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RELIABILITY INDICES OF SOME ELEMENTS OF AUTOMATIC SYSTEMS

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Yu. V. Tul'chinskii

Mekhanizatsiya i Avtomatizatsiya Proizvodstva, 1, pp. 43-45 (1966)

Translated from the Russian

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Translation Branch
Redstone Scientific Information Center
Research and Development Directorate
U. S. Army Missile Command
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Various automatic systems find an ever increasing application for calculating the reliability of certain devices. Data on the reliability of various elements and parts as cited in this paper expand to a certain extent the possibilities of using such information for evaluating the intensity of operational failures. The data concerning the reliability of elements are the results of statistical processing of information obtained by testing an experimental system of automatic control of refrigerating units on a fishing trawler.

The practice involving the planning of various automatic systems finds an ever increasing application for calculations of reliability of developed devices.

In all calculations of reliability, the basic initial data are the λ-characteristics of the employed component parts. The accuracy of the calculated results depends on how completely these characteristics are provided with data (modes and operating conditions of the component parts, reliability of the data, etc.).

Usually cited in literature are the values of the intensity of the failures to operate represented by the generalized characteristics of the reliability of the various types of the same type of parts and assemblies. Therefore, when based on such initial data, the values of the reliability of systems prove to be mostly approximate, while the requirements for exact calculated results of reliability continue to increase. Therefore, the obtaining of the λ-characteristics of each type of elements (with their specific operating conditions taken into account) represents an urgent problem.

The data on reliability of certain elements and parts cited below expand to a certain extent the possibilities of using the information on the intensity of failures to operate.

A reference to the conditions and modes at which the elements and parts were functioning and also the confidence range of values of the intensity of failures to operate make it possible to employ the reliability indices shown below in calculations determining the order of the value of reliability.

These data on the reliability of elements are the results of statistical processing of information obtained by testing an experimental system of automatic control of refrigerating units of a fishing trawler, type BMRT, performed under conditions of a fishing cruise.

The automation system installed on a trawler served to maintain the operating condition of the refrigerating unit and protected it against the inadmissible deviations of the system's parameters and also the operating and the emergency signalling.

For an optimum selection of the type of elements, a part of the automation system was made with series ELM, 50 cycles, magnetic elements and with series VUM output magnetic amplifiers. The other part of the system was made with transistorized logical and amplifying elements developed by the institute "Pishchepromavtomatika" (automatic food industry). This series consists of logical elements, timing elements, output amplifiers, auxiliary elements, and sources of power.

The logical elements, output amplifiers, auxiliary elements, and voltage stabilizers are assembled on Getinaks (paper-filled phenolformaldehyde resin) plates located in metallic zinc-plated cassettes with detached joints (Figure 1). The time elements are made in form of individual blocks (Figure 2).

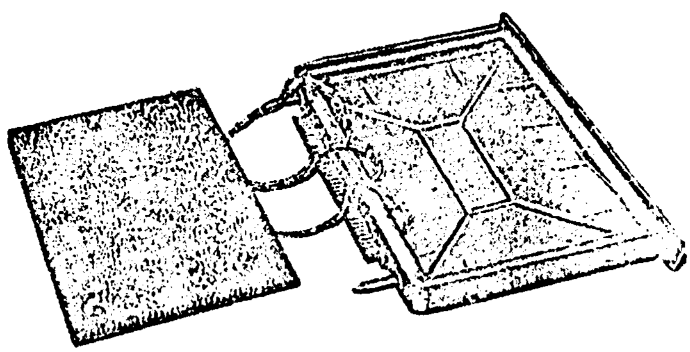

FIGURE 1. LOGICAL ELEMENTS, OUTPUT AMPLIFIERS, AND VOLTAGE STABILIZERS MOUNTED ON GETINAKS PLATES

The designed cassettes and blocks are not air tight. The power transformers and the rectifying diodes are located on open movable panels (Figures 3 and 4).

All magnetic elements of the system, the cassettes with semiconductor elements, the time-elements, sources of power, and the auxiliary equipment are located in a cabinet installed in the refrigerating part of the vessel.

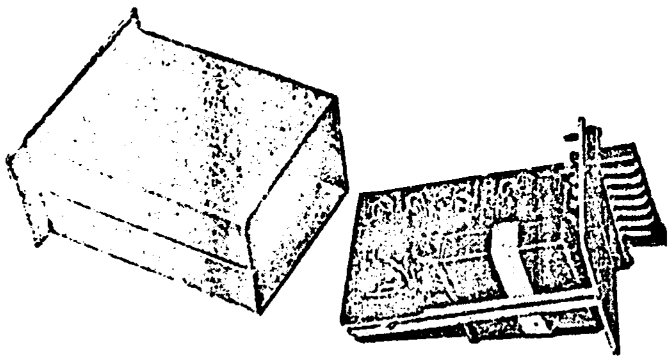

FIGURE 2. TIME-ELEMENTS IN FORM OF BLOCKS

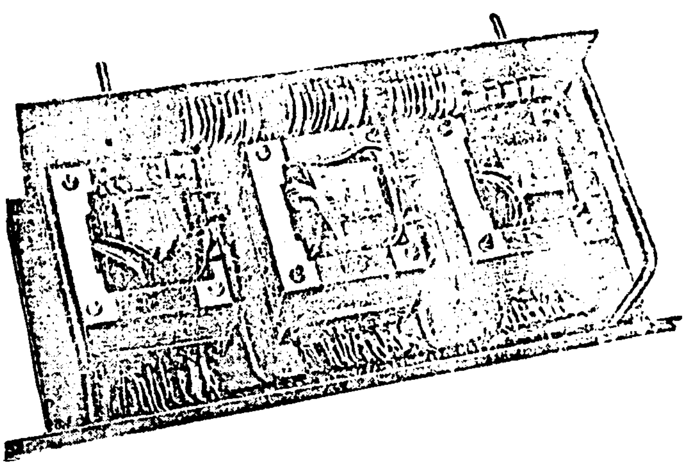

FIGURE 3. POWER TRANSFORMERS ON OPEN SLIDING PANELS

Table I shows the percent of the number of parts of a given type operating at a definite load-factor K_H. The load factor is the ratio of the parameter's value of a part under the employed electrical load and the rated (nominal) value of the parameter.

The system operated for more than 5000 hours under the following conditions: maximum temperature of surrounding air, up to +40°C, a relative humidity of up to 50 percent; ship rolling up to 17 degrees of the vertical; a voltage fluctuation of ±20 percent, and voltage drops of up to 35 percent of nominal.

The obtained information was statistically processed on the assumption that the law of distribution of the duration of the service life of the elements can serve as an index. The tests were performed in accordance with the (n, B. t)-type plan. This plan requires the testing of n elements for a duration of t. Each element that fails to perform is replaced by a new one (the letter B indicates this fact).

During the tests there were m random failures. In accordance with the plan used for the tests, the estimate of the experimental value of the intensity of failures by elements was determined by the expression

$$\lambda = \frac{m}{nt} .$$

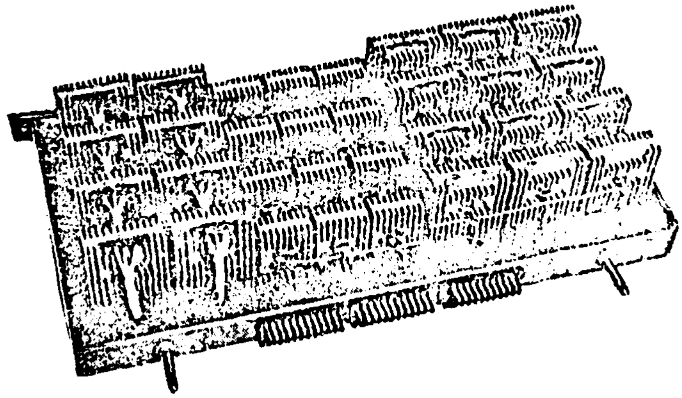

FIGURE 4. DIODES OF RECTIFIRES ON OPEN SLIDING PANELS

The confidence boundaries for the magnitude of the unknown value of the intensiveness of failures (the general characteristic of the intensiveness of failures) was determined by the equation

$$\lambda_H = \frac{m}{ntr_1} = \frac{\lambda}{r_1} ;$$

$$\lambda_B = \frac{m}{ntr_2} = \frac{\lambda}{r_2} ,$$

where λ_H, λ_B - respectively, the lower and upper confidence boundaries of the the values of the intensiveness of failures;

r_1, r_2, r_0 - coefficients determined from table P19 [Statistiches-kiye Metody Analiza i Kontrolya Kachestva i Nadezhnosti (Statistical Methods of Analysis and Control of Quality and Reliability) published by Sovetskoye Radio, 1962].

In case of m = 0, we have

$$\lambda_H \to 0 ; \lambda_B = \frac{r_0}{nt} .$$

The obtained values of the confidence ranges of the intensiveness of failures of elements and parts are summarized in Table II.

The processing of the experimental data resulted in obtaining the confidence range of values of the average intensiveness of failures to perform by the magnetic and semiconductor elements and for the group-average intensiveness of failures for the resistors, semiconductor diodes and triodes and also for the windings.

The average intensiveness of failures by the elements characterizes the reliability level of the circuits built of magnetic and semiconductor logical elements for the above mentioned relationship between the quantities of the diverse elements contained in the circuit.

Table I

Load Factor, K_H	Resistors		Diodes				Triodes		
	MLT-0.5, MLT-1.0, MLT-2.0	Wire	D9E	D810, D811, D813	D7G, D7Zh	D202, D303, D214A	P14, P15	P103	P4B, P202
Up to 0.1	71	72	100	73	96.3	20	93	100	55
0.1-0.2	2	-	-	-	2.7	-	3	-	27.5
0.2-0.3	25	-	-	-	1.0	20	3	-	11
0.3-0.5	-	-	-	27	-	-	1	-	6.5
0.5-0.7	1	-	-	27	-	60	-	-	-
0.7-0.9	-	28	-	-	-	-	-	-	-

Table II

Name of Elements of the Parts	Characteristic of Reliability	Confidence Range of Values of the Characteristic of Reliability
Elements of the magnetic logical system	Average intensity of failures	Upper limit $(0.42 \times 10^{-6} \leq \lambda$ ave $\leq 7.4 \times 10^{-6}) = 0.9$
Elements of the semiconductor logical system	Average intensity of failures	Upper limit $(0.76 \times 10^{-6} \leq \lambda$ ave $\leq 5.1 \times 10^{-6}) = 0.9$
Resistors	Group-average intensiveness of failures	Upper limit $(0 \leq \lambda \leq 0.43 \times 10^{-6}) = 0.96$
Semiconductor diodes	Group-average intensiveness of failures	Upper limit $(0.006 \times 10^{-6} \leq \lambda \leq 0.55 \times 10^{-6} = 0.9$
Semiconductor triodes	Group-average intensiveness of failures	Upper limit $(0.136 \times 10^{-6} \leq \lambda \leq 1.273 \times 10^{-6}) = 0.9$
Windings	Group-average intensiveness of failures	Upper limit $(0 \leq \lambda \leq 1.55 \times 10^{-6}) = 0.95$

The group-average intensiveness of failures characterizes the reliability of type MLT resistors with capacities of 0.5, 1.0, and 2.0 watts; of the types D9E, D7G, and D7Zh diodes at $K_H \leq 0.1$; of the type P14, P15, and P202 triodes used in key-operated circuits at $K_H \leq 0.1$ to 0.2; of the windings of the magnetic type ELM-50 logical elements, of the secondary windings of the VUM-amplifiers and of the transformers up to 180 watts power.

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