding parts (the accessory drive gear box, engine wheelcase, drives, etc.) as well as flexible hoses should be wrapped in three layers of paraffine paper and tied up with twine. Put a cover of thick fabric on the engine, tie up the cover openings and seal them.

EXTERNAL DESLUSHING

Remove the fabric cover from the engine, cut the twine and carefully take off the paraffine paper (it is prohibited to tear the twine). Clean

the slushed external parts of petrolatum, using a gasoline-soaked brush.

Wash the parts until all the traces of compound are removed. Wipe the washed places carefully with clean pieces of cloth. Drain oil from the oil sump of the engine front casing.

After the slushing compound is washed away, inspect the engine on the outside. Check tightening of the attachment parts, examine for absence of broken or damaged pipes and wires, mechanical damage of assemblies and units, and for presence of seals on the adjustable elements of the units. Should any defect be detected, draw up a statement to that effect and send it to the Supplier.

The engine must not be installed on the aircraft unless the causes of the defects have been identified and eliminated.

INTERNAL DESLUSHING

The fuel system of the engine should be deslushed after the engine has been installed in the aircraft and properly connected to the aircraft systems.

Use only gasoline and kerosene for deslushing the engine.

Internal deslushing of the fuel system should be carried out as follows:

1. Drain the remaining oil from the tank, cooler and compressor front casing of the engine and fill the oil tank with fresh oil.

2. Prime the oil lines delivering oil to the engine and starter oil pumps and the pipes for measuring oil pressure in the starter (see Section "Preflight Inspection and Preparation of Engine for Slushing", Chapter III).

3. Deslush the starter fuel system and the engine starting fuel system as follows:

a) disconnect the plug connector of the wire feeding current to the КП-21 booster coil;

b) disconnect the plug connectors feeding current to two КПП4-2Р1 booster coil units;

c) fill the tank and prime starting fuel through the inlet line before the starting fuel filter. Connect the inlet line to the filter after fuel starts flowing out in a solid spray;

d) disconnect the fuel inlet pipe from the starter fuel manifold and turning on the COLD-CRANKING OF ENGINE switch, prime the fuel system up to the starter fuel manifold for which purpose crank the starter one or two times from an external airfield source of power supply, from 15 to 20 *sec* each time until a solid spray of fuel, free of air bubbles, begins to flow from the free end of the pipe. After priming, connect the pipe to the starter fuel manifold;

e) prime the starter fuel system with fuel by cold-cranking the engine three or four times, from 15 to 20 *sec* each time, bringing the starter speed to 4500—5000 *r.p.m.*

Proceed with cold-cranking the engine until the gasoline, flowing out of the starter combustion chamber drain pipe, becomes clean, without any signs of oil;

f) cold-crank the starter to remove fuel from the combustion chamber;

g) press the STARTING IN AIR button 2 or 3 times, from 15 to 20 *sec* at a time, with at least one minute interval between successive startings. Finish pumping fuel through the starting system as soon as clean gasoline starts flowing from the drain pipe of the engine combustion chamber casing;

h) connect the plug connector of the КП-21 booster coil.

4. Deslush the main fuel system, for which purpose:

a) switch on the aircraft booster fuel pump and shift the engine control lever to the idling rating position;

b) remove the air from the main fuel system for which purpose unlock and undo the union nut from the pipe connection of the adapter feeding fuel to the ПН-28Б and ПН-15Б pumps; install the С170-54 device on the pipe connection and press the needle of the device to drain some fuel from the system into a vessel until the fuel flowing from the device is free from air bubbles;

c) preliminarily start the starter 2 or 3 times bringing its speed to 8000—15000 *r.p.m.* depending on the rise of the gas temperature in the starter exhaust unit;

d) cold-crank the engine once or twice until fuel begins to flow from the drain pipes of the nozzle diaphragm assemblies and combustion chamber casing.

CAUTION! While cold-cranking the engine for the first time check the operation of the starter by observing the readings of the instruments. If the performance factors of the starter are beyond the permissible limits, stop starting the engine and repeat the deslushing operations, following Item 3 of the present section.

5. Move the engine control lever to the CUT-OFF position and cold-crank the engine once to remove the remaining fuel from it.

6. Drain the remaining fuel and oil from the drain tank through the drain plug.

7. Wipe dry all the surfaces of the engine and its compartment which have been smeared with fuel or oil.

8. Examine the oil and fuel piping.

Note. Aircraft accessories should be deslushed in conformity with the Instructions issued by the respective Manufacturing Plants or Suppliers.

LIST OF ENGINE ELEMENTS USED FOR ADJUSTMENTS IN SERVICE AND SUBJECTED TO LOCKING AND SEALING

Name of elements to be locked and sealed	Locking means	Sealing means
ПН-28Б Fuel Regulating Pump		
Cap and threaded sleeve of idling rating adjusting screw	Wire	Seal
Hydraulic decelerator flow restrictor plug	Wire	Seal
Hydraulic decelerator adjusting screw locknut and cap	Same	Same
FULL THROTTLE stop screw locknut and throttle valve housing	Same	Same
ПН-15Б Fuel Regulating Pump		
Starting control unit adjusting screw locknut, cap and nut fastening starting control unit cover	Wire	Seal
Air bleeding jet and body of starting control unit	Same	Same
ЦД-3 Centrifugal Transmitter		
Fixing nut of carrier used for adjustment of centrifugal governor spring	Wire	Seal
Pressure Oil Pump Unit		
Handle and union nut of pressure control valve	Wire	Seal
ПТ-4В Starting Box		
Port lid	Wire	Seal
ПНР10-3М Starting Fuel Pump		
Pressure control valve	Wire	Seal
THP-3P Fuel Regulating Pump		
Centrifugal transmitter spring adjusting screw	Enamel	
Pressure control valve screw	Same	
Starting adjusting screw	Same	
Adjusting screw locknuts	Wire	
Emergency Rating Control Mechanism		
Screw *14* (Fig. 11) for adjusting maximum speed	Wire Lock	Seal

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