The Ministry of Education and Sciences of the Russian Federation
Samara State Aerospace University
(National Reserch University)

MATERIALS FOR EXAMINATION

on the subject "Reliability and Operation of Airplanes"

Electronic Methodic Instructions

SAMARA
2011

The development programme for 2009-2018 of Samara State Aerospace University named after Academician S. P. Korolyov (National Research University)

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Mrykin, S. V. MATERIALS FOR EXAMINATION on the subject “Reliability and Operation of Airplanes”. = Контрольно-проверочные материалы по дисциплине “Надёжность и эксплуатация самолётов”. [Electronic resource]: Electronic Methodic Instructions/ S. V. Mrykin; The Ministry of Education and Sciences of the Russian Federation, Samara State Aerospace University. — Electronic text and graphic data (2.4Mb). - Samara, 2011. - 1 CD-ROM.

The materials are used for current and intermediate examination. Questions and tasks for current examination are classified by three levels: learning, reproduction, practical application.

Examination materials are intended for tutors and used for training students and masters on the subject “Reliability and operation of airplanes”.

This materials are a part of postgraduate programmes which were developed based on using new educational technologies, resources and distance-learning systems for the Masters programme “Designing, construction and CALS-technologies in aircraft engineering”.

Prepared by the Department of Aeronautical Engineering SSAU.

Introduction

In the document presented materials which use for flowing control of knowledge over curriculum and intermediate certification.

The flowing control of knowledge solves tasks:

1. Check results independent work students by preparation for laboratory works: knowledge theoretical material at level recognize and reproduction.
2. Check results performance laboratory works: knowledge theoretical material at level reproduction and practical application.

Intermediate certification solves tasks:

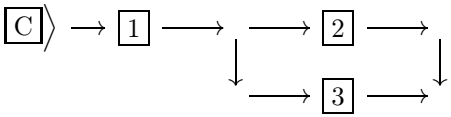
1. Estimate works of the student in a semester.
2. Estimate got theoretical knowledge by curriculum for a semester.
3. The got practical skills.

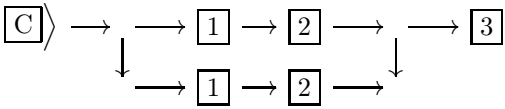
1 Learning and reproduction level

The control is conducted in the form of oral (written) interrogation or at lecture to previous laboratory work, or in the beginning of laboratory work with the purpose of quality check independent work of students. The students who have received a unsatisfactory estimation are recommended to repeat (to study) theoretical material under abstracts of lectures or the textbook.

1.1 Method of block diagram

1. To interpret concepts: failure, physics of failure, fault, defect, damage, mistake, external effect.
2. Method of block diagrams is accounted nature and character failures element, isn't it?
3. What phisical sense assumption about independent failures elements in system?
4. To interpret concepts: reliable, fail-safe.
5. Reliability model and method of block diagrams is accounted probability simultaneous failures two and more elements, isn't it?
6. In what case element failure character has influence for use method? Example.
7. May use method for analysis reliability system by wear-out failure? Yes? No? Why?
8. Read following diagrams:





9. What diagram according to equation?

$$P(C) = P(A_1)P(A_2)P(A_3)$$

10. What diagram according to equation?

$$P(C) = P(A_1) + P(A_2) + P(A_3)$$

11. What diagram according to equation?

$$P(C) = 1 - [1 - P(A_1)][1 - P(A_2)][1 - P(A_3)]$$

12. What is statistical measure for $\lambda(t)$?

13. What is statistical measure for $\omega(t)$?

14. Why frequently use identical value for $\lambda(t)$ and $\omega(t)$?

15. What is link between failure intensity ω and operating time to failure T?

1.2 System reliability analisys

1. Which kind of tasks have to solve in process design and analisys airplane systems and units with point of view reliability?

2. What initial data are necessary for analysis links between functional systems airplane?

3. To interpret concepts: expected operating conditions, extreme operating conditions, recommended modes of flight, operational limitations, extreme limitations.

4. To interpret concepts special situations: complication of flight conditions, complex situation, emergency situation, disaster situation.

5. What basis is used for conclusion about occurrence special situation?

6. To interpret concepts random events: probable, improbable, extremely improbable, practically incredible.

7. To correlate list of special situations with list of random events: frequent, moderately probable, improbable, extremely improbable and practically incredible.

2 Practical application level

Control is conducted in conversation during reception of reports on laboratory works. Task formulation for laboratory work N 1 is in section 2.1.1, task variants is in section 2.1.2; for laboratory work N 2 — in section 2.2.

2.1 Method of block diagrams

1. May, in principle, method use for analysis reliability statically indeterminate structure?
2. What diagram according to equation?

$$P(S) = 1 - \tau\tau^2(\lambda_1\lambda_2\lambda_3)$$

3. What diagram according to equation?

$$\lambda_C = \lambda_1 + \lambda_2 + \tau^2\lambda_3^3$$

2.1.1 Task formulation

1. For certain block diagram and time of working cycle τ find reliability function $P_\tau(S)$ and operating time to failure $T_f(S)$:

   $\tau = 1$ hour (var. 1–6),

   $\tau = 2$ hours (var. 7–14),

   $\tau = 3$ hours (var. 15–22).

   Failure rate for elements get from table.

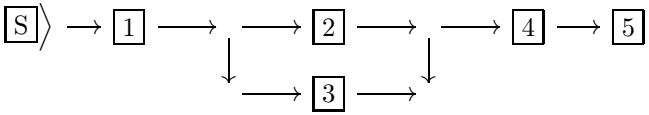
NN element	Failure rate $\lambda_i(t)$, h^{-1}
1	0,04
2	0,05
3	0,06
4	0,07
5	0,08
6	0,09

2. Write answers on following questions:

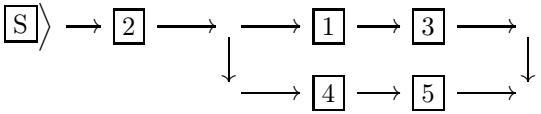
   - May operating time to failure for system is increased twice by changing failure rate for element number 1? Calculate reliability function.
   - Calculate reliability function for system if element number 1 is failure-free absolutly?

2.1.2 Task variants

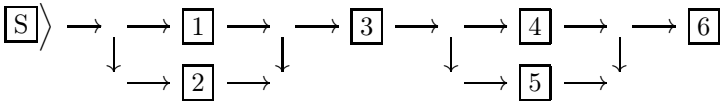
Variant 1



Variant 2



Variant 3



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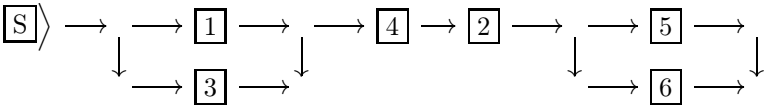

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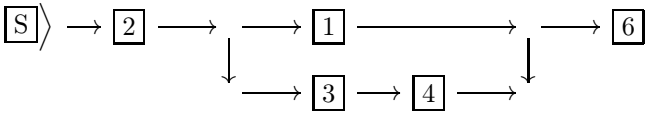

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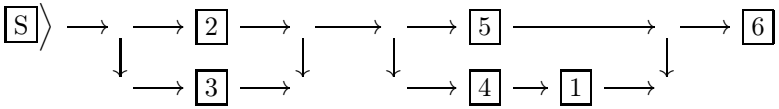

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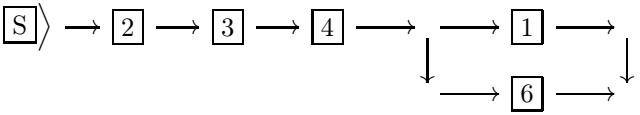
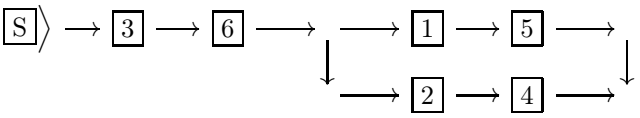
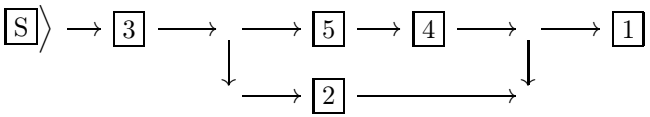


Variant 8



Variant 9



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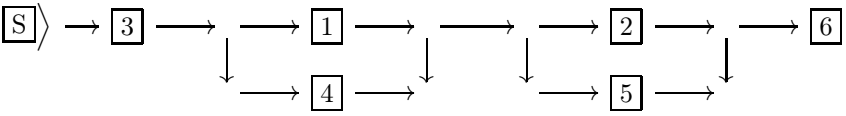
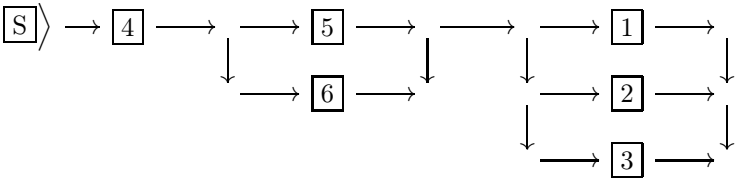
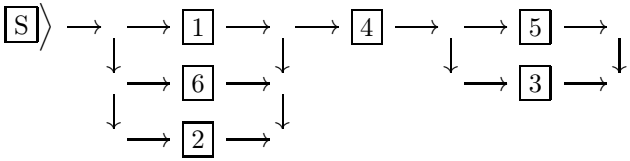


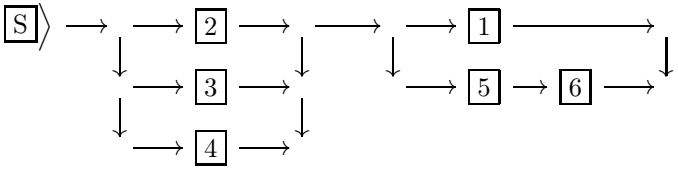
Variant 11



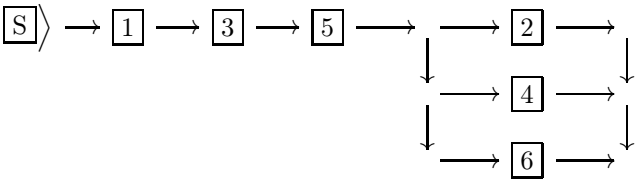
Variant 12



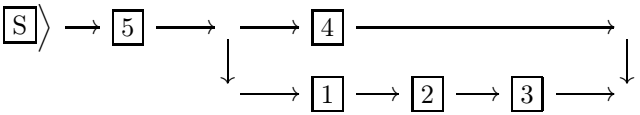
Variant 13



Variant 14



Variant 15



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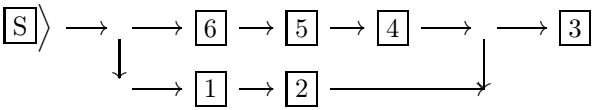
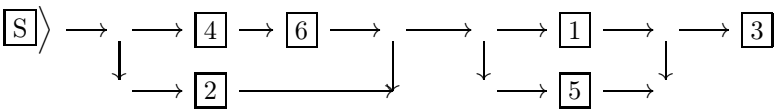
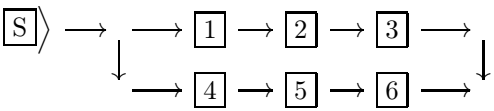


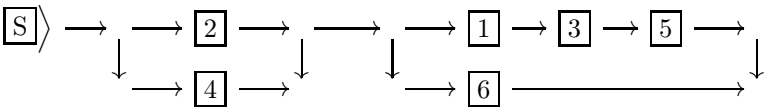
Variant 17



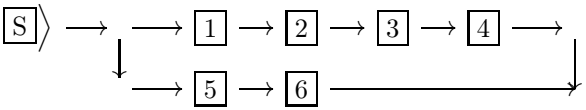
Variant 18



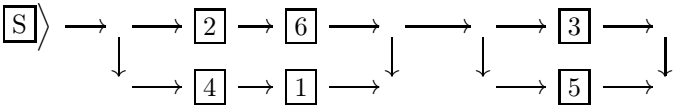
Variant 19



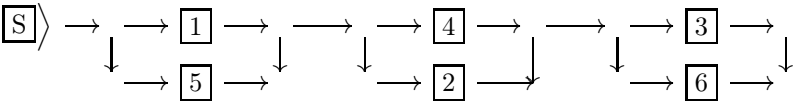
Variant 20



Variant 21



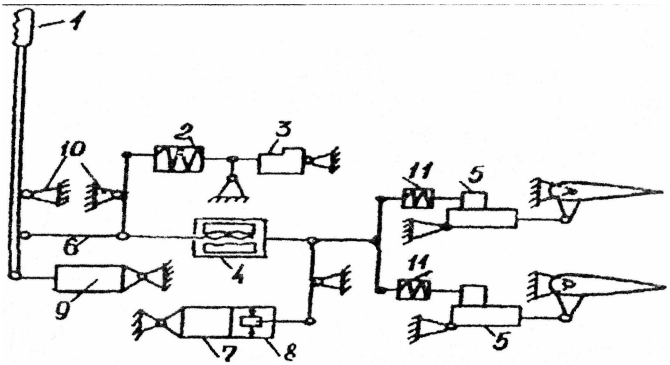
Variant 22



2.2 System reliability analysis

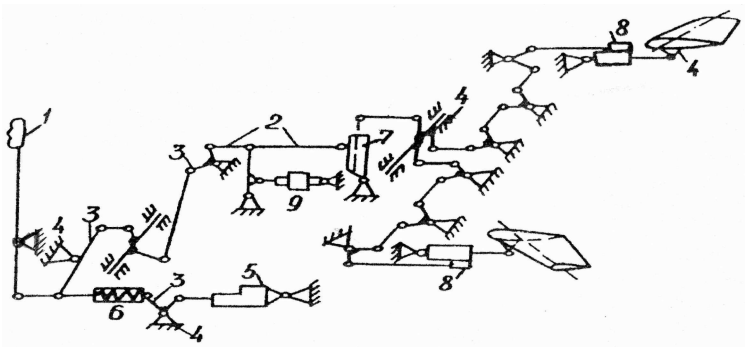
Failures analysis and calculation of reliability function under the set basic scheme of system and failures statistics elements [1, 2, 3].

Redesign system for set reliability. Basic schemes of systems are shown on figures 1–15.



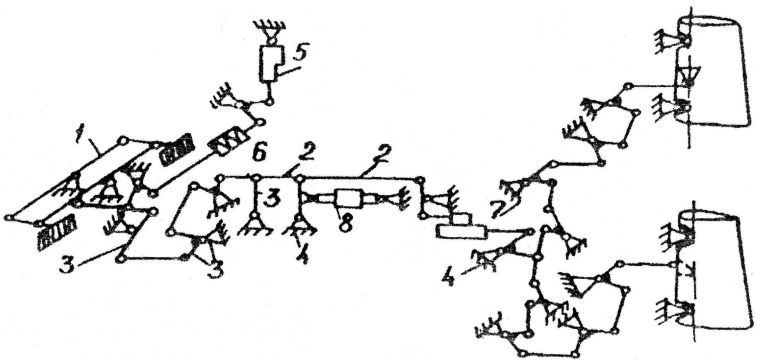
1 — control handle; 2 — artificial spring feel unit; 3 — trimming effect mechanism; 4 — executive mechanism system of improvement stability and controllability; 5 — hydraulic booster; 6 — rigid rod; 7 — executive mechanism of system trajectory controls; 8 — mechanism switching-off of the executive mechanism; 9 — limitation mechanism of extreme modes; 10 — arms; 11 — spring rod.

Figure 1— Basic scheme of a control system of supersonic airplane



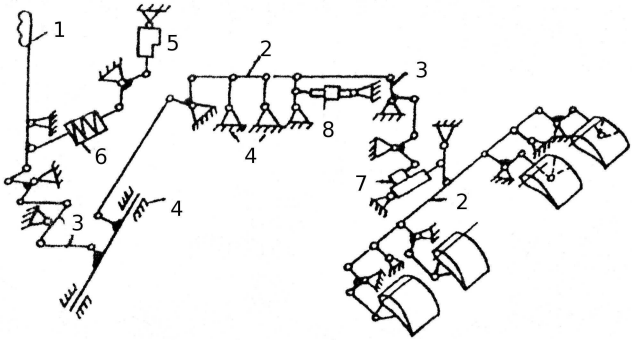
1 — control handle; 2 — rod; 3 — cranck; 4 — arm; 5 — trimming effect mechanism; 6 — artificial spring feel unit; 7 — automatic device regulation efforts; 8 — booster; 9 — autopilot steering machine.

Figure 2— Scheme of the pitch channel control systems



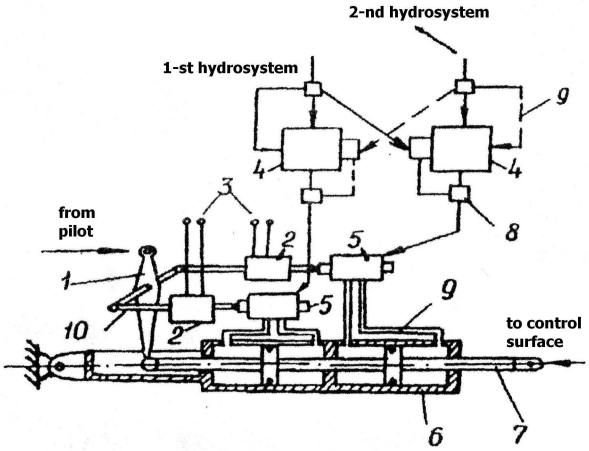
1 — rudder pedal unit; 2 — rod; 3 — crank; 4 — bracket; 5 — trimming effect mechanism; 6 — artificial spring feel unit; 7 — booster; 8 — autopilot steering machine.

Figure 3— Control channel of rudders



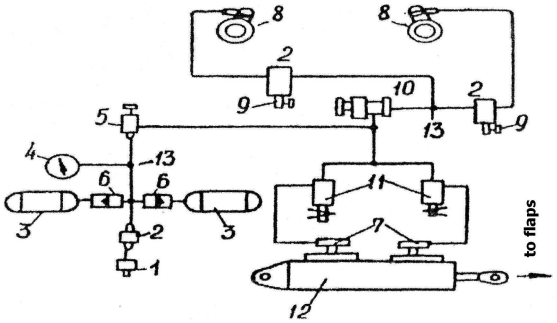
1 — control handle; 2 — rod; 3 — crank; 4 — arm; 5 — trimming effect mechanism; 6 — artificial feel spring unit; 7 — booster; 8 — autopilot steering machine.

Figure 4— Control system of roll channel



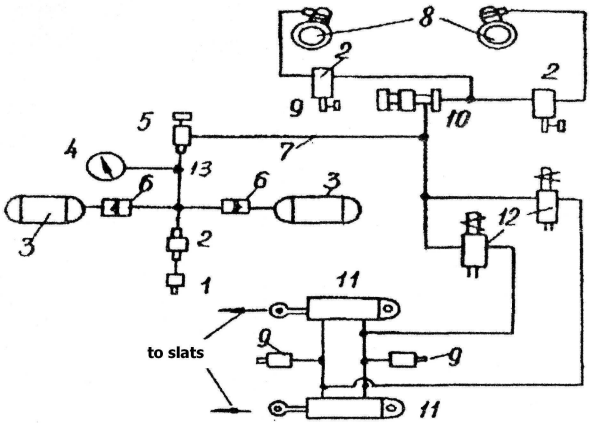
1 — entrance lever; 2 — spring rods; 3 — electrosignal system of jamming for operating slide-valve; 4 — valve for switching hydrosystems; 5 — operating slide-valve; 6 — cylinder of hydraulic booster; 7 — rod with pistons; 8 — tubing joint assembly for hydrosystem; 9 — pipelines; 10 — rigid rods.

Figure 5— Power supplies of chests of the two-chamber hydraulic booster



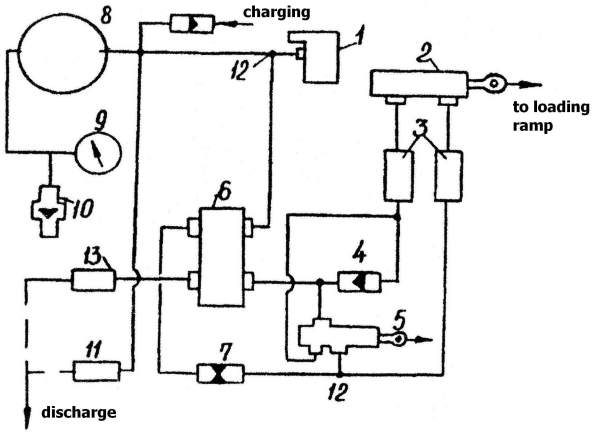
1 — charging valve; 2 — filter; 3 — air cylinder; 4 — manometer; 5 — cock; 6 — back pressure valve; 7 — operating slide-valve; 8 — compressor; 9 — release valve; 10 — automatic pressure control; 11 — electromagnetic valve; 12 — air cylinder; 13 — tubing joint assembly.

Figure 6— Air control system of flaps



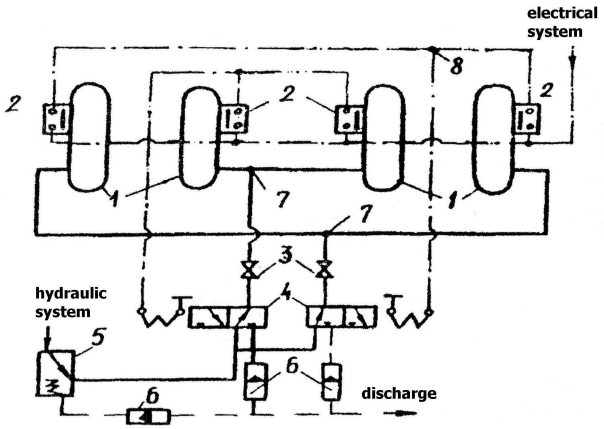
1 — charging valve; 2 — filter; 3 — air cylinder; 4 — manometer; 5 — cock; 6 — back pressure valve; 7 — pipeline; 8 — compressor; 9 — release valve; 10 — automatic pressure control; 11 — air booster; 12 — electromagnetic valve; 13 — tubes joint assembly.

Figure 7— Air control system of slats



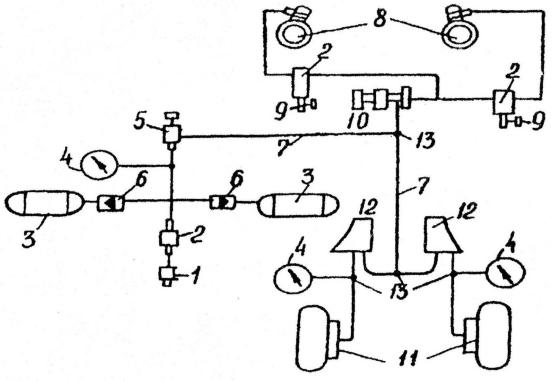
1 — relay of pressure; 2 — booster; 3 — swivel gland; 4 — back pressure valve; 5 — hydraulic booster for lock gangway; 6 — electromagnetic valve; 7 — throttle; 8 — hydroaccumulator; 9 — manometer; 10 — charging valve; 11 — release valve; 12 — tubes joint assembly; 13 — drain cock.

Figure 8— Pipeline for lower and lift onboard gangway



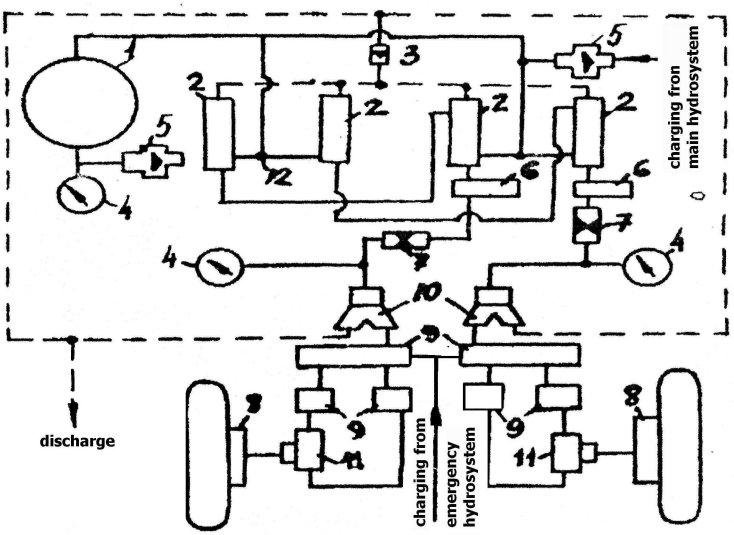
1 — brake wheel; 2 — inertial gauge for automatic device of braking; 3 — throttle; 4 — electromagnetic cock for automatic brake; 5 — reducing valve for brake; 6 — back pressure valve for drain; 7 — tubes joint assembly; 8 — connection for electric system.

Figure 9— Basic scheme of brake system



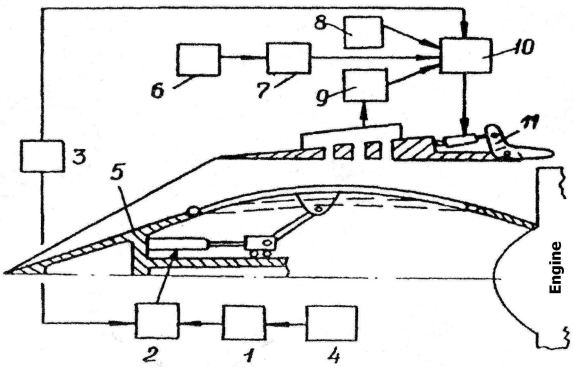
1 — charging valve; 2 — filter; 3 — air cylinder; 4 — manometer; 5 — electrohydraulic cock; 6 — back pressure valve; 7 — pipeline; 8 — compressor; 9 — filter; 10 — automatic pressure control; 11 — brake chamber; 12 — reducing valve; 13 — tubes joint assembly.

Figure 10— Air system for braking wheels



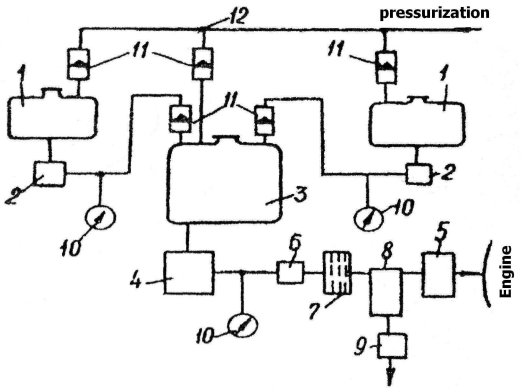
1 — hydroaccumulator; 2 — reducing valve; 3 — back pressure valve; 4 — manometer; 5 — charging valve; 6 — switch hydraulic; 7 — throttle; 8 — brake chamber; 9 — swivel glands; 10 — electrohydraulic cock; 11 — shuttle valve; 12 — tubes joint.

Figure 11— Hydraulic system for braking of wheels



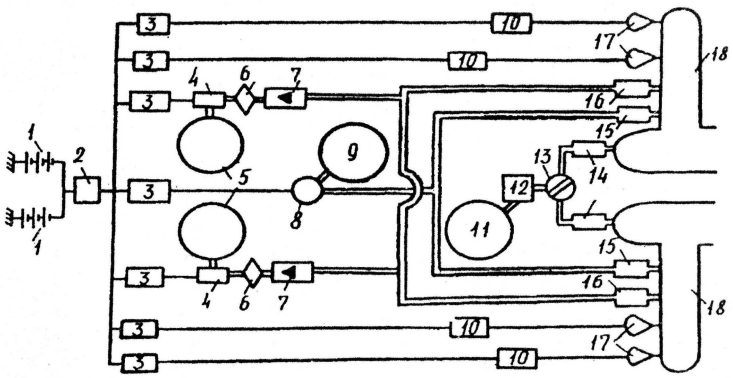
: 1 — gauge of M number in throat; 2 — regulator for central body; 3 — manual control; 4 — surge gauge; 5 — central body with the mechanism of adjustment; 6 — stall gauge; 7 — control system for start; 8 — gauge of M number for flight; 9 — gauge of shock position; 10 — regulator for by-pass shutters; 11 — by-pass shutters with the mechanism of control.

Figure 12— Regulation supersonic air intake



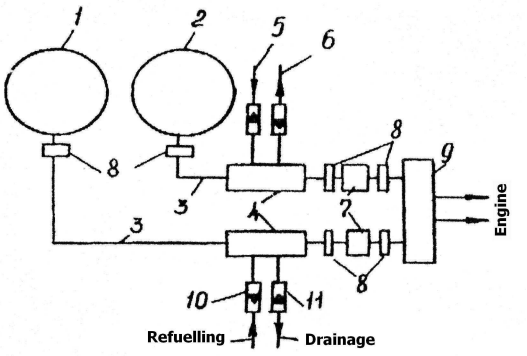
1 — fuel tanks; 2 — transferring pumps; 3 — fuel consumed tank; 4 — aircraft pumping up pump; 5 — engine pumping up pump; 6 — shut off valve; 7 — filter; 8 — sedimentation; 9 — drain cock; 10 — manometers; 11 — back pressure valve; 12 — tubes joint assembly.

Figure 13— Pump fuel supply to engine



1 — storage battery; 2 — starting button; 3 — electrosafeguard; 4 — oxygen electrocock; 5 — oxygen cylinder; 6 — oxygen reducer; 7 — back pressure valve; 8 — pump for firing fuel; 9 — tank for firing fuel; 10 — ignition coil; 11 — tank for working fuel; 12 — pump for working fuel; 13 — lever for engine control; 14 — atomizer for working fuel; 15 — atomizer for firing fuel; 16 — atomizer oxygen; 17 — candle electrostriking; 18 — case of firing igniter.

Figure 14— Basic scheme of high-altitude start



1 — fuel tank; 2 — oxidizer tank; 3 — primary pipeline; 4 — shut off valve; 5 — refueling pipeline; 6 — drainage pipeline; 7 — bellows; 8 — flange connections; 9 — turbopump unit; 10 — back pressure valve; 11 — drainage valve.

Figure 15— Basic scheme for fuel system two-componental starting accelerator

3 Control questions to examination

Examinations are conducted under tickets in the written and-or oral form. In the ticket one or two theoretical questions (depending on volume and complexity) and task in method of block diagrams from section 2.1.1.

1. Special situations. The reasons of occurrence special situations. Definitions and examples.
2. Categories of random events. Classification special situations on categories of random events. Example of numerical value probability of random event.
3. Safety and fail-safe. Classification product conditions with damages.
4. Product reliability. Reliability properties.
5. Statistical analogues for parameters of density probability failures elements systems.
6. Reliability equation nonrestorable elements. Likelihood sense failure rate and failure intensity.
7. Method of block diagrams. Conditions of application and the procedure of calculation.
8. Ways of a combination elementary events of failures. Example of dependence combination elementary events from failure cause. Full groups events. Calculation reliability function.
9. Probability failure-free operation at exponential law distribution failures. Ways for increase reliability: replacement of element base, redundancy.
10. Method of logic schemes. Conditions application. Example calculation reliability function for fuel system.
11. Algorithm estimation failure-free operation airplane at design.
12. Reliability measures.
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