CONTRIBUTIONS ON THE ACHIEVEMENT OF THE ELECTROMECHANICAL ACTUATORS WITH LIQUID USING OF THE ANALOGY TECHNIQUE

Petru LEONTE*, Dorel CERNOMAZU, Elena SAVU and Elena-Daniela OLARIU
**"Gheorghe Asachi" Technical University of Iaşi*
Bd. Profesor Dimitrie Mangeron nr. 51- 53, RO-700050 Iaşi
"Ştefan cel Mare" University of Suceava
str. Universităţii nr.13, RO-720225 Suceava
savue@eed.usv.ro

Abstract: *In this study are presented some aspects on the application of the intuitive creation methods used in the technical creation, which it is applied to stimulate the spontaneous creation on the achievement of the innovative models in the technical field. Some constructive models of the electromechanical pumps and actuators with liquid are presented by analogy with the making and the operating principle of the gas-bubble protective device used at the transformer's gas protection. These electromechanical pumps and actuators must operate on the classical effects and phenomena.*
Keywords: *gas relay, analogy, insulating oil, electromechanical actuators.*

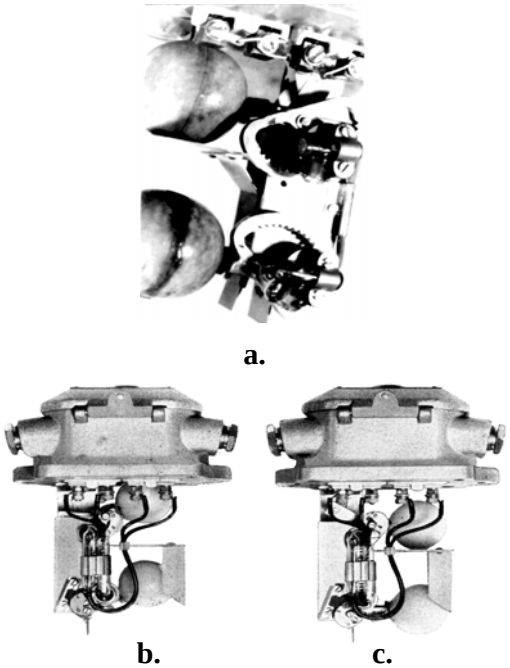
Introduction

The analogy and extrapolation represents the psychologically technics that have the object in the stimulation of the technical creativity.
From point of view of the inventique, the analogy and extrapolation suppose to transfer the conceptions from an analogous solution, which is more or less similarly [1].
More scientifically fields are based on analogy and extrapolation, like follows:

- the bionique is the science based on the analogies and extrapolations which are optimized from nature into the technical field;
- the fluidique is the science based on the analogies and extrapolations of the electronical law, of the operation of the control circuits, into the hydraulically feed control;
- the hydrodynamyc theory of the metal removal at high speed is based on the analogy and extrapolation of the laws of the fluids flow [1].

In this paper, the interest is to find new solutions for technical realization of the electromechanical pumps with liquid. These solutions are suggested by analogies and extrapolations with the making and the operation of the gas relay Bucholtz [2, 3].
The gas relays have the operation principle based on the thermal decomposition of the insulating oil and of the original materials, which compose the electroinsulating constructive elements.
Because of the heating process, these materials are decomposed and, in this way, is formed an gaseous mixture, which is accumulated to the oil conservator because of his density.
In the case of the critical defects, the gas decomposition can have an inside upper pressure with increased value and can displace the insulating oil to the conservator. This process is knowed in literature review as wave of oil.
Any type of gas relay is constituted by an metallic tank with two orifices for raccord to the lubrification pipe. This pipe makes the connection between oil conservator and transformer tank.
On the lateral wall of the tank are placed some peepholes for the appreciation of the accumulated volume of the gaseous mixture.
Inside of the relay tank are mounted the commutation systems constituted by an

mechanic part (float, cup or actuation damper) and an electric part (electric contacts system).
The float, the cup or the actuation damper are binded. Changing their positions, the state of electrical contacts system is changed (the contacts are closed or open).
The system of external commutation is, in fact, an signal system, which give the switching off impulse in the moment of an internal fault, when the oil's level decrease or when the gases are slowly accumulated.
In this case, the float descends in the same time with the descent of the oil's level that is placed inside of the relay's tank.



a. **b.** **c.**

Figure 1. Gas relay Bucholtz [4]
a – with make-and-break mercury contact;
b – magnetic actuated contact (side view);
c – magnetic actuated contact (front view).

The system of internal commutation represent an switching system of tripping, which give the switch opening impulse when the transformer have an oil loss and the level decrease under an certain limit or when the speed of the oil's wave is upper than value of the release electric threshold, if appear an internal fault. The electric part of the commutation system can be made using the make and break mercury contacts or contacts with magnetic action.

In the both cases, the switch's contacts are protected inside of a sealed tube. Also, the commutation systems, which have the switch's contacts protected in an oil bath, are known [4, 5, 6].

Contributions regarding the achievement of new solutions of electromechanical pumps with liquid

A first solution of electromechanical pump with liquid is showed in figure 2. This pump use the insulating oil as active medium and have an operating principle based on the thermal decomposition of the oil [3, 12].

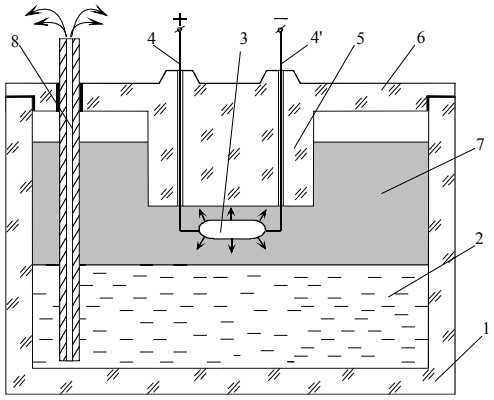


Figure 2. Model of electromechanical pump with immiscible liquids based on the Joule-Lenz effect [12]
1 – cylindrical carcass; 2 – evacuated liquid;
3 – resistor; 4 and 4' – conductors;
5 – support; 6 – sealing head;
7 – electric insulating oil; 8 – drain channel.

The upper pressure, which is created inside of the pump by Joule-Lenz effect, is used to evacuate an liquid by an drain channel.
Another solution made using the analogy technique is suggested by the gas relay showed in figure 3, which represent an gas relay with magnetic actuated contact, and where two cylindrical floats are vertically displaced on a axe fixed to the sealing head [4, 5].
Using the analogy technique, it was achieved and experimented the solution showed in figure 4 that represents a longitudinal section through the body of a pump achieved in the variant with

a single cavity, with two non-miscible liquids, of which one is the electrical insulating oil that represents the active liquid, which provides the gaseous mixture by Joule-Lenz effect [3, 12].

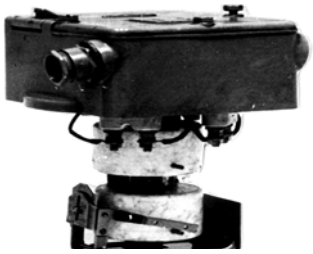


Figure 3. Gas relay A.E.G. [4]

The solution starts from the hypothesis that the travelled liquid is located over the generating liquid, obligatory being an insulating oil of the transformer, which is located in the upper part.

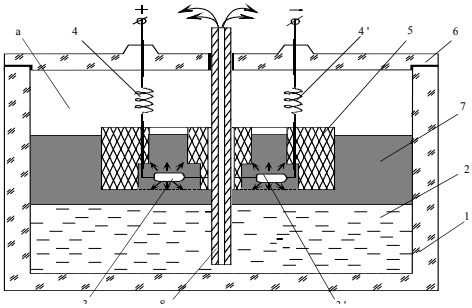


Figure 4. Model of electromechanical pump with immiscible liquids based on the Joule-Lenz effect [3]

a – main cavity; 1 – cylindrical carcass; 2 – evacuated liquid; 3 and 3' – resistors; 4 and 4' – conductors; 5 – float; 6 – sealing head; 7 – electric insulating oil; 8 – drain channel.

For solving this situation, the pump has an evacuation channel 8 placed in central zone of the cavity that also represents the slide way on which glides the float 5 that permanently checks the level of oil level. The float has two heating resistance 3 and 3', permanently immersed in the oil that is thermally decomposed in a gaseous mixture by Joule-Lenz effect.

Two flexibly lead 4 and 4' to the supply terminals located on the lid 6, make the connection with the resistances, which are located on the sliding float 5 [3, 12].

The ways of float location, of the non-miscible liquid layers and of the heating resistances, ensure the continuous working of the pump, even in the conditions of reducing of the thickness of the level and layers.

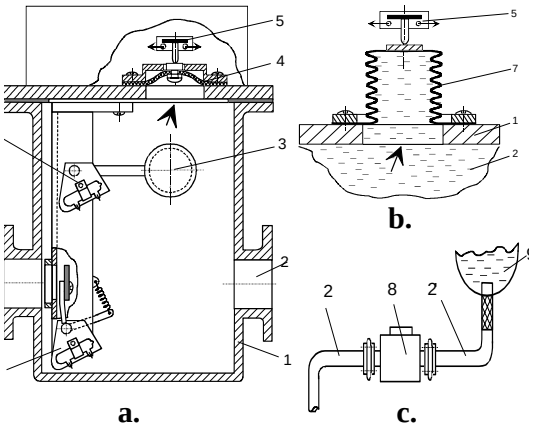


Figure 5. Gas relay Bucholtz with three distinct functions [8]

a – variant with elastic membrane; b – variant with bellow; c – circuit arrangement of the gas relay; 1 – carcass; 2, 2' – channel of connection between transformer and conservator; 3 – float; 4 – elastic membrane; 5 – upper system switching; 6 – median system of switching; 6' – down system of switching; 7 – bellow; 8 – gas relay Bucholtz; 9 – transformer conservator.

In the figure 5 is showed an embodiment of an gas relay with three distinct functions.

These are: to signal in the case of the gases accumulation, to signal or to open the switch in the case of decrease of the insulating oil level under the admissible value and to open the switch if appear a oil's wave [5, 8].

The upper system of switching is constituted by an elastic element and work only in the moment when the inside pressure increase, as a result of the gas accumulation. This inside upper pressure act on an elastic element (membrane or bellow), which operate on the switching system constituted by an off-on switch.

The median system of switching is represented by an float and is displaced in the moment of the oil level's decreasing. Finelly, the response of this system is an light signal or an switching off signal.

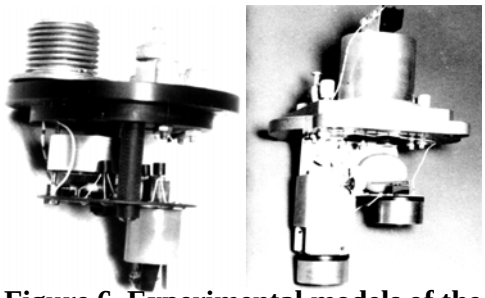


Figure 6. Experimental models of the gas relays with distinct functions [5, 8]

At this type of relay, the inferior system of switching, represented by an damper, work only at oil wave's action. The final result is to give the switching off signal.

By analogy with the external system of commutation, was achieved another solution of electromechanical pump with liquid.

The model resulted is achieved by analogy with the gas relays showed in figure 5 and the figure 6.

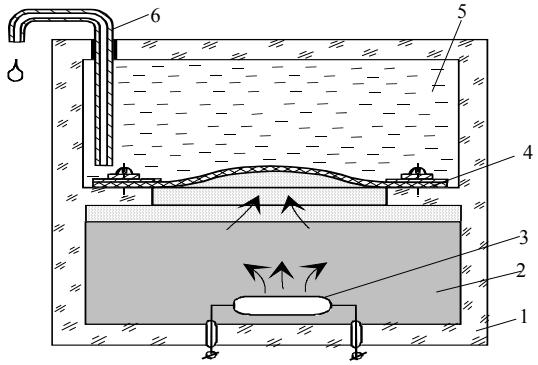


Figure 7. Model of electromechanical pumps with liquid using the elastic membrane

1 – carcass; 2 – electric insulating oil; 3 – resistor; 4 – elastic membrane; 5 – evacuated liquid; 6 – drain channel.

An logitudinal section through the body of an electromechanical pump with liquid in variant with superposed coaxial cavities is shown in figure 7.

The basic elements of this electromechanical pump consist of a cylindrical carcass 1 made from a transparent plastic material, provided with a cavity in which is placed the insulating oil, which it is heated with a resistor 3. In a superposed position it is achieved the other cavity in which is stored a liquid 5 submitted to evacuation. By the Joule-Lenz effect created in the heating resistance, the insulating oil is decomposed in a gaseous mixture, which, in rapport of the temperature, can be: methane, ethane, ethylene or acetylene and which, being accumulated in the upper part, creates the necessary pressure for push the elastic membrane 4, which act for evacuation of the liquid 5 in outside space.

The elastic membrane can be changed with a bellow. In this way, results another solution of electromechanical pump with liquid, which is showed in figure 8.

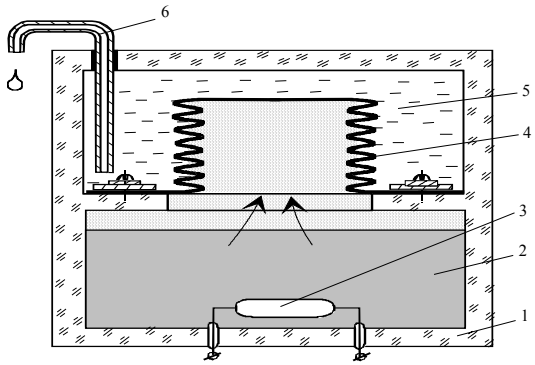


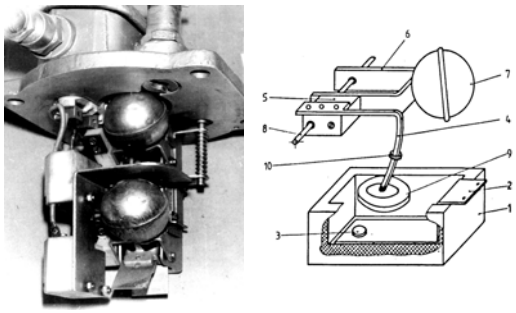
Figure 8. Model of electromechanical pump with liquid using the elastic membrane

1 – carcass; 2 – electric insulating oil; 3 – resistor; 4 – elastic bellow; 5 – evacuated liquid; 6 – drain channel.

The analogy technique can be applied if is used, as starting point, the gas relay represented in figure 9. The mechanic elements of the switch's contacts can be a float or a flap and is equipped with a magnetic element, which action on the REED relays placed nearly.

The switch's contacts are protected in an oil bath and act with a make and break switching off /on signal.

This signal is due to a magnetic device, which a ring shaped magnet and a ferromagnetic armature constitutes it, placed by mobile contact [7].



a. **b.**

Figure 9. Gas relay with magnetic switching system [7]

a – general view; b – detail view; 1 – relay cup make of polyamide resin; 2 – plate for contact; 3 – fixed contact; 4 – mobile contact; 5 – insulating support; 6 – mobile arm; 7 – float; 8 – beam; 9 – ring shaped magnet; 10 – ring shaped magnetic element.

The analogy with this gas relay was used to achieve a model of electromechanical pump, showed in figure 10, which it is constituted by a cavity created inside of a transparent carcass 1.

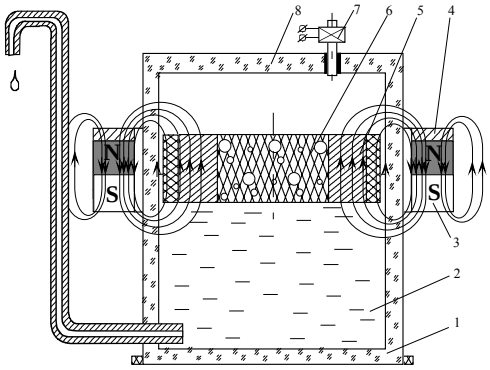
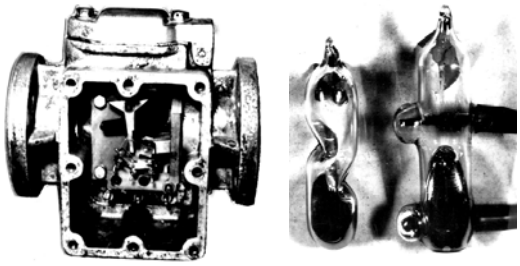


Figure 10. Model of electromechanical pump with magnetic actuation

1 – carcass; 2 – evacuated liquid; 3 – ring shaped magnet; 4 – ballast; 5 – ferromagnetic armature; 6 – float; 7 – air-control gate; 8 – drain channel.

In this cavity it is placed the liquid submitted to evacuation 2. The liquid is evacuated by action of the pressure of the float 6, which is provided with a ring shaped armature 5 made by ferromagnetic material.

The float is pressed by a ring shaped magnet 3, placed outside of the carcass, the force of actuation being dependent of the level of float's immersion. The flow rate can be adjusted by change of the mass of the ballast 4. Between the armature and the magnet it is established a magnetic coupling, which action on the float [7].



a. **b.**

Figure 11. Gas relay with switching system using mercury contact [8, 9]

a – general view; b – make and break mercury contact

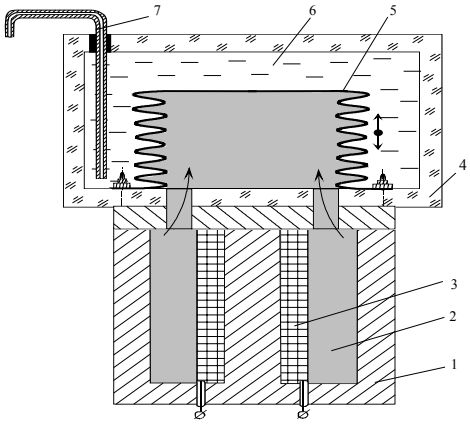


Figure 12. Model of electromechanical pumps with liquid actuated with mercury: 1 – carcass; 2 – evacuated liquid; 3 – ring shaped magnet; 4 – ballast; 5 – ferromagnetic armature; 6 – float; 7 – drain channel.

Another variant of gas relay is showed in figure 11 [8, 9]. This relay is equipped with a switching system using the make and break mercury contact.

The utilisation of mercury as working liquid suggest, by analogy, an solution of electromechanical pump (figure 12) where the evacuation of the liquid is possible by thermal dilatation of an mercury volume, which is placed into an elastic bellow.

For the thermal dilatation of mercury, a transformer is the main element of the pump. The transformer is constituted by a magnetic cup core made by ferrite and a primary winding supplied from an alternating current source.
In the space placed between the outside of this winding and the core's walls it is placed a ring shaped bath of mercury, which represent, in fact, the secondary winding constituted by one short-circuit turn.
The mercury is placed at the bottom of the cup core and it is dilated by heating and actuates the elastic bellow 5.

Conclusions

1. The analogy method has proved an important place in the scientific and technical creation, especially in the electromechanical disciplines, in this study being possible the achievement of six solutions of electromechanical pumps with liquid.
2. The analysis of mentioned solutions make evidently a number of five models, which are remarkable by novelty, cleverness and inventive level (figure 2, figure 4, figure 5, figure 7 and figure 8).
3. The other solutions, though accurately from point of view of the technical creation, needs some subsequent improvements and perfecting which can by applied by using the psychological technique, known as *perfecting-improving-development* technique.
4. Regarding the using of the analogy technique as psychological method of technical creativity to achieve new solutions of pumps, the study must be continued in order to highlight point out the analogy between the gas relay with cup and the electromechanical pumps and actuators with liquid.

References

[1]. BELOUS, V. *Manualul inventatorului*. Bucureşti : Editura Tehnică, 1990, p. 155-118.
[2]. BELOUS, V. *Inertia*. Iaşi: Editura Gheorghe Asachi, 1992, p. 266-274.
[3]. SAVU, E. *Micropompă electrochimică cu o singură cavitate.* Cerere de brevet de invenţie nr. A/00849, din 2003-10-17, O.S.I.M., Bucureşti.
[4]. CERNOMAZU, D. ; MICHIU, G. Aprecieri privind evoluţia releelor de gaze şi contribuţii la perfecţionarea lor. In: *Energetica.* Nr. 5-6, mai-iunie 1980, p. 243-249.
[5]. CERNOMAZU, D.; MICHIU, G. Consideraţii privind perfecţionarea releelor de gaze. In: *Energetica.* Nr. 8, august 1984, p. 376-380.
[6]. CERNOMAZU, D.; CIOBANU, C.; RAŢĂ, M. Studii pentru perfecţionarea releelor de gaze. In: *Volumul de lucrări al Conferinţei Internaţionale de Transformatoare Electrice CITE'96. Exigenţe. Evoluţie. Eficienţă.* Bucureşti: Editor ICPE-ME SA, 9-10 mai, 1996, p. TT46-TT51.
[7]. CERNOMAZU, D. *Dispozitiv de comutaţie.* Brevet RO 102626.
[8]. CERNOMAZU, D. *Întrerupător basculant cu mercur.* Brevet RO 94028.
[9]. CERNOMAZU, D. *Releu de gaze.* Brevet RO 86943.
[10]. CERNOMAZU, D. *Releu de gaze cu funcţii multiple.* Brevet RO 77677.
[11]. CERNOMAZU, D. *Releu de presiune.* Brevet RO 75672.
[12]. SAVU, E.; CERNOMAZU, D.; MANDICI, L. A study of theoretical and experimental aspects about the achievement of some variants of electromechanical pumps and actuators with liquid. In: *Proceedings of The Fifth International World Energy System Conference. A Reliable World Energy System*. Volume I, May 17-19, 2004, Oradea, Romania, p. 168-172.