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THE METHOD TO INCREASE THE RELIABILITY OF ELASTIC SENSING ELEMENTS OF CONTROL SYSTEMS AND AUTOMATION

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Abstract: *Proposed a method for improving the reliability of membrane systems reed contacts, by reducing the bounce and dynamic noise, as well as increase the life of the elastic sensing element. Proposed design and technological solution to the membrane reed with modifiable regular microrelief of the working surface of the membrane.*
Key words: elastic sensor, reed switch, a membrane, a regular microrelief, magnetically-controlled contact.

1. INTRODUCTION

Growth of requirements for sensors, microsensors and switching elements and, primarily, to their metrological characteristics and reliability, makes an urgent problem of increasing the quality of elastic sensitive element. Such important characteristics of microsensors and magnetic contacts as performance, mechanical stability and strength are ensured by the quality of elastic sensitive element.

The reed switches are related to the switching elements of automatics and find wide application in the relay on their basis. The latter are widely used in the programming and logic circuits of automation and remote control, signalling and protection, weighing and control, automatic valves in radio, telephone and electrical equipment [1].

A great contribution to creation and development of methods of analysis of elastic sensitive elements has made: Andreev A.N., Korsunov V.P., Vollmer A.S., Panovko A.G., Reissner E., Hamad M., Fujita K., Kashima H. [1].

However, the problem of increase of currents of switching, as well as a decrease in bounce contact system of reed switches is still relevant from the point of view of providing high reliability, including, and increase the service life of switching elements.

2. MODIFICATION OF THE MEMBRANE CONTACT SYSTEMS OF REED SWITCHES WITH REGULAR MICRORELIEF OF THE WORKING SURFACE

Operating experience elastic sensing elements reed switches convincingly shows that their quality and reliability depend on the nature of mating parts contacting with each other or with the liquid phase (dry reed contact surfaces; wetted reed contact surfaces, such as mercury), determines the state of the surface layer in contact parts.

To increase the reliability on the surface of elastic sensing elements of reed switches offered regular microrelief applied [2]. Formed on the surface of elastic sensitive element regular microrelief creates the system regularly situated zones in the surface layer and often, and in the entire thickness of elastic sensitive element. Application of partial regular microrelief II or III of the form [2] on the surface of motile elastic sensitive elements of reeds entails the formation continuous or discrete located recesses between which remains untouched original, often irregular, micro relief of the treated surface. When

completely regular microrelief of elastic sensitive element of the residual voltage under the deformation is distributed evenly throughout the material details, especially for structures of membrane reed switches, as provided by the uniformity of the deflection of the diaphragm when triggered, relieve tension in the zones thermocouple junction with cylinder reed switch, increases the stability of the reed switch. In addition, decreases the hysteresis value, increases the stiffness of the elastic sensitive elements, sensitivity reed switches, a growing number of operations per unit of time and, therefore, are provided with long life and high performance reed switches [1,3].

In mercury wetted reed switches contacting surfaces of elastic sensing elements, vibration-free for the closure is carried out through their amalgamation mercury or periodic supply of mercury on the contacting surfaces. Application vibrations (IV form completely regular microrelief) [2] on the surfaces after amalgamation elastic sensing elements is significantly improved penetration and consolidation of mercury molecules inside the material elastic sensing elements. In the case of periodic supply of mercury to the place of contact for polycapillary formed on the sensitive surface of the elastic element itself, the closure of the mercury is displaced from the contact zone. Application of type III regular microrelief [2] on the surface of elastic sensing elements would eliminate this harmful phenomenon. Of particular interest may be the brand new (in terms of technology) reed switch is a combination of membrane structures and mercury reed switch. Offered on the membrane surface for membrane reed switches of any kind applied first mercury film by amalgamation (centrifugation), and then implement vibration forming regular microrelief IV species [2]. As a result, apart from improvement of the sensitivity (response magneto motive force) of the elastic characteristics and mechanical sensing elements, such as stiffness, elasticity, uniformity of deflection, will be completely eliminated chatter harmful phenomenon (vibration) with the reed switch. Rich functionality, high reliability and high performance of the reed switches make them very promising [4,5].

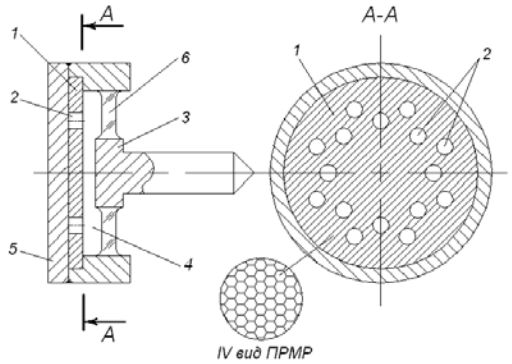

Figure 1. Membrane reed switch

In elastic membrane reed switches movable sensing element formed as a membrane. Sketches of the proposed modifications are shown in the figure. Figure 1 shows a membrane reed contacts one of which is designed as a membrane perforation (movable contact), and the other - in the form of a ferromagnetic core. Magnetic membrane 1 found 2 carries contacting with the magnetic core 3 by its central disk by the magnetic flux in the air gap 4. Core 3 is insulated from the metallic shell 5 glass ring 6. Membrane reed switch has a larger area of the working gap and hence minimal magnetic resistance which increases the sensitivity. The membrane has a larger area of contact with the core, which provides a large switching currents. Varying shapes and sizes of cut-outs can change the amount of deflection of the membrane and the sensitivity of the contact. Current technologies allow for the amount of movement of the membrane under stress in the elastic zone on the order of 10^{-6}-10^{-7} m, which provides a very high sensitivity of the membrane structures. Both have full contact core regular microrelief work surface and in the contact zone wetted by mercury, which significantly improves the dynamic characteristics of the reed switch.

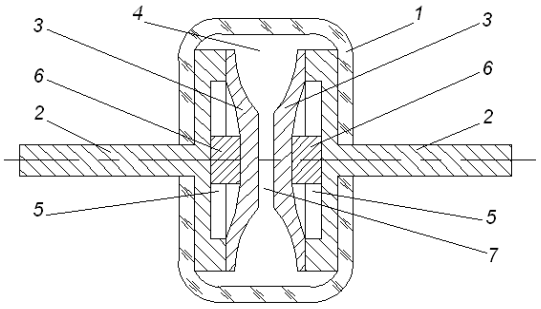

Figure 2. Membrane reed switch

The second modification of the membrane reed switch, shown in Figure 2, involves the performance of both cores in the form of contact with mercury amalgamated membranes completely regular microrelief IV according to [4,5]. Figure 2 marked glass bottle 1 soldered magnetic cores that are running corrugated membrane 3 with regular topographical work surface. Each membrane is separated from the main cavity 4 5 autonomous cavity within which is set a nonmagnetic focus 6. Summary and autonomous cavity filled with an inert gas with different pressure, which contributes, together with an emphasis 6 vibrostability membrane 3. Between the membranes 3 set working air gap 7. Under action of a longitudinal magnetic field of the membrane bend towards each other and close an electrical circuit. The membrane can be installed in only one magnetic core, however, the sensitivity of the reed switch is lowered.

4. CONCLUSION

The authors proposed parameters with regular topographical surfaces [4,5]: for surfaces with partially regular microrelief - regular roughness depth h=16 m, the relative area occupied by regular irregularities F_n = (60-70)%, direction angle Θ=50°; for surfaces with completely regular microrelief - the height of the surface R=(10-16) mm, and the relative bearing surface T_r = (60-80)%. With these options, work surfaces membrane reed switch was reached sensitization elastic sensing elements by 5-7% reduction chatter switching currents increase by 6-8%, which increases the reliability of this type of switching elements.

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6. REFERENCES

1. Tkalich, V., Labkovskaya, R., Pirozhnikova, O. Reliability increase method of elastic sensing elements of

control systems and automation. Scientific and Technical Journal of Information Technologies, Mechanics and Optics, 2011, **2** , 136-137.
2. Kozlov, A.S., Labkovskaya, R. Ya., Tkalich, V.L., Pirozhnikova, O.I. Modeling the dynamics of electromechanical elements sensors control systems. Fundamental and Applied problems of Technics and Technology, **5**, 131-135.
3. Pat. No. RU 156527 (U1), Int. Cl. F16J 3/04. Membrane bellows// Labkovskaya R. Ya. (RU), Tkalich, V.L. (RU), Pirozhnikova, O.I. (RU), Kozlov A.S. (RU); applicant and patent holder of Federal state educational institution of higher professional education "Saint-Petersburg national research university of information technologies, mechanics and optics" (ITMO University) (RU). – 2015126427/05, field 01.07.2015; publication data 10.11.2015.
4. Kozlov, A.S., Labkovskaya, R. Ya., Pirozhnikova, O.I., Tkalich, V.L. Taking account for associated masses of fluid in mathematical models of bellows sensing elements of control systems. Journal of Instrument Engineering, 2015, **6**, 1016-1021.
5. Pat. No. RU 144833 (U1), Int. Cl. H01H 1/66. Membrane switch // Labkovskaya R. Ya. (RU), Tkalich, V.L. (RU), Pirozhnikova, O.I. (RU); applicant and patent holder of Federal state educational institution of higher professional education "Saint-Petersburg national research university of information technologies, mechanics and optics" (RU). – 2014114689/07, field 14.04.2014; publication data 10.09.2014.