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Film ispalators

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***Abstract*. New physical objects, ispalators based on free soap films, exhibit persistent flows of the soap solution in open and closed volumes in air with additions of gases of the C_8F_{18} type ($p = 20$ Torr) at temperature drops on the films of the order of tenths and hundredths of kelvin. The flows move continuously at a velocity of 5 – 20 cm s^{-1}. It is found that the parts of an inclined ispalator film show anomalous behaviour upon heating: their weight increases and they move downward over the film, whereas the unheated parts of the film move upward. Continuous radial vortex flows accompanied by the formation and washing of the regions of a thin black film are observed on circular films in closed volumes upon their uniform external cooling by evaporating water for 5 – 10 hours. The rapid flows make film ispalators the efficient heat carriers, which operate at small temperature drops (tenths and hundredths of kelvin) and surpass copper in the amount of thermal energy being transferred. The outlook for the further study and applications of film ispalators for detecting thermal fields and laser radiation is discussed.**

Keywords: *ispalator, fluorocarbon, soap film, self-organisation, surface tension, phase transitions, hydrodynamics, thermal conduction, origin of life*.

Ispalators [a term coined as a combination of evaporator ('isparitel' in Russian) and oscillator] [1 – 3] are various devices demonstrating the features of the action of gases on the surface tension of liquids. As shown in papers [1 – 3], a contact of many liquids with gases, for example, fluorocarbons (at pressures of 10 – 100 Torr) results in the development of persistent oscillations or rotations at a velocity of 1 – 3 cm s^{-1} on the liquid surface during its evaporation. Ispalators, as lasers, belong to an interesting class of self-organising systems with nonequilibrium phase transitions in which the oscillation states are energetically more stable and appear under certain threshold conditions. However, an operating ispalator does not require any energy supply because it is naturally self-excited during evaporation.

The discovery of ispalators showed that the parameters of liquids, such as surface tension, wettability, and nonwettability, which have always been considered as slowly varying and independent of the type and pressure of inert gases over them, can vary in different parts of a vessel for fractions of a microsecond without large energy consumption in the presence of surface-active complexes (SACs) consisting of liquid and gas molecules. This opens up new fields of studies and applications in physics, chemistry, and synergetics, which can be called the hydrodynamics of open SAC systems or SAC hydrodynamics.

Physically, ispalators are new self-organising systems, and therefore it is interesting to extend their class and to study the mechanism of their persistent movement. At present, the experimental study of ispalators is ahead of their theory and makes it possible to analyse the properties of unstable intermolecular complexes, which cannot be described or calculated theoretically so far. These are simple open systems in which there is no thermal equilibrium but self-sustained oscillation states spontaneously appear in liquid flows, where a successive switching of wetting and non-wetting regimes occurs due to a change in the van der Waals interaction between unstable complexes of liquid and gas molecules. These systems represent a convenient model for studying quantum-mechanical properties of weak intermolecular interactions and effects in two-dimensional interphase physics [3].

The aim of this paper was to fabricate an ispalator based on free thin liquid layers in which the appearing flows would not be strongly slowed down due to the viscous interaction with lower-lying stationary liquid layers.

To fabricate film ispalators, the solutions are required capable of forming stable thin films like soap bubbles, which would not break immediately upon contact with fluorocarbon liquids and vapours but responded to their presence. At the same time, it is known that fluoride compounds with a very low surface tension (~ 10 – 15 din cm^{-1}) are the most efficient foam quenchers [4].

Because aqueous solutions of common lump soap [3] or Triton X-305 and SDS surfactants weakly respond to fluorocarbon vapours, we used in our first experiments the dish-washing aqueous solution of liquid soap 'Bingo' with glycerol (Hayat Chemical Industry), which is more sensitive to fluoride compounds. We found that the strength of films of this solution increased substantially after the addition of a small amount of dibutyl phthalate.

Upon usual immersion of a loop of diameter 5 cm into the solution, a film is produced on the loop. Then, the loop with the film is lowered sideways in air into an open glass with a layer of liquid and chemically inert fluorocarbon perfluorooctane C_8F_{18} at its bottom. At a distance of 1 –

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2 cm from the C_8F_{18} layer level to the loop, liquid flows appear on the film, which move upward at a velocity of 5–10 cm s^{-1} in the form of an intense two-dimensional fountain. This is accompanied by the formation of small droplets in the upper part of the film, which return back over the film to the bottom of the loop by gravity (Fig. 1a). The intensity of the flows increases when the film is further lowered and touches the C_8F_{18} layer. The flows are noticeable because of the moving irregularities of the surface, drops, and ripples, which deflect a light beam propagating through them approximately by 1°.

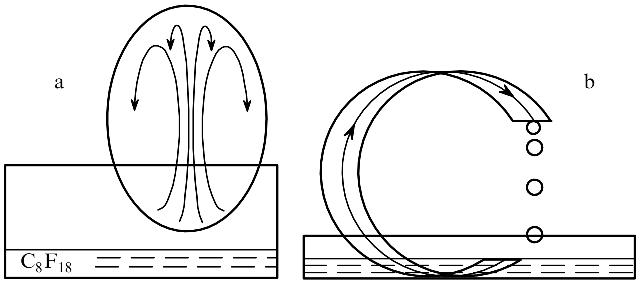

Figure 1. Scheme of the movement of flows on film ispalators.

The mechanism of the liquid motion, which was considered in detail in paper [3], is related to a change in the surface tension of the liquid upon contact with fluorocarbon vapours and to the nonuniform distribution of vapours over the height. The continuous motion of rapid liquid flows on a film ispalator occurs for several tens of minutes until the film rupture. The film ispalator in this experiment operates as an illustrative and sensitive indicator of the presence of the C_8F_{18} vapour in a glass, which is rather difficult to detect by other methods.

When a loop with the film was lowered into the same soap solution poured on the C_8F_{18} surface (a part of the C_8F_{18} surface was not covered by the solution in this case) in a shallow cup (of height 5 mm) in air, the solution also rapidly rose upward (at a velocity of 10–20 cm s^{-1}) over the film. When the loop had the form of a rectangular strip of width 1 cm and length of about 8 cm bent in the form a letter C (of diameter ~4 cm), the raised solution was collected on the upper hanging end of the loop and was dripping down (Fig. 1b). The surface tension of this soap solution at room temperature in air estimated by the drop method [3] with an accuracy of ±3 % was 25 dyn cm^{-1}. In a bottle with air and saturated C_8F_{18} vapours, the estimated surface tension was 20 dyn cm^{-1}.

The flows of substance in a film ispalator move in the same way as in the so-called soap bridge (tunnel), where a soap film with the total area of up to 100 m^2 runs downward in a flow by gravity over the loop [5, 6]. The difference is that the soap film in the ispalator runs upward over the loop by overcoming its weight. In this experiment, the film ispalator operates as an unusual pump for raising and pumping solution at a height of several centimetres at a rate of about 0.5 cm^3 min^{-1}.

When a loop of diameter 10–40 cm was lowered sideways in air into C_8F_{18} and was installed horizontally, the rapid randomly moving flows on the evaporating coloured film changed the film thickness and colour. As a result, the film observed in the reflected light was turned into unusual living abstract picture with bright rich colours and continuously varying original patterns existing for several minutes (Fig. 2).

In our opinion, this effect opens up the prospects for applying film ispalators for series production of unique various pictures created by nature before our eyes, as well as of samples for filigree decorations and high-quality works of art of virtually any size (1–100 cm) with a full spectrum of harmonically combining colours and a detailed working of the finest (micron) dynamic patterns.

Since the ambient air conditions always vary, and uncontrolled air flows and evaporation of water and C_8F_{18} are also present, to obtain a reproducibility, we performed some experiments with films in closed volumes. For this purpose, we poured 50–100 cm^3 of the soap solution and several grams of C_8F_{18} into a usual transparent plastic or glass bottle of diameter 6–16 cm with a neck and a tight cork. After stirring the solution, liquid C_8F_{18} forms a whitish layer of fine non-agglutinated balls of diameter 0.1–0.01 mm at the bottom of the bottle. By rotating the inclined bottle, as upon rinsing, we managed, after several attempts, to prepare inside (usually at the neck level) a continuous soap film, which can exist for many hours in the closed volume, depending on the composition of the soap solution and the film tilt. Such films can be prepared many times, which is convenient for performing a series of experiments under the same conditions.

An inclined film in a closed volume observed in the

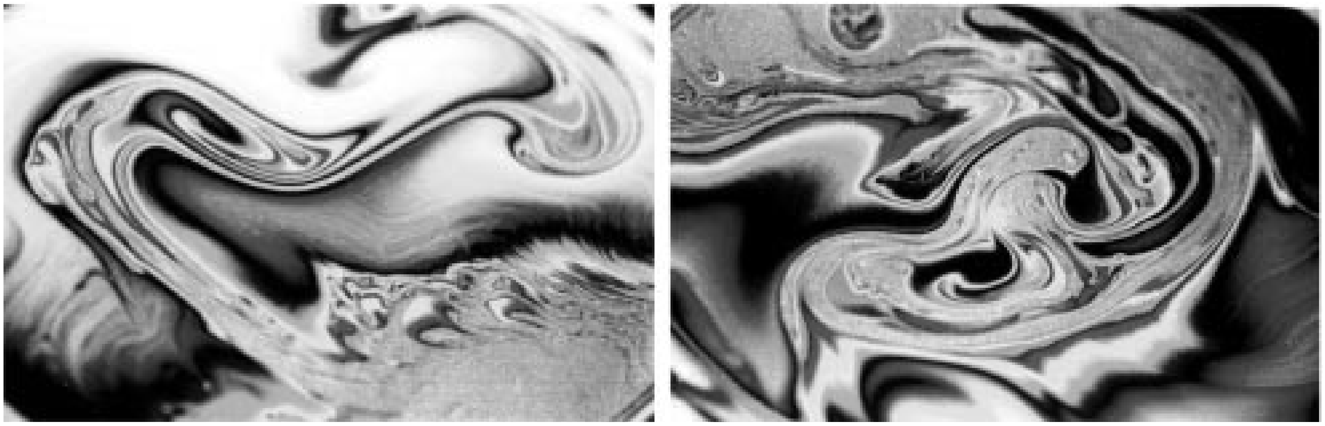

Figure 2. Typical multicoloured pictures exhibiting intense flows observed in reflected light in a horizontal film ispalator (of diameter 40 cm) in air.

reflected white light is transformed, as usual soap films, from a thick colourless film to a thin coloured film with 5 – 10 bright horizontal interference fringes due to the draining of solution from the film for several minutes. The colour of fringes allows one to estimate the film thickness [7], which increases towards its base. The film becomes gradually thinner, the fringes broaden, their number decreases down to 1 – 2, and a usual thin black region with a distinct boundary appears at the top [8 – 10]. It is called black because its thickness is noticeably smaller than the wavelength of light, and upon observation in the reflected light the film appears black due to its weak reflection (less than 0.1 % – 0.2 %). The black region gradually expands to cover almost the entire film, and the film breaks. Unlike usual films, our films have a great strength, exhibit highly contrast and bright interference fringes, and their surface tension is reduced in C_8F_{18} vapours.

When the film is heated from one side through the bottle wall by light from a lamp, breathing or by a hand (or cooled with ice), the influence of C_8F_{18} vapours is manifested in an evidently anomalous behaviour of the film regions. A slightly heated part of the inclined film unexpectedly rapidly (at a velocity of 5 – 20 cm s^{-1}) moves downward (!), whereas a cold part of the film moves upward over the film at the same velocity. Therefore, upon heating from one side, a rapid persistent circular flow is formed on the entire film, which causes the replacement of the initial horizontal interference fringes by the S-like fringes, delays the appearance of the black region, and noticeably increases the lifetime of the film. In the absence of C_8F_{18} vapours, the films prepared from the same solution behave in a standard way: a heated part of the film moves upward at a velocity of 0.5 – 1.0 cm s^{-1}, while a cold part of the film moves downward. At some low pressures of C_8F_{18} vapours in the volume, the film can show no response at all to heating or cooling.

The anomalous behaviour of the film is explained by the features of its interaction with C_8F_{18} vapours. We found that, when in air a piece of cotton wetted with C_8F_{18} was brought from above near the inclined film, the C_8F_{18} vapours incident on the film caused its local expansion and thinning, and a thin part of the film moved upward over the film being light as an air ball. The observed reverse rotation of the film in C_8F_{18} vapours shows that a part of the film heated by 0.1 – 10 K loses a fraction of C_8F_{18} molecules from its surface (the lifetime of complexes in this part is shorter [3]). The surface tension increases, the contraction of the liquid causes an increase in the thickness and weight of this part of the film, and it rapidly moves downward over the film. The surface tension of a cold part of the film is lower, its thickness is smaller, and the cold part moves upward.

Therefore, a rapid circular motion of a film ispalator in a closed volume is related to the features of the interaction of C_8F_{18} molecules with heated and cold surfaces of the film, resulting in the anomalous temperature dependence of the surface tension. Strong films withstand without a rupture the higher temperature drops at their edges (up to 30 – 40 K) for several minutes and rotate at a velocity of about 1 m s^{-1}. Without cooling, an inclined film becomes coloured in several minutes, and slow colourful flows are observed on it, which are produced by very small (hundredths of kelvin) random differences of temperature of the bottle walls. A palm placed for 10 – 20 s at a distance of 10 cm from the bottle causes a change in the direction and velocity of the movement of these flows on the film.

The high temperature sensitivity of the film can be used for the detection or indication of laser radiation upon the local heating of the film. The local heating results in a change of the colour of the ispalator film, which allows the use of a laser for transient data storage or for purposeful modification of the patterns observed. Film ispalators featuring liquid flows and changes of colour caused by very low temperature gradients (of the order of thousandths of kelvin) can be used as low-cost, large-scale (up to 1 – 2 m in diameter) two-dimensional temperature sensors for the detection and display of nonuniform thermal fields, which appear, for example, in complex and costly integral semiconductor circuits in the process of their testing and ‘burning’.

The anomalous temperature behaviour at which the surface tension increases with temperature is comparatively often observed at the liquid – liquid interface [11], but we believe that such behaviour for the liquid – gas interface was observed for the first time in this paper. It is because of the anomalous temperature dependence of the surface tension that a cold condensate formed on the walls is pulled to a warmer film, increasing its lifetime. Below, we consider the features of this motion, and now we describe the results of the next series of experiments with horizontal ispalator films in closed volumes.

A horizontal or slightly convex (of height 0.5 – 1 cm) film in a bottle also responds to the heating or cooling of its edges. Its circular interference fringes are pulled to the heated region and move away from the cooled region. Because the solution returns to the cooled region along the thickened edge of the film near the wall, this motion can occur in the case of zero gravity as well. A piece of cotton or fabric wetted with water, which gradually evaporates, in contact with the bottle wall can be used as an external cooler. We assumed that there was no sense to cool all the edges of the film equally because no motions or displacements can be expected on the film upon its uniform and simultaneous cooling.

However, nevertheless we performed the experiment with the ispalator film cooled at the edges and obtained quite unexpected results. Upon the external uniform cooling of the convex film on which interference rings already appeared, we observed rapid multicoloured vortex flows moving from the film edges to its centre and resembling liquid flows observed upon two-dimensional boiling. These flows changed their direction and evaded the slower and less colourful flows returning to the wall. The entire pattern can be compared with a dance of multicoloured tongues of flame in a circular bonfire pulled to its centre or with revived Khokhloma paintings. Gradually, for ten minutes, the film is becoming thicker, and colours disappear, but the flows with ripples do not stop.

Upon external cooling, the continuous vigorous motion persists on the film at a rate of 10 – 20 cm s^{-1} in a closed volume for 5 – 10 hours until the film rupture. Before the rupture, colour flows appear again on the film, a slowly expanding black spot dancing in the flows emerges at the film centre (Fig. 3), and then the film breaks. If the bottle is inclined before the film rupture and the film edges are slightly washed with the solution in the bottle, then the black spot on the horizontal film is washed off with the flows in 10 – 20 min, and the film exists for many hours.

Figure 3. View of a horizontal thin-film ispalator (of diameter 6 cm) observed in reflected light in a closed volume upon cooling the film edges with a piece of fabric wetted with evaporating water.

The presence of flows noticeably increases (by an order of magnitude) the lifetime of the film, but does not make it perpetual. The heating of a part of the bottle below the film with warm water or by hands results in a sharp increase (almost by an order of magnitude) in the velocity of flows on the film, whereas the heating of the top of the bottle has no effect on the flow velocity. There are no persistent radial vortex flows on the cooled concave film (they are noticeable upon heating the film edges) because the solution droplets are collected at once at the film centre and fall downward, and the film rapidly (in minutes) breaks. The pattern of flows on the film ispalator is weakly sensitive to ambient temperature and is virtually the same at all ambient temperatures (from 5 to 35 °C) and the ambient humidity below 98 %.

It has become clear after the described experiments that the central part of the film has a slightly higher temperature than the film edges because of its contact with gas in the volume. The temperature of the film edges is lower by fractions of kelvin or a kelvin, which results in persistent vigorous flows. The velocity of the flows increases with increasing convexity of the film, when light regions more rapidly rise upward, while heavy regions more rapidly descend downward. The flow velocity decreases with decreasing film thickness, when the film becomes coloured, and there are no flows on a black film.

A black spot of a variable shape that appears against the colourless background on the film has a distinct flashing boundary observed in the reflected light (edges of width of about 0.1 mm). The black region of soap films has long attracted the attention of researchers and has been studied in detail under stationary conditions [8 – 10]. In ispalators, it is possible to analyse the behaviour of the black spot when approaching flows strongly and permanently perturb it. The spot readily changes its form, separates into parts like a two-dimensional bubble or drops with long and thin tails, which then tear, draw together, again separate, and rapidly blend (Fig. 3). A very small transverse size of the tails (less than 0.1 mm) indicates that the difference of the surface tensions of the block spot and thick film is insignificant. The size of the black spot on the film can be reduced not only by the flows but also by a mechanical action. For this purpose, it is necessary first to wash the film edges with the solution and then to shake vigorously the bottle with the film in the horizontal plane to disperse over the film the liquid accumulated at the film edges.

The lively and graceful motions of the black spot in the approaching and outgoing radial flows resemble the movements of a jellyfish or a skate and are no less attractive than the picture of dancing colourful tongues described above. While the tongues appear and disappear during the motion, change the place of their detachment from the wall, their shape, colour, and area, the black spot, whose shape, motion, and division into parts vigorously change, does not exhibit the changes in its colour and area.

Being surrounded by a thick film, which well reflects light, a thin black spot behaves like a leaving creature struggling for its existence in the flows of life. Small parts of the thick film entering the black spot acquire a circular shape in seconds. The black spot does not virtually respond to the presence of C_8F_{18} vapours in the volume, and one can see by individual particles of dust upon heating the spot edge on the inclined film, how the heated region slowly (1 cm s^{-1}) moves upward rather than rapidly downward, as in the case of a thick film.

The flows of substance moving over the film transfer the thermal energy, and it is interesting to estimate this heat transfer. We did not perform detailed calorimetric measurements and estimated the thermal conductivity of the film by a simple method. In a series of experiments, a closed bottle with an external cooler wetted with water (piece of fabric) was placed on a balance, and the rate of decreasing of the bottle weight, i.e., of evaporation of water from the cooler was measured for several tens of minutes under the invariable external conditions in two cases: when there was the ispalator film in the bottle at the level of the cooler and when the film was absent. An increase in the volume of the evaporated water in the presence of the ispalator film by 10 ± 1 % (Fig. 4) allowed us to estimate the mean power required for this (~ 20 mW) and the heat transferred from the film in the bottle to the cooler for a fixed time.

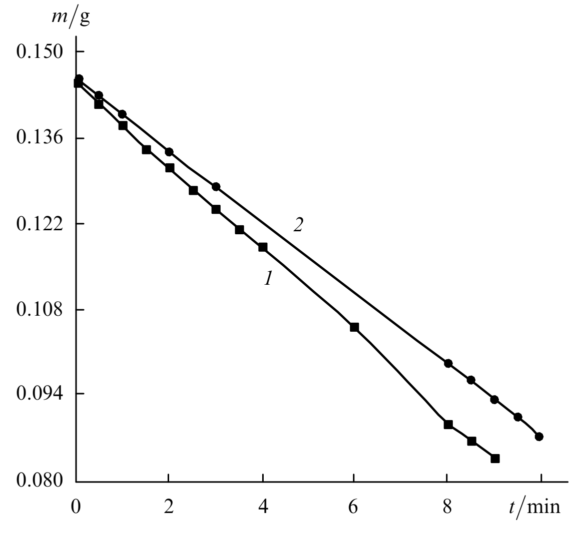

Figure 4. Water evaporation from the cooler in the presence of the ispalator film (*1*) and without it (*2*).

Assuming (with a margin) that the difference of temperatures between the film centre and its edge is 1 K (actually, it is smaller) and the film thickness (also with a margin) is 10 μm, we obtain that the heat transfer in the film is several times greater than that in a copper sample of the same size. Note that we neglected the fact that the central part of the film and air in the bottle may have different temperatures (see below) and that there is a temperature drop between the bottle walls and an immobile liquid thicker rim of the film at its contact with the wall. Taking into account all these corrections, the actual heat transfer can be noticeably higher.

Therefore, the film ispalator is a new efficient heat carrier operating at very small (fractions of kelvin) temperature drops, which is similar to thermal tubes, but employs an unusual gas – film medium in which fluorocarbon molecules are deposited on the surface of the moving liquid and fly off from it. On an inclined film, the heat is transferred in an unusual direction, from top to bottom. Let us emphasise this new semiconductor unidirectional heat transfer because the same inclined ispalator film does not virtually transfer heat from bottom to top.

Note that a horizontal ispalator film, which efficiently diverts heat to the side, is simultaneously a good heat insulator (!) during heat transfer over gas in the bottle from bottom to top. Heat is poorly transferred upward through the film. This can be observed when two parallel films separated by ~ 1 cm and equally cooled from the sides are placed in the ispalator. In this case, rapid flows are observed on the lower film, whereas the velocity of flows on the upper film is an order of magnitude lower. If the lower film breaks, the motion of flows on the upper film immediately becomes more intense.

Direct measurements of the air temperature in the bottle with a precise mercury thermometer (± 0.05 K) show that the air temperature under stationary conditions directly over the ispalator film is lower by 0.4 – 0.7 K than under the film. Some estimates show that the film itself cannot maintain such a stationary temperature drop between its boundaries without the supply of high powers (of the order of several watts) because of the high heat conductivity that is typical of liquids. This suggests that the observed temperature gradient is provided by a thin layer of cold gas, which continuously moves downward from the film surface together with C_8F_{18} molecules at the film bottom.

The film ispalator efficiently cools the adjacent air from both sides of the film. However, over the film, this heavier cooled air remains near the film, whereas below the film, the air is retained only in a thin dynamically maintained layer because it rapidly moves downward from the film and is replaced by warmer air. Note that there are no flows in a thin black region of the film, and this region, on the contrary, well conducts the heat from bottom to top and poorly conducts it to the side. Therefore, the black spot complicates the dynamics of the system by introducing perturbations to the directions of motion of gas flows adjacent to the film.

At the same time, the dynamics of interaction of the film with adjacent air flows is very important for the understanding of the mechanism of its motion. The gas flow contains diffusing C_8F_{18} molecules, which, as water vapours, are deposited on cold parts of the solution surface and walls (by heating them with the formation of complexes), move together with the film and leave it upon heating. The decomposition of complexes leads to the cooling of the liquid surface. Then, C_8F_{18} molecules are heated with ambient air, transferred by the gas flow to cold parts of the surface, and precipitate again on them, terminating the cycle of movement.

Gas flows continuously circulate near the film, change its composition and exchange the energy with the film, which additionally complicates the trajectories of two-phase flows. Despite the simplicity of the experiments described above, the intense interaction between liquid and gas in film ispalators, as in volume ispalators earlier considered in [3], severely complicates the mathematical description and simulation of their interrelated motion. To predict 'the weather' on a local part of the film (direction of flows, temperature, composition of the surrounding atmosphere) is as difficult as to predict the weather on the Earth. At the same time, the experiments with film ispalators are quite simple and informative.

A decrease in the film thickness and its aging with time occur in a usual way. A solution is first drained from the film by gravitational and capillary forces into a boundary trihedral rim near the wall, where the inner pressure is lower than that in the film due to a small radius of curvature of faces forming this rim [12]. Then, the solution is slowly pulled from the film rim over the walls to more heated parts and flows downward because the surface tension of the cold film is smaller than that of the heated film. This slow drain of the solution from the film makes it thinner after several hours, which results in a decrease in the difference between the density of different parts of the film and leads to the appearance of coloured flows and a black spot, and the film rupture.

If the film is located close (3 – 6 mm) to the surface of the main solution in the volume, when it can be additionally fed by capillary forces, the film lifetime increases up to several weeks. However, it is still unclear why the lifetime of the ispalator pump film is limited and the film breaks although the substance of the film is completely changed hundreds times by pumping solution.

The motion of the flows on the film looks like a two-dimensional motion, although it is known that the drain of the solution from some films bounded from both sides with dense monomolecular layers of surfactant molecules can occur inside the film, the surface layers being immobile [10]. The dynamics of ispalators is complicated by the fact that the flows change the properties of the film, its thickness, the disjoining pressure, and the marangoni and asymptotic (Gibbs) surface elasticity [13].

The heat transfer over the ispalator film occurs rapidly, whereas the heat transfer through the film rim (as in the volume liquid) occurs substantially slower, so that the foam of small cells in the ispalator bottle does not virtually transfer heat.

We found that the ispalator, as any self-organising system with the energy (or mass) transfer, operates only when its presence accelerates energy transfer in the system where the ispalator is located. This general rule for self-organising systems of all types (including social systems) is demonstrated in experiments with the acceleration of evaporation of water in a cooler. From the point of view of the surrounding system, the appearance of a new self-organised structure inside it is a competition, a challenge to it, and by-pass of the surrounding system (earlier, energy was transferred through the system, while now the energy is transferred more rapidly through new structures, by-passing the surrounding system). The condition of self-organisation means that, by increasing the total energy transfer, a new structure cannot spend much energy for maintaining itself because it should transfer the energy, which is the only sense of its existence. By transferring rapidly the energy through itself, the new structure increases the entropy of the environment (accelerates the temperature levelling), thereby shortening its lifetime. The study of the self-organisation of flows in ispalators will allow one to estimate the threshold conditions (synergetics) for their appearance on the liquid surface.

The complexity of the dynamics of motion and interaction between liquid and adjacent gas flows observed in the film ispalator can be probably compared to the picture of the unrepeatable appearance and transfer of intercellular excitation in the brain cortex, which is not controlled in detail so far but can be imagined visually. In this respect, coloured patterns running on the film can serve as a visual model (or a prototype) of the self-organisation of mental processes, which are closely interrelated with each other, the environment, and the historical memory of their previous states.

Theoretical problems formulated earlier in the study of volume ispalators [3] refer equally to film ispalators as well. However, some new problems have appeared. It is interesting to analyse the dynamics of motion of film flows under the conditions when the velocities of gas flows, the temperature and density of active fluorocarbon molecules in the flows are not equal above and below the film.

It is necessary to measure experimentally the temperature dependence of the surface tension of various liquids in vapours of various fluorocarbon (and other gases) at a fixed vapour density. Is it possible to prolong the lifetime of a film ispalator and to make it ‘perpetual’ by using continuous cooling with evaporating water? What compositions of solutions turn to be optimal in this case? Note, for example, that the strength of films obtained from our solution increases noticeably after the addition of several percent of the Giant Bubble powder (USA, Cricket Hill, Inc., Winter Haven, FL 33880) or Colgate Total Plax mouth rinser containing active ingredients: sodium fluoride (0.025 %), triclosan (0.03 %), and co-polymer PVM/MA (0.20 %); and ingredients: water, sorbitol, ethanol, glycerol, sodium laurilsulphate, sodium methylcocoiltaurat, aromatic compounds, menthol, disodium phosphate, sodium hydroxide, saccharin, and CI 42090 dye. It is interesting that the aqueous solution of the Giant Bubble powder and the rinser itself also produce durable films, but they, like films prepared from aqueous solution of lump soap, exhibit no flows in closed volumes in the presence of C_8F_{18} vapours. It is interesting to find out in the future with what molecules in films and how fluorocarbon compounds interact. It is also interesting to combine dynamic film ispalators with tunable dye lasers for the development of sensitive sensors and laser projectors for large screens.

Coloured regions appearing on the film are usually unstable and tend to transform to black spots or thick regions, as upon stratification of two-component solutions. For this reason, a sharp edge flashing in light is usually observed between a black spot and a thick film (with rapid flows) instead of a gradual thicker part with coloured fringes. But what is the shape of this distinct edge of the black spot? At what height in the running thick film is the black spot located? At what extent the upper surface of a film ispalator on the thick film can move independently of the lower surface? It is of interest to determine the near surface tensions of the thick film and the black spot, to consider the equilibrium condition for forces at their interface and estimate the effect of these forces and the disjoining pressure on the dynamics of motion of black drops with long tails and of the mutual transformations of films of different thickness. Also, it is interesting to study the influence of stereoforms, the spatial structure (for example, cis- and trans- in $C_{10}F_{18}$) and the chiral symmetry (twisting) of linear fluorocarbon molecules on their interaction with molecules on the liquid surface [17].

To understand in detail the mechanism of the nanoscale interaction of chemically inert molecules, which causes the self-organisation of macroscopic motions in liquids, it is necessary to develop the relevant theory and perform simulations and computer calculations for elucidating the features of this interaction and its possible applications. Video films about the motion of flows in film ispalators are available free in Internet [21 – 24].

Note that, by studying film ispalators, we found that they can be prepared not only based on fluorocarbon compounds. The flows having almost the same velocity or slightly slower were observed in our soap films upon the interaction with pentane C_5H_{12} vapours when a frame with the soap film was lowered sideways into an open vessel with vapours of liquid pentane poured on the vessel bottom, or in a sealed film ispalator with saturated vapours of pentane, ether or usual gasoline. This substantially extends the endemicity of ispalators and makes it possible to produce them using low-cost compounds.

The features of the interaction of pentane molecules with the liquid surface under stationary conditions were studied experimentally and theoretically in a number of papers [18, 19]. Pentane is insoluble in water [20], but upon a contact of its saturated vapours ($\sim$400 Torr) with water, a monomolecular pentane layer is precipitated on the water surface [18, 19]. According to our estimate, the surface tension of water decreases by 14 %. In saturated pentane vapours, the surface tension of the soap solution decreased by 37 %. The decrease in the surface tension is proportional to the pressure of pentane vapours, which causes, under nonequilibrium conditions, a permanent motion of flows in the film ispalator. The results of our studies of film ispalators with such compounds, which are cheaper than fluorides, will be reported later.

Nanotechnology, which has been developed world-wide for the last decade (the fabrication of motors and devices on the molecular scale), can use the motion of molecular complexes discovered by us [3] as nanoengines for rapid transfer, for example, of fluorides or other molecules from one site to another over the liquid surface, as this already occurs in ispalators (over large distances of several centimetres). Indeed, the ispalators are in essence nanomolecular engines. Note that the velocity of flows in film ispalators and their transverse size are an order of magnitude greater than those in their volume analogues [3].

Film ispalators are of interest from the physical point of view and for applications in the following cases:

(1) The creation of unique two-dimensional physical systems with new principles of the permanent motion.

(2) Observations of the equilibrium, two-dimensional stratification, and reversible phase transitions between a thick and a thin black film under the action of different alternating components of the disjoining pressure.

(3) A detailed study of the mechanism of motion of gas and liquid flows in volume and film ispalators themselves.

(4) The use of the reciprocal vortex motion of two-

dimensional systems for simulations of air flows of the type of atmospheric cyclones and the weather change.

(5) The series production of high-quality, unrepeatable 'living art pictures', sketches for filigree decorations, and continuously changing fantastic stills for cinema and TV.

(6) The study of the mechanism of formation of patterns in nonequilibrium physical systems upon amplification of noise by instabilities [14, 15].

(7) The development of inertial sensors of the gyro type, which detect the angular rotational velocity of systems by the variation in the pattern of radial flows (a horizontal film inside a bottle of diameter ~ 10 cm can rotate without rupture at a velocity of above 10 rps).

(8) The study of thermodynamics of two-dimensional systems with the anomalous property of expansion upon cooling.

(9) The use as sensitive, low-cost, and large-scale two-dimensional thermal displays and sensors

(10) The fabrication of efficient, unidirectional heat (cold) carriers, which are similar to those used in thermal tubes, but operate employing an unusual gas – liquid film filler and transfer energy from top to bottom.

(11) The extension of the number of objects for studying the general physics of soft condensed systems [16] and testing the gas – liquid models of theoretical hydrodynamics of open systems with surfactant complexes [3].

The appearance of film ispalators based on wide-spread organic gases shows that no special extreme environmental conditions are required for obtaining systems with self-organisation and macroscopic motion. All one need is a common film prepared from an appropriate mixture of natural compounds, which is, as shown above, is capable of responding to extremely small temperature drops without any energy supply and chemical transformations, by producing the flows of substance on its large surface and accelerating the combination and separation of atoms and molecules in these flows.

A simple and natural composition of the solutions, the high sensitivity to the environmental conditions, the easiness of spontaneous formation of the flows of substance at small temperature drops suggest that such or similar film structures have provided the foundation for the appearance of self-organising systems in ocean and of life on the Earth.

It seems that the first living creatures on the Earth were not microorganisms but simple macroscopic balls – thin-film ispalator bubbles in ocean waves with permanent self-organising flows, highly sensitive to heating, humidity, and chemical composition. They have a characteristic property to produce and maintain different condition on different sides of the film, to combine in flows the molecules spatially oriented on surfaces, and select the most viable structures. The ancient legend about Aphrodite who emerged from the sea foam can be now reasonably grounded by ispalator features.

In this connection, of interest is a general question of whether there are other, simpler physical systems possessing self-organisation, high sensitivity, and a variety of possibilities to combine their constituent compounds at minimal energy (mass) flow through them, which could be responsible for the origin of life on the Earth?

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