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Human Energy Field

Study With GDV Bioelectrography

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This book is dedicated to the presentation of the scientific foundations and practical applications of the Gas DischargeVisualization (GDV) technique. This technique represents a revolutionary new method for the study of biological subjects, namely biological energy fields. This research extends scientific tradition, developed in Russia in the twentieth century. The Human Energy Field carries information on physical, mental and spiritual states of a human being, and the GDV Bioelectrography technique is the first method in the world which gives an opportunity to study this information. Utilizing the latest advances in technology, such as microelectronics, computer imaging, and data mining, scientists have been able to create an entirely new class of scientific instruments that allow the practitioner to view, measure and analyze biological subjects in a manner that has never been possible before. The GDV technique has been found to have numerous highly important applications in medicine, sports, consciousness studies, material testing and other areas, discussed in this book...

Whether the reader is a physicist, poet or philosopher, this technique offers an entirely new understanding of the world in which we live. Each encounter simply confirms the wisdom contained in all the holy books of every religion. We are all one. We are all connected. We are the interrelation of Matter, Information and Spirit.

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Introduction

One of the main questions of the GDV-graphy technique is as follows: "What is the principal difference between the mechanisms of fluorescence of non-organic and biological subjects and what is the particular feature of information about the human state?" Wide introduction of the technique and overcoming of the continuing vigilance of the academic investigators are impracticable without answering these questions. Therefore, when describing the basic mechanisms of GDV-graphy, we should distinguish the settled theories and grounded hypotheses from the suppositions and scientific fantasies. The study is based on the hierarchical system approach, illustrated by fig. 9.1. Constructing hierarchical systems, we follow the principle accepted in systematic studies [Wilber, 1996; Presman, 1997]: each subsequent level is based on all the previous ones and can not do without them, while a previous level is able to exist without the subsequent ones. Let us look at the figure. We see a kind of hierarchy, going bottom-up, from one level to the other, to a more and more complex one. All phenomena and processes on the Earth follow fundamental physical laws, and biophysical processes have their own specific character: emergence of life became a quantitative leap forward in the evolution of the Earth. Psycho-physiological activity emerged as a certain stage of self-organization of the biophysical processes, as the highest phase of their organization. The next level describes these processes both from the viewpoint of energy metabolism in Western or Eastern terms and from the viewpoint of system theory and information theory. In both cases we consider the biological system as an open one, exchanging energy and information with the environment. From a modern standpoint these aspects of system organization are described by an entropy-synergetic approach. And, finally, the principle of field structures appears as the organizing and structuring basis for all the previous levels.

Thus, these are rather like steps or levels of development and complication of the substance existence forms, from inert physical structures, endless in their diversity, to the more and more sophisticated forms of biological life. These steps lead us to the highest level – the level of Consciousness, the processes of which indirectly manifest on all the previous levels. For example, it is impossible to measure the amplitude of a magnetic field directly – it is measurable only through its influence on physical processes, say, position of the magnetic arrow. The same is true with the processes of Consciousness and Soul, which cannot be measured directly. They belong to the other, nonphysical dimension. However, we can judge

these processes through the transformation of physical activity. Thus, from our viewpoint, modern scientific methods enable us to strictly investigate many spiritual, metaphysical processes, "secret phenomena of the human psyche," such as telepathy, healing, and telekinesis, and to still remain within the scope of a Western scientific paradigm. A number of such approaches are discussed in this book. Investigating these phenomena, we will move step by step, stage by stage, passing from the habitual notions to the more and more abstract ones, studying various approaches, each describing some or another side of the enigmatic and alluring Kirlian fluorescence phenomenon.

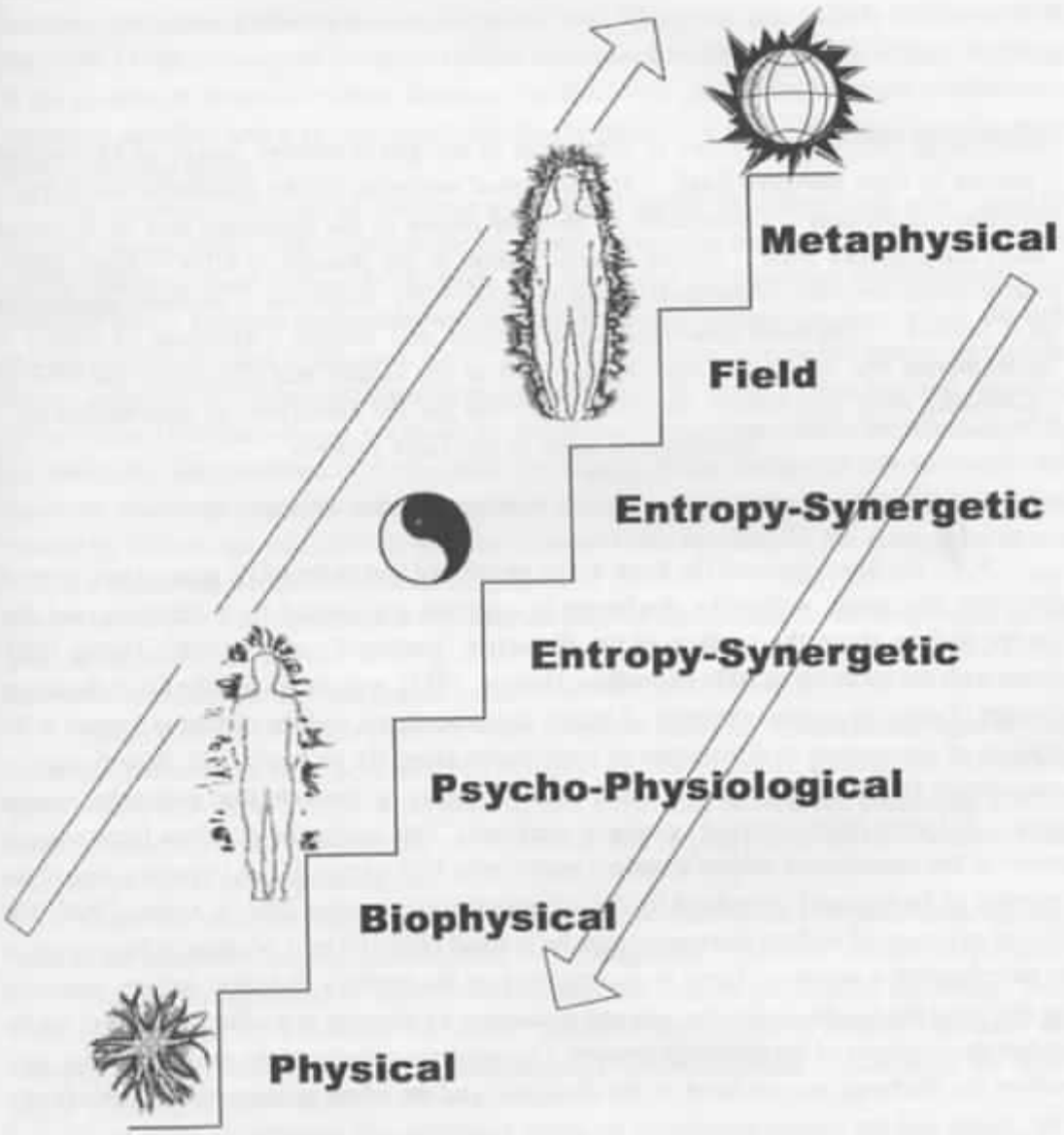

Fig. 9.1. Hierarhical system approach to the study of biological systems.

Chapter 9. Physical approach

Analysis of physical processes of formation of the gas discharge image of bio-subject placed in high intensity EMF – Mathematical modeling of the avalanche discharge development process – Calculation of thermal power in the discharge and its influence upon the subject's state – Liquid structurization in the process of GDV – Main informative characteristics of subjects found with the GDV technique – Intristic conduction of a subject – Structural heterogeneity of surface and volume – Moisture of subject – Spontaneous and stimulated optical radiation in the visible and ultraviolet spectrum – Choosing most informative radiation spectrum for the extraction of information on bio-subject's state in the GDV process

In the first chapter of the book it was mentioned that in the GDV process two types of discharge take place: **avalanche discharge** in a narrow gap limited by a dielectric, and **discharge sliding along the surface of the dielectric** [Bankovsky et al., 1986]. Taking BEOgrams with the zoom up to 100x [Korotkov, Hmirov, 1982], with the avalanche GDV the image consists of separate points (elements of image decomposition), and the picture is formed at the expense of unevenness of distribution of these points along the picture's field. A particular decomposition element is formed as a result of the influence by local electron avalanche, exerted upon a dielectric (photomaterial or optical electrode). This avalanche develops from separate points of the investigated subject's surface under quite high electrical field intensity, due to the presence of background or emitted by the subject charged particles [Mic & Kregs, 1960]. The time of existence of such an electron avalanche is small (10^{-7}-10^{-8} sec), because in the process of its development a negative charge is accumulated on the carrier's dielectric surface, screening the electrical field in the avalanche area and decreasing its intensity to a value insufficient for the further development of the discharge process. Changing the polarity of the external voltage neutralizes the discharge accumulated on the dielectric, and the whole process repeats periodically. The charge and the energy, transferred by every avalanche, are respectively equal to 10^{-9}-10^{-12} Coulombs and 10^{-7}-10^{-9} J. The subject's image is formed when the probabilities of emergence of

avalanches at several points of its surface differ significantly, for example, because of the surface heterogeneity of the subject's emission characteristics or from local disturbance of the electrical field because of micro-irregularities of a metal surface or impurities in the dielectric volume. A great number of avalanches possessing higher intensity are formed at the points where this surface is larger, and the decomposition elements, merging together, produce light parts of the image. This type of discharge is well studied [Mic & Kregs, 1960].

A **sliding discharge** is such an electrical discharge, which develops on the interface of two media: one is a gaseous dielectric, and the other one – a dielectric or semi-conductor with a condensed phase (solid or liquid). A sliding discharge appears under rapidly changing voltage on the surface of a thin-layer dielectric, when its other side is covered by a conducting layer, and under a sharply uneven electrical field. Moreover, due to little thickness of the dielectric a high intensity of electrical field is maintained in the head of the sliding discharge in the process of its development. Because the discharge process under these conditions is extremely specific, and it is very important for the process of GDV bioelectrography, let us study it in more detail.

To examine details, let us substitute a thin metal bar for the subject, and apply upon it a positive voltage pulse, with respect to the electrode. Obviously, the intensity of electrical field will be maximal close to the bar electrode, (having radial configuration near the surface of dielectric plate). Electron avalanches will emerge in the near-surface gas layer when the field reaches its critical value in this area, under which the electrons accumulate energy enough for the gas particles' collision ionization on the free path length. These avalanches will, however, spread not in a free gas volume, but along the dielectric's surface, moving in the direction of the bar electrode. The electrons of avalanches, developing on the surface of this electrode, will leave the discharge channels with the positive charge on the dielectric. The electrical field created by this charge will sum up with the external field, resulting in the emergence of new similar avalanches, which will now develop towards previously formed channels. As a consequence of this process, a gradually branching network of such channels will keep being generated on the dielectric surface, as long as the electrical field on the periphery of this charge formation remains less than the critical value.

Pictures of a set of such channels were given the name of "**Lichtenberg figures**" and numerous publications have been devoted to them (see, for example, bibliography in [Mic & Kregs, 1960; Korotkov, 1995]). Analogous figures might also be received possessing a difference as compared to the bar electrode configuration. But in either case the electrical field near it should be highly heterogeneous.

Under the reversed voltage polarity, the avalanche electrodes will move from the electrode to the periphery in the direction of the weakening field. Therefore, the discharge picture formed will be distinguished by significantly smaller dimensions and smaller branching. These types of discharge have become known as "**positive and negative sliding (surface) discharge,**" correspondingly, and the studied stage of its development – **avalanche or crown phase** [Dashuk, 1999].

If we gradually increase the amplitude of the pulse voltage or the gas pressure, at particular values an intensive streamer develops from the discharge figure described above.

Thus, the next streamer discharge phase starts, which then turns into a **sparkle discharge**. Only the low-current – avalanche and streamer – phases are used for the GDV, when the integral value of the current pulse does not exceed 50 mA.

Figures similar to those described above might be observed in the case when the upper electrode is not pressed to the dielectric plate, but separated from it by a small gas gap, usually not exceeding several millimeters. In this case, however, the discharge's form becomes more complicated: an avalanche discharge develops apart from a surface, which should be taken into account when interpreting the images received.

In practice, to obtain discharge figures a series of bipolar voltage pulses is often applied to the electrodes. In this case, a corresponding discharge phase arises at each pulse, and the final picture represents a superposition of images from the positive and negative discharges (taking into consideration electrical field distortion by a positive surface charge, which remained after the previous discharges).

Let us study the data on the influence of various factors upon these parameters. Three stages of development of the discharge figures might be distinguished, depending on the ranges of change of pressure and U voltage amplitude. Within each stage the Lichtenberg figure radius is correlated with the size of pressure and voltage by the power dependence in the following form:

$$R = Cp^{-D}U_m^n - Fp^{-1/2},$$

where the constants C, D, F, n are different for every stage, depending on the range of pressure and voltage. In [Toepler, 1921] an empirical formula is given, demonstrating the correlation between the sliding discharge's length, specific surface capacity, amplitude, and steepness of the applied voltage:

$$L = k\ C^2 U_0^3 V^{0.25}$$

where C [Farad*cm^2] – specific surface capacity; $2 < L < 10$ mm – length of sliding discharge; U_0 [kV] – applied voltage; [V*s^{-1}] – the speed of voltage increase; k – coefficient equal to $21 \cdot 10^{13}$ for the positive and $13 \cdot 10^{13}$ for negative polarity, depending on the dielectric material and form of influencing voltage. It is worth stressing that the leading edge steepness and voltage pulse length influence the value of the constants and, hence, the discharge figures' characteristics. According to the data [Rodewski et al, 1941] the discharge of this type does not develop at all, if the pulse length is less than 10^{-9} sec for a negative figure and 10^{-8} for a positive one.

Under positive polarity of the voltage pulse the discharges seem to be complex "treelike" formations with sharp heads. The discharge length (L) depends on the voltage amplitude (U) and dielectric thickness (d). Increasing the voltage, the L(U) curve first grows approximately linearly, and then reaches saturation. With the increase of the dielectric's thickness within the range of L = (0.25-5) mm, the length of the positive discharges also grows [Dashuk, 1999]. Under negative voltage polarity the discharges represent formations possessing diffuse heads, practically the same length, and, as a rule, lacking branching (except the very tips). The length of negative discharges increases with the rise of voltage according to the linear law without visible saturation. With the growth of dielectric thickness, the discharges' length under negative

polarity decreases. Under both polarities L (U) dependencies might be obtained only to a certain U_s value. Respectively, for each dielectric length, assuming $U > U_s$, the discharge passes into a leader phase. Transition voltage grows with the increase of the dielectric thickness, and the length of negative streamers is 2-10 times smaller as compared to the positive ones.

The main peculiarity of the sliding discharge in the streamer phase consists in the following fact. The length of positively charged electrode streamers does not decrease with the growth of dielectric thickness, as it occurs for the streamers of sliding discharge under negative polarity and sliding discharge in the leader phase under both polarities, but, vice versa, significantly increases. Changing dielectric thickness from 0.25 to 5 mm, the length of streamers of positive polarity doubles, and that of the negative polarity falls by the same value. In addition, in the latter case an abrupt length decrease takes place under $d > 1.5$ mm.

The width of the discharge channel (a) under U = 10-15 kV falls approximately linearly, moving away from the electrode. At first, under negative polarity the streamer's width in the zone adjoined to the electrode (L = 1-3 mm) abruptly grows, and then it remains constant till the very head. Thus, for example, under U = – (10-30) kV, L>1 mm, d = 0.5 mm, the streamer's width a = 0.55-0.7 mm.

In electro-positive gases (air, nitrogen, hydrogen, etc.) the form of gas discharge figures is qualitatively identical, while the introduction of electro-negative admixtures (for example, CCl_4) causes a cardinal modification of the whole figure: an abrupt decrease of size and suppression of the image "thin structure." According to the data [Merill, Hippel, 1939], this fact is connected with the three main processes: absorption of the slow initiating electrons, which impedes the development of electron avalanches; absorption of the secondary electrons, born in the avalanche; and electrical field distortion at the expense of negative ions. It was also found that the magnetic field, normal to the surface, initiates the curvature of the discharge figure branches, which is explained by the characteristics of electrons, moving in the magnetic field [Anders, 1985].

The discharge figure parameters also depend on the characteristics of the dielectric covering the electrode. For example, having all the other parameters constant, the length of the discharge track and the voltage of transition into the streamer phase is in an inverse proportion to the square root of the specific surface capacity [Dashuk, 1975]:

$$U_{str} \sim L \sim 1/\sqrt{C},$$

$$C = k\,\varepsilon / \delta.$$

In compliance with the results of the research implemented, coinciding with the data from Practorius [1940], the presence of roughness, dust, or moisture on the surface does not affect the image, if these are not related to the change of surface conductivity.

Positive streamers' length rises in proportion as the dielectric thickness increases, negative streamers' length falls according to the rise of the dielectric thickness, linearly with regard to ln d. Since for the negative streamers both dependencies: L(U) and L(d) – are linear, the total dependence might be described by the following empirical formula:

$$L = -4 + 0.85U - \ln d,$$

where L [cm], 3<U<30 [kV], 0.1<d<10 [mm]. Streamers' frequency m does not depend on the voltage amplitude on the electrode and is only defined by the thickness of dielectric d. With the increase of the dielectric thickness, under both polarities the frequency of streamers falls, it is however always 2-3 times larger under positive polarity comparing to the negative one. Dependence of number of streamers m on the dielectric thickness d per 1 cm under negative polarity might be described by an empirical formula:

$$m_{(-)} = 12\ d^{-0.5},$$

As demonstrated by the given data, the values of currents and intensities in the channels of the **streamer and leader discharge phases** are by order of magnitude (10^5-10^6 times) greater than the currents and intensities in the bio-subjects. Therefore, carrying out the GDV of bio-subjects, it is advisable to use mainly initial: **avalanche and the beginning of streamer phases**, because only these phases include information about the emission processes on the bio-subject's surface, significantly influencing the discharge autographs in these phases. The picture of discharge at the end of the streamer and leader stages, as well as under the repeating and oscillatory voltage pulses, only complicates the decoding of information.

In the case of the rod-plane electrode system, the surface discharge always gives strictly symmetrical figures. While investigating complex subjects, especially biological, mostly complex figures are observed.

Analyzing the GDV process special attention was paid to the interaction of the investigated subject with the EMF and the gas discharge, including the following main components (fig.9.2):

- Formation and development of the gas discharge, specific for the GDV;
- Influence of the processes upon the investigated subject and image carrier's surfaces;
- Influence of the processes in the volume of the investigated subject;

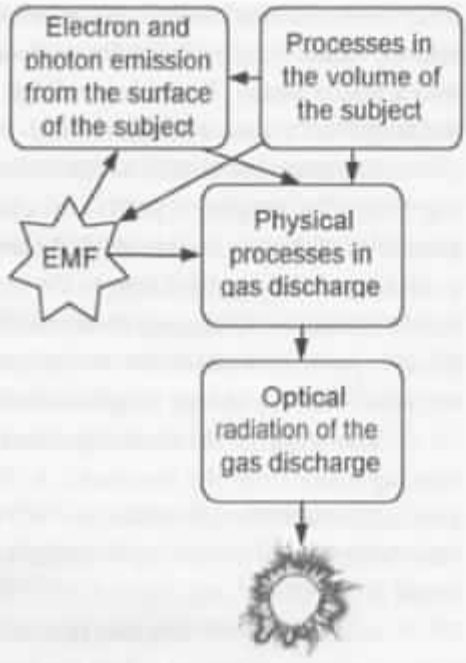

Fig. 9.2. The scheme of information transfer from the subject under study to GDV-gram parameters.

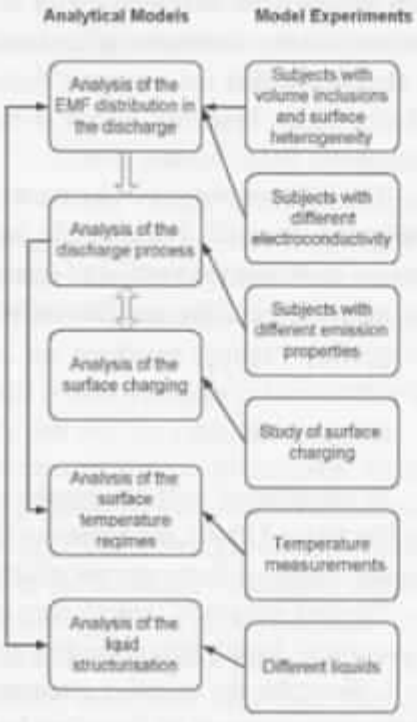

Fig. 9.3. Program of stuoly of the physical processes in the GDV technique.

• The process of formation of a two-dimensional image on the gas discharge image carrier.

A series of analytical patterns was created and model experiments were implemented in order to study these processes, revealing the main informative parameters of the subject, showing up in the gas discharge characteristics, their correlation with the gas discharge parameters being registered, and optimal conditions for extraction of information on the subject's state.

The program of the research carried out is schematically represented on figure 9.3. It includes the theoretical analysis of the EMF distribution in the model visualization device, the analysis of physical processes of the gas discharge development, characteristic of the GDV, taking into account the surface and volumetric processes in subjects of diverse-nature, and analysis of typical thermal modes. To evaluate the developed analytical models, they were compared with the model experiments.

Analysis of physical processes of formation of the gas discharge image of bio-subject placed in high intensity EMF.

Methodical schemes of investigation of the biological subjects.

For analysis the bio-subjects might be conditionally divided into two categories: solid-body and liquid-phase bio-subjects. The main principles of investigation of the gas discharge characteristics are general for these two categories, however there is a series of special features: particularly, the dynamic processes of structure-formation inside the liquid are essential for the liquid-phase subjects. Naturally, the patterns of experiment differ. For analysis, the bio-subjects investigated might be represented in the form of certain conditional patterns. The solid-body subjects might be represented by way of a multi-layer dielectric, which has surface heterogeneities and inner impurities. Parts of human and animals' skin, leaves, plant fruit and stems pertain to such solid subjects.

For liquid-phase subjects the main subject of investigation is a liquid drop suspended over the electrode or placed in a dielectric vessel (fig. 9.4). In this case a determining role in the dynamics of the discharge development is played by the modification of volumetric characteristics of liquid medium

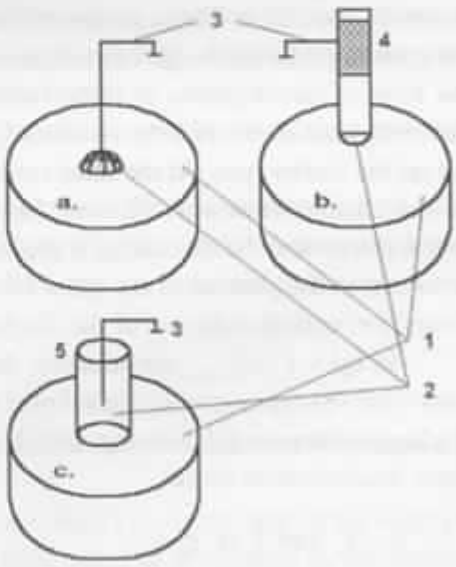

Fig. 9.4. Principles of study of liquid – phase subjects: 1 – electrode; 2 – liquid; 3 – grounding; 4 – capillary; 5 – glass cup.

under the influence of the applied electromagnetic field. And the most important factor of the discharge process development is the EMF distribution over the bio-subject surface, depending on the surface and volumetric heterogeneities of the subject. Therefore, to analyze the gas discharge images (GDI) formation process, it is necessary to study the character of electromagnetic field distortion over the subject surface, which might be implemented for a number of model cases.

The analysis of electrical field distribution in a discharge gap.

The analysis of the avalanche gas discharge development processes in a plain-parallel gaseous gap demonstrates [Miz, James, 1973] that the electronic avalanche appears in the moment when the value of outer voltage U(t) applied to this gap becomes equal to the $U_з$ discharge ignition potential. This value depends on parameter Pd, where P – gas pressure, and d – value of inter-electrode gap. For every gas this dependence correlates with the corresponding Pashen curve [Granovsky, 1971]. Electron avalanche, having arisen in some space point, spreads linearly to the anode. Its emergence is accompanied by a current pulse in the discharge circuit and gas fluorescence. As voltage U(t) becomes higher than $U_з$, the amplitude of the current pulse grows and the fluorescence intensity increases in proportion to it, as well as a number of discharge acts arise (avalanches), determined by the unit of surface of the electrode area. Parameters of fluorescence emitted by the avalanche depend upon the gas medium chemical composition, which defines the spectrum structure and intensity of this fluorescence.

Having constant pressure, the ignition potential grows with the increase of the inter-electrode gap value. Direct measurements revealed that this phenomenon is accompanied by the growth of the discharge current pulses' amplitude and the fluorescence intensity, however the form of oscillograms of these values does not practically change. On the given image carrier (certain dielectric) the visualized glow arises at a definite U/p parameter value, depending on the carrier type. At the same time, the properties of image on the photo film practically do not change when a transparent dielectric layer, 10-15 mcm thick, is placed between the image carrier and the discharge. It appears from this invariance with imposition of a dielectric layer that in the process of the glow formation, the key role is played by volumetric gas processes, i.e. optical radiation of the discharge.

In $\lg I = f(d)|_{E=const}$ coordinates, dependence of the discharge current on the inter-electrode interval represents straight lines, which is the evidence of the Townsend (avalanche) discharge character [Granovsky, 1971], when the current density J is proportional to the electrons' multiplication speed:

$$J - v_e \sim e^{ad} F(a, g, d),$$

where a – ionization coefficient, g – absorption coefficient, F – function, depending on the gas sort.

The fluorescence emerges in the range of pressure from the atmosphere to the tore units in the multi-composed gaseous medium. (Our investigations were carried out in helium, argon, nitrogen, and oxygen [Ban'kovsky, Korotkov, 1982, 1985, 1986, 1987]). The current amplitude

grows with reducing the gas pressure (a sufficient illumination might be obtained under the pressures exceeding ~ 10 mm Hg). In all practically interesting cases the values of E/P ratio lie to the left of the stoletovsky maximum [Granovsky, 1971]. The fluorescence intensity increases insignificantly when the decrease of pressure is observed in the measurement range from the atmosphere to ~ 450 mm Hg, after which it starts going down. This is obviously determined by the fact that the excitation function has its maximum under smaller electron energies, as compared with the ionization function.

Gas composition in the inter-electrode gap influences the discharge characteristics considerably. The following condition is equitable for a wide range of pressures:

$$U^{air} > U^{N_2} > U^{Ar} > U^{He},$$

which is typical of a weak-current discharge. The volt-ampere characteristics determine that under every voltage value the following ratio is correct:

$$I^{Ar} > I^{N_2} > I^{He} > I^{a}.$$

Such an order is established by the values of the gas atoms' ionization section by an electron impact. In the case of discharge an oppressive effect of the electron component manifests itself in the air. The marked order maintains for the fluorescence intensity curves as well.

Taking into consideration the permanency of the visualization device parameters, the data obtained enable drawing the conclusion that the GDV-gram's form is determined by the character of electrical field distribution over the investigated subject's surface. In the case of an isotropic subject of constant thickness, the electrical field will be homogenous along the whole gap area, which leads to a uniform illumination of the image carrier. The presence of a heterogeneity-defect on the surface, or in the volume of the non-conducting subjects, results in the distortion of electrical field in a gap close to the subject's surface, which effects the form of the image. This fact can be demonstrated on some examples.

Let us discuss the character of electrical field distortion caused by the surface and inner heterogeneities-defects.

Let us schematically study the interaction of a subject with the electromagnetic field by an example of analysis of the field in a flat multi-layer condenser (fig.9.5). It follows from the electrostatic Gauss theorem that the decrease of voltage on the discharge gap is defined by the expression:

$$U(t)/d = E(t) = U_0(t) / (d/\varepsilon + d_1/\varepsilon_1 + d_2/\varepsilon_2), \qquad (9.1)$$

where $U_0(t)$ – momentary value of the applied voltage amplitude; d, d_1, d_2, e, e_1, e_2, – thicknesses and dielectric penetrabilities of the gas gap and dielectric layers astride the discharge gap, correspondingly.

The resulting potential of the diffracted (disturbed) field j is determined by the superposition of the external field potential φ_0 and secondary field potential φ_1, created by the charges, induced on the cylindrical cavity surface:

$$\varphi = \varphi_0 + \varphi_1. \qquad (9.2)$$

In addition, an induced field with potential φ_2 occurs inside the cylindrical cavity.

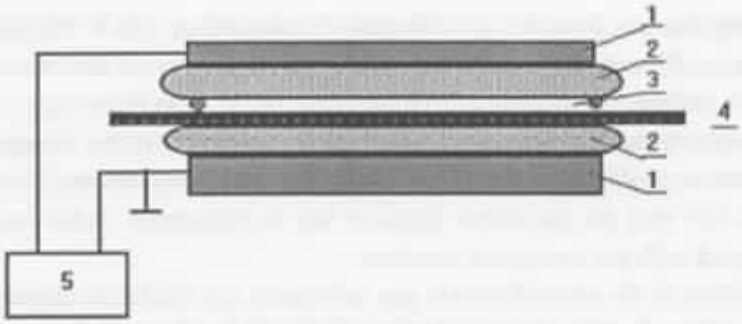

Fig. 9.5. GDV device for avalanche discharge: 1 –electrode; 2 – dielectric; 3 – gaseous gap; 4 – subject; 5 – generator.

A Laplas equation solution enables deriving the distribution of electrical field intensity (without taking into account time processes) for the cylindrical defect (cavity) with the radius "a" with dielectric penetrability ε_b and axis parallel to the surface of the dielectric with penetrability ε_1 (fig. 9.6) [Korotkov, 2001].

$$E_d = -\,\mathrm{grad}\varphi = E(1 - a^2/r^2 \cdot \gamma)\cos\upsilon - E(1 + a^2/r^2 \cdot \gamma)\sin\upsilon\,, \qquad (9.3)$$

where $\gamma = (\varepsilon_1 - \varepsilon_b) / (\varepsilon_1 + \varepsilon_b)$.

As long as it is necessary to determine the field intensity for various cavities' radii and various occurrence depths, it is convenient to pass over to dimensionless quantities:

$$q = b/a; \quad \lambda = x/a; \qquad (9.4)$$

where b – distance from the cavity axis to the dielectric boundary; x – distance from the projection to the cavity along the pattern surface.

Field intensity on the boundary of the pattern and registering material is defined as follows:

$$E(\lambda) = E\,[1 + (\gamma - 2\gamma(q^2 - \lambda^2))/(q^2 - \lambda^2)]^{1/2}. \qquad (9.5)$$

While $1 \le q < \infty$, $0 \le \lambda < \infty$, it results from (9.5) that the field directly above the cavity (in the $\gamma = 0$ point) is weakened under $\gamma > 0$:

$$E(\lambda)\big|_{\lambda=0} = E(0) = E\,(1 - \gamma/q^2). \qquad (9.6)$$

The field structure (9.5-9.6) defines the GDV-gram character as follows. Having dielectric penetrability of the inclusion ε_b, larger than that of the material ε_1 ($\varepsilon_b > \varepsilon_1$), the inclusion develops an increase of the electrical field in the gas gap above it, i.e. to a more intensive development of the discharge process in the given area, while having $\varepsilon_b < \varepsilon_1$ – to the electrical field weakening.

Indeed, investigating samples possessing $\varepsilon_b > \varepsilon_1$ (metallic inclusion) a more intense illumination of the image carrier is observed in the defect area. Having $\varepsilon_b < \varepsilon_1$ (inclusion in the form of air cavity $\varepsilon_b = 1$), under the correctly selected parameters, illumination in the inclusion area is considerably weaker than the background illumination. Increase of dielectric penetrability of the subject's material leads to a larger image illumination area.

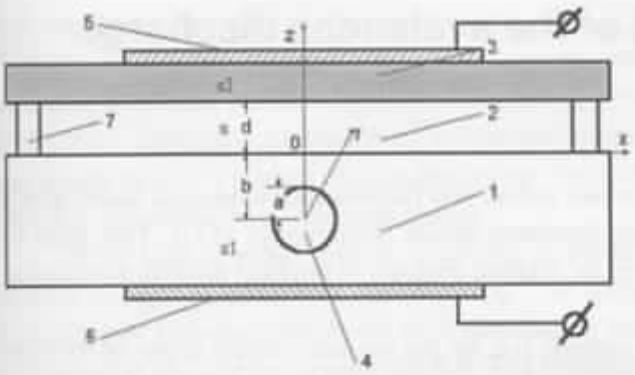

Fig. 9.6. Model for calculations: 1, 3 – dielectric; 2 – gap; 4 – defect; 5, 6 – electrode.

It also results from calculations analogous to those given above, that the disturbing influence of a spherical inclusion falls considerably quicker with the growth of the depth of occurrence in the dielectric in comparison with the cylindrical cover. This effect is confirmed experimentally.

These conditions are illustrated by the computer modelling (fig. 9.7) in compliance with the expressions (9.5), (9.6). As seen from the given curves, the presence of an inclusion with $\varepsilon_b < \varepsilon_i$ considerably weakens the field above the subject's surface, while under $\varepsilon_b > \varepsilon_i$ with the ε growth, the field goes up at first, but rapidly approaches saturation. With the increase of the depth of the defect occurrence, its influence goes down quickly and under $q = 4$ practically does not manifest itself in the example given (calculation parameters: $\varepsilon_b = 30$, $\varepsilon_i = 5$, $\lambda = 0$). Fig. 9.7 demonstrates electrical field spatial distribution (medium parameters: $\varepsilon_b = 30$, $\varepsilon_i = 5$, $q = 1$). The figure shows that under $\varepsilon_b > \varepsilon_i$, moving away from the defect projection point, the field quickly goes down to its initial value, passing through the minimum at the defect's edges. Such a field structure leads to the increase of image contrast in the process of GDV-gram formation at the expense of ring area emergence (in the zone $x/a = 2$) with the reduced value of electrical field.

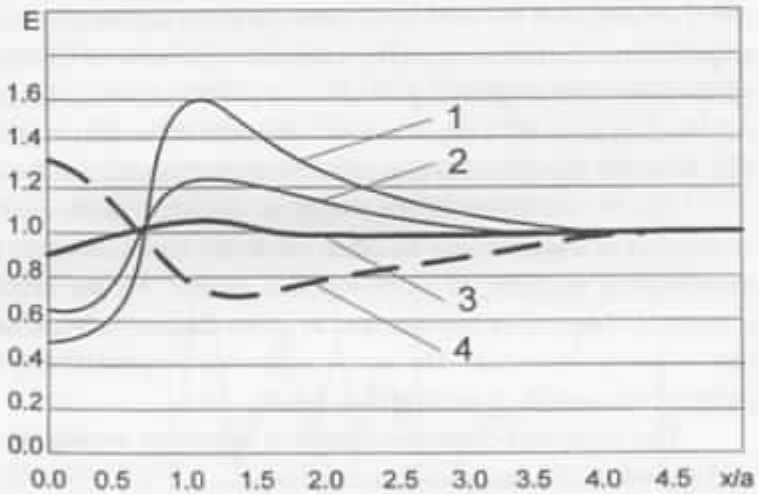

fig. 9.7. Computer modeling of the electrical field spatial distribution above the inclusion positioned at x/a=0:
1-3 – $\varepsilon_b > \varepsilon_i$; 4 – $\varepsilon_b < \varepsilon_i$; 1, 4 – q=1; 2 – q=2; 3 – q=4.

The calculations stated allow the character of electrical field distribution in the air gap to be determined, depending on the presence of heterogeneities on the surface or in the volume of the subject investigated. The presence of the magnetic field vector causes the electrons' trajectory curvature and the corresponding image distortion. The EMF distribution determines gas discharge development processes, which are given below.

Mathematical modeling of the avalanche discharge development process

The dependencies of discharge current pulses and fluorescence explained above give a good fit with the Townsend (avalanche) discharge model [Granovsky, 1971]. This good fit allows using the Townsend model for a more detailed analysis of physical processes according to the given GDV form.

The emission of electrons by the cathode (i.e. by the studied subject) is one of the most important factors influencing the development and parameters of the electron avalanches. Therefore, this cathode electron emission is a question of special attention in the literature devoted to the GDV physical processes. As rather high electrical field intensity is needed to receive the GDV images, a supposition was expressed by Adamenko [1975], that the autoelectronic emission (AEE) makes a decisive contribution to the formation of avalanches. More detailed research, however, demonstrated that although under high electrical field intensities the AEE is really observed, it does not play a determining role, because it is also possible to receive images using the avalanche GDV technique in the absence of the AEE. For example, smooth dielectric surfaces were particularly investigated: the microprojections on these surfaces did not exceed 0.3 mcm, i.e. the field amplification coefficient caused by roughness [Slivkov, 1972] was close to one. A uniform illumination from such subjects appeared under 10^4 V/cm, which is considerably lower than the AEE threshold equal to 10^6 V/cm. Thus, the AEE can influence the process of the GDV-grams formation, however this emission process is not a determining one for all the cases.

Specific conditions of the avalanche discharge under the GDV prevent experimental investigation of contributions by other electronic emission types to its development. Therefore, mathematical modeling of a development process for the avalanche discharge single act was performed. Analysis is implemented in a two-dimensional spatial approximation, as long as the task is axially symmetric. The z-axis is directed perpendicularly to the plane-parallel electrodes surfaces, the cathode is in z=0 point, anode – z=d.

The initial self-consistent system of equations, analogous to the one used in [Sahni, Lanza, Howard, 1978], includes four equations:

$$dn_e/dt + dn_eV_e/dz = \alpha n_eV_e + Dd^2n_e/dz^2 - \xi n_en_i\,, \tag{9.7}$$

$$dn_i/dt + dn_iV_i/dz = \alpha n_eV_e - \xi n_en_i\,, \tag{9.8}$$

$$dE/dz = e/\varepsilon_0(n_i - n_e)\,, \tag{9.9}$$

$$\sigma = e/d \int_0^t \int_0^d (n_eV_e + n_iV_i)dtdz\,, \tag{9.10}$$

where (9.7, 9.8) – equations of continuity for the electrons and ions, (9.9) – Puasson equation; (9.10) – equation describing the process of the discharges' accumulation on the dielectric surfaces of electrodes at the expense of electron and ion currents; n_e, n_i – concentrations of electrons

and ions (in the functions of z and t); $V_e(z,t) = V_{e0} + \mu_e E(z,t)$ – electron-drift velocity; $V_i(z,t) = m_i E(z,t)$ – ion-drift velocity; V_{e0}, μ_e, μ_i – constants, numerical values of which were selected according to the data [Granovsky, 1971; Mic, Kregs, 1960]; α, D, ξ – avalanche multiplication coefficients, diffusion and recombination, correspondingly, depending on the electrical field intensity E(z,t); $\sigma(z, t)$ – surface charge density on the dielectrics limiting the gap; ε_0 – absolute dielectric penetrability; e – electron charge.

In the case of metal cathode or anode, in the last equation, only one of the currents – electron or ion – is taken into consideration. The surface charge being accumulated at every time moment influences electrical field distribution between the dielectric layers and the gas gap, which is allowed for in equation 9.9. The boundary conditions of emission of charges by the subject's surface are determined from the equations:

$$\partial n_e/\partial t \,|\,(Z=0) = n_{e0} + \gamma_i n_i(0,t) + \gamma_F n_e(0,t) + \gamma_A E(0,t),$$

$$\partial n_i/\partial t \,|\,(Z=0) = 0.$$

where γ_i, γ_F, γ_A – coefficients of ion-electron emission (IEE), photo-electron emission (PEE) and auto-electron emission (AEE), correspondingly; n_{e0} – background particles concentration.

The analysis was carried out by way of computer numerical simulation according to the finite difference method using explicit path of control: the number of spatial mesh points (m) and time step were selected from the Kurant condition: $tu_e m / d<1$. Parameters for calculation: $m = 300-500$, $\tau = 10^{-10} - 10^{-11}$ sec., gas – nitrogen, $p = 760$ mm Hg, $d = 10^{-3}$, $\delta_1 = \delta_2 = 10^{-2}$ cm – dielectric layers' thicknesses on the cathode and anode, correspondingly; constant, lineally growing or bipolar impulse voltage (values of parameters characteristic of the GDV conditions). Results of analysis provided the time and spatial characteristics of electron and ion concentration, of electrical field intensity, and of current and surface charge densities, as well.

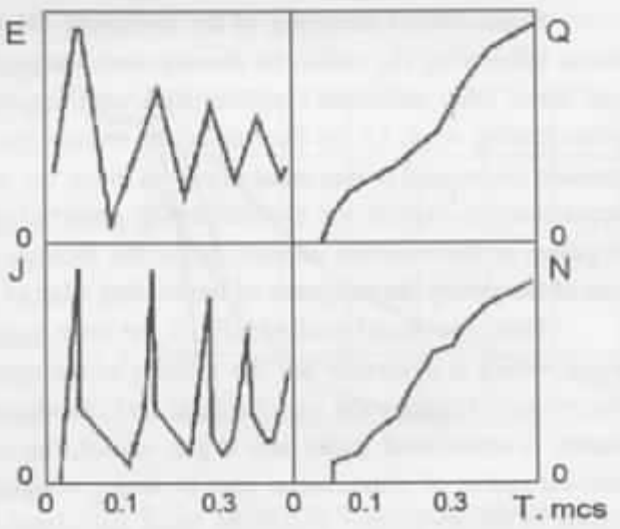

Fig. 9.8. Results of computer modeling.

Fig. 9.8 gives a family of time characteristics of the discharge process. As seen from the data obtained, having constant potential, applied to the electrodes, electrical field and system current have an impulse character, which is connected with the electrical charge accumulation on the dielectric surfaces. Time length of the current pulse on the half-height has 0.01 mcsec order, time of the whole process development makes up 0.5 mcsec order, with separate discharge pulses at 10^7 Hz frequency. Such qualitative estimations give good fit with the experimental data of oscillographic investigations.

IEE and PEE contributions to the development of the discharge were taken into account when the calculations were carried out, by way of variation of the corresponding emission coefficients under boundary conditions in the range from 0.1 to 0.001 [Dobrezov, Gomounova, 1978]. It turned out that the IEE effects the amplitude of the discharge current pulses only when gradual accumulation of positive volumetric charge is possible in the discharge gap, i.e. under quite a long sequence of bipolar cycles of external voltage. The PEE influence upon the discharge, stipulated by the radiation from the discharge avalanche, appeared to be more significant. The PEE coefficient's variation in the given range caused a pronounced change of both amplitude values and time conditions of the estimated characteristics (considering maintenance of their general form). Consequently, a conclusion might be drawn that under the avalanche GDV a determining role is played by the photoelectron emission, although other types of emission might be observed under certain conditions.

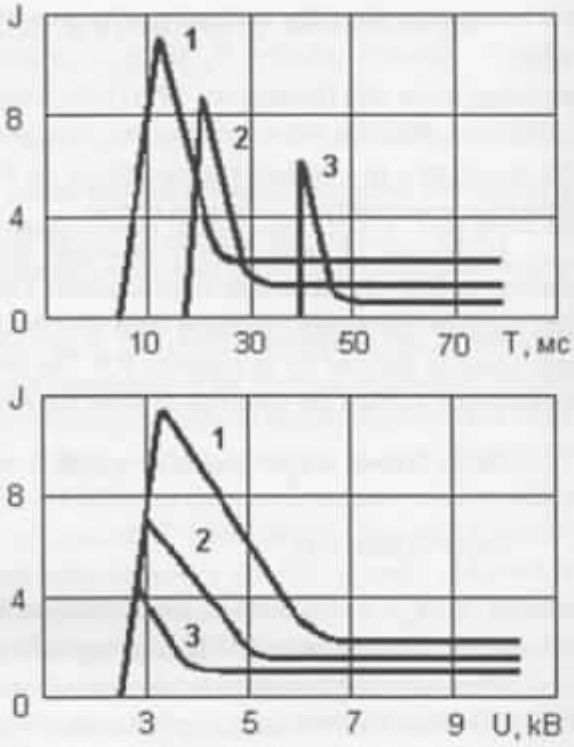

Fig. 9.9. Results of computer modeling.

Mathematical modeling of the avalanche discharge process revealed another important factor influencing the avalanche development: the amplitude of the avalanche discharge current, and hence other estimated characteristics, significantly depend on the steepness of the voltage pulse leading edge, i.e. on the rate of the voltage rise (fig. 9.9), whereas the ignition potential remains unchanged (rising areas of curves in fig. 9.9 lie on one line). This phenomenon gives an opportunity to explain the experimentally observed rise of amplitude of the discharge current impulses or fluorescence intensity under the increase of sinusoidal voltage frequency: with the rise of frequency the steepness of the leading edge of every voltage half-period goes up.

Thus, the model studied reflects the main aspects of the visualization process development, which is evidence for the validity of the notions developed. At the same time, some discrepancy between the experimental and calculation data was found. The experimental research revealed that under any d gap values, the average magnitude of an experimentally defined radius of illumination spot of single avalanche r, significantly exceeds the diffusive radius of the electronic avalanche head, calculated based on the Townsend model for the avalanche discharge single act development.

Measurements of GDV-grams of illumination of sensitive photo-material in the system of electrodes analogous to those given on fig. 9.6 has demonstrated the following. With d increase, size of decomposition single element r rises in accordance with the empirical depen-

dence r = Ad^k (fig. 9.10), where A and k are empirical coefficients; at the same time "tailing" is observed of the boundaries of decomposition elements (fig. 9.11). Under d > 600 mcm, photo-material illumination attains a "star-like" character. This phenomenon disappears after the photo-emulsion layer is covered with a transparent dielectric, which confirms the hypothesis on the photo-emulsion illumination in these areas directly at the expense of electrodes.

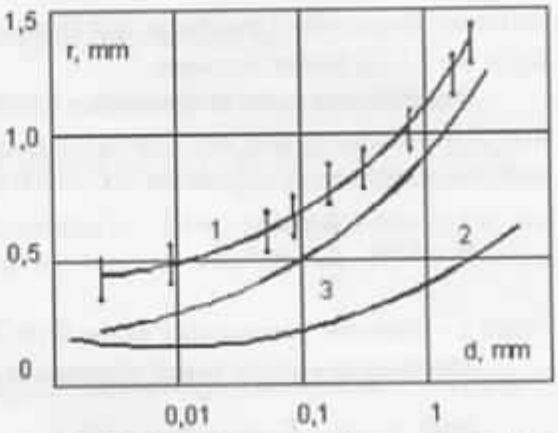

Fig. 9.10. Dependence of an image element on the air gap at atmospheric pressure: 1 – experimental data; 2 – computer modeling for a bell-shaped charge spot; 3 – same for gauss form of charge spot.

A supposition was proposed that this discrepancy is produced by the accumulation of negative charge on the dielectric surface of the image carrier. The charge spot creates a potential, additively summing up with the outer potential. A tangential component of electrical field arises near the dielectric surface, stimulating widening of the discharge avalanche head, because the energy of electrons in the avalanche does not surpass some tens of electron-volts and they are able to react to this field [Mic, Kregs, 1960]. To substantiate this hypothesis an estimated model was developed.

Analysis of the dielectric surface charge processes in the course of the GDV.

Let us study the interaction of a single avalanche discharge with the surface of an isotropic non-polar dielectric, d_1 thick, located on a metal electrode [Korotkov, 1985]. Let us assume that a positive potential, in regard to the second electrode, is applied to this electrode, i.e. study the charging of the image carrier surface by the discharge electron current. Let us analyze the electron bunch, bombarding the surface from the gas discharge. On the dielectric surface the electrons form a charge spot; the created potential additively sums up with the potential established by the external voltage. If the energy of the electron bunch is not large (for the avalanche electrons, energy does not exceed some tens of eV), they will deviate from a linear trajectory under the influence of $E_r(r,Z)$ field tangential component, rising with the increase of the dielectric thickness. This

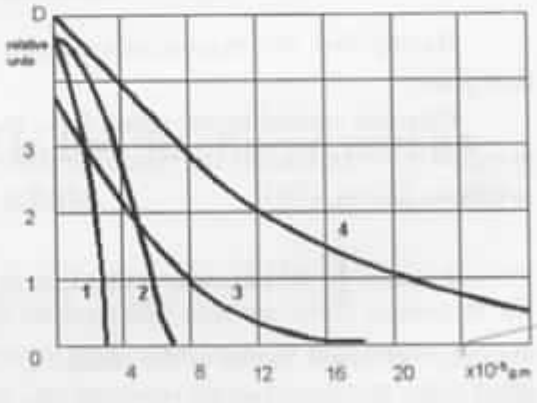

Fig. 9.11. Hystograms of image density along the radii of the discharge image for different air gaps. d: 1 – 0.1 mm; 2 – 0.3 mm; 3 – 0.5 mm; 4 – 1 mm.

will cause the growth of the charge spot diameter relative to the bunch diameter, and correspondingly, the $E_r(r,Z)$ further increases.

The electrons move to the surface with $v=\mu E$ drift speed, determined by the superposition of the discharge spot and external field (μ_e – electrons' mobility), having only a normal component, defined by expression 9.1, which might also be written as follows:

$$E_i = U/[\varepsilon_i \sum_{j=1}^{n} (d_j/\varepsilon_j)] . \qquad (9.11)$$

where ε – dielectric penetrability of the layer with d thickness.

The trajectory of the bunch electrons is determined by the system of equations:

$$\partial z/\partial t = -\mu_e (E_{2z}(t) - \partial\varphi_2(r,z)/\partial z) ,$$

$$\partial r/\partial t = -\mu_e E_r(r,z) = -\mu_e \partial\varphi_2(r,z)/\partial z . \qquad (9.12)$$

The first equation determines time t of the electron passing through the gap. Under the E_{2z} insignificant change with respect to the disruptive value in the discharge process (at the expense of both external voltage and spot field), t changes weakly, therefore this magnitude might be regarded as constant in the first approximation. At the same time, as shown by the experimental data, the time of a single discharge act development does not exceed 10^{-8} sec, i.e. it is comparable with the time of a single electron avalanche flow through the inter-electrode gap. Therefore, carrying out the analysis, it might be considered that the radial electrical field, conditioned by the charge spot, does not change within the time of the electron avalanche flow. In addition, as compared with (9.11), the value of deviation of the electron from the normal trajectory will be determined by this expression:

$$\int_0^{r_e} E_r^{-1}(r,z)\, dr = \mu_e t_e . \qquad (9.13)$$

Having Z=d, this expression evaluates the diameter of the charge spot on the anode in t time point.

Potential created by the round-form charge spot with a symmetrical charge distribution in regard to the axis, under the condition that $d>>r_0$, can be presented in cylindrical co-ordinates as follows [Zirlin, 1963].

$$\varphi_2(r,z) = \int_0^{\infty} \alpha f(\alpha) \exp(-\alpha z/r_0) J_0(\alpha r/r_0)\, d\alpha , \qquad (9.14)$$

where r_0 – effective radius of the charge; J_0 – Bessel function; f(a) – amplitude of decomposition of the dielectric surface potential into the Fourier-Bessel integral.

Solving the given expressions, taking into account literature data, we receive an analytical expression for r_e. For example, having bell-shaped charge distribution in the spot in the form $\sigma = \sigma_0 (1 + r^2/r_0^2)^{-3/2}$, we will receive the following equation after the integration from (9.14) having Z=d:

$$\varphi^*(r,z)=\sigma_0^* r_0^2(r_0 + z)/[r^2 + (r_0 + r_2)^2]^{3/2}*4\pi/\varepsilon_0\varepsilon_1 . \qquad (9.15)$$

For the Gaussian-shaped charge spot $s = s_0 \exp(-r/r_0)$ we will get:

$$\varphi^e(r,z) = 2\pi\sigma_0 \int J_0(kr/r_0) \exp(-k^2/4)[\mathrm{ch}(kz/r_0) - \mathrm{sh}(kz/r_0)/\mathrm{th}(k(d + d_1)/r_0)]Fdk;$$

$$F = [\varepsilon_1 \mathrm{ch}(kd/r_0)/\mathrm{th}(kd/r_0) - (\varepsilon_1 - 1)\mathrm{ch}(kd/r_0)/\mathrm{th}(k(d + d_1)/r_0) - \mathrm{sh}(kd_1/r_0)]^{-1}. \quad (9.16)$$

Having differentiated this expression with respect to r, let us substitute it into (9.14), and then, assuming that z = d and integrating, we will receive:

$$r_e^2 = [\,15\mu_e t_e \sigma_0 r_0^2 (r_0 + d)d_1/4\pi\varepsilon_0\varepsilon_1 + d^5]^{0.4} - d^2 .$$

$$\mu_e t_e = 2\pi\sigma_0 \int (\mathrm{ch}(k\,d/r_0) - \mathrm{sh}(k\,d/r_0)/\mathrm{th}(k(d + d_1)/r_0))^{-1} F^{-1} \exp(-k^2/4) r_0/k \int I_1(k\,r/r_0)\,dr\,dk. \quad (9.17)$$

The $r_e(d)$ dependencies built according to this formula are demonstrated by curves 2 and 3 in fig. 9.10 (under $r_0 = r_D$; $t_e = 10^{-9}$; $\sigma_0 = 10^{-3}$ Coul*cm^2; $\mu_e = 100$ cm^2/V*sec). As seen from the picture, by an order of magnitude r_e corresponds to the experimental data. For the Gaussian-shaped spot this correspondence is even better. This fact indicates that the spot being formed has a shape similar to the Gaussian shape. It is also worth considering that r_e characterizes the charge spot size in the t_e time point, with the experimental data – in the t_p time point, while $t_e < t_p$.

Thus, the obtained equations enable evaluating the size of the charge spot practically over the whole *d* range studied. As follows from the comparison of the calculated and experimental data, these estimations confirm the hypothesis on widening the charge bunch close to the surface under the influence of the tangential field component created by this spot.

The expressions obtained are also equitable for the case of interaction of ions with the dielectric surface. The ions' mobility is, however, approximately two orders smaller than that of the electrons, and the influence of the longitudinal electrical field only weakly tells upon the ions' movement. Because of the radiation diffusion in the gas, the size of the illumination spot might slightly exceed r_D, which is observed experimentally.

Calculation of thermal power in the discharge and its influence upon the subject's state

As demonstrated by experimental research on the GDV process, initial heating of the subject's surface takes place, under a long-term voltage application or under high frequencies, in the course of visualizing a model subject. Therefore, to choose an optimal impulse recurrence rate and to estimate the extent of the method's invasiveness, it is necessary to evaluate the energetics of thermal processes relating to the gas discharge development on the bio-subject's surface.

The thermal effect exerted by the discharge upon the investigated subject's surface can be estimated with regard to the processes in the discharge gas column. For calculating this magnitude, let us evaluate the power evolved per the discharge volume unit. The energy transferred in an electron-ion collision can be estimated as follows:

$$\Delta\varepsilon = 2^{m_e}/_{m_i} * m_e v_e^2/_2 , \tag{9.18}$$

where m_e, m_i — electron and ion mass, correspondingly; v_e — electron velocity.

The transferred power might be expressed as follows:

$$dP_{(v)} = 1/\tau_e * 2^{m_e}/_{m_i} * m_e v_e^2/_2 * dn(v), \tag{9.19}$$

where dn(v) — number of particles in [v, v + dv] interval; (it is implied that v – vector, dv = $dv_x dv_y dv_z$)

Presenting dn in the form , under the normalization condition

$$\int f_0 d\vec{V} = n_0 , \tag{9.20}$$

the following expression for the power might be obtained:

$$P = \int_0^{\infty} 1/\tau_e * 2^{m_e}/_{m_i} * m_e v_e^2/_2 * f_0 d\vec{V} . \tag{9.21}$$

To solve this integral, let us use ratios:

$d\vec{V} = 4\pi v^2 dv$, $f_0 = C * e^{-m_e v_e^2/2kT_e}$, — Maxwell function, whence:

$$\int_0^{\infty} f_0 d\vec{V} = 4\pi C \int_0^{\infty} v^2 * e^{-mv^2/2kT_e} dV = n_0;\ 4\pi C * 1/4 * \left(\pi/\alpha^3\right)^{1/2} = n_0 : \alpha = m/2kT_e ;$$

$$C\left(\pi^3 \left(2kT_e/m_e\right)^3\right)^{1/2} = n_0;\ C = n_0 \left(m_e/2\pi kT_e\right)^{3/2} ;$$

$$f_0 = n_0 \left(m_e/2\pi kT_e\right)^{3/2} * e^{-m_e v_e^2/2kT_e} , \tag{9.22}$$

here T_e — electrons' temperature.

Taking account of the received expressions, the expression for P might be rewritten:

$$P = \int_{-\infty}^{\infty} n_0 * v_{ex}/\lambda_e * m_e/m_i * m_e v_{ex}^2/2 * \left(m_e/2\pi kT_e\right)^{3/2} * e^{-m_e/2kT_e * \left(v_x^2 + v_y^2 + v_z^2\right)} dV_x dV_y dV_z \tag{9.23}$$

We will get the estimation for P, assuming that the electrical field is applied along the "x" coordinate and, accordingly, all the ionization goes in this direction. After a number of conversions we will receive:

$$P = n_0/\lambda_e * m_e^2/4m_i * \pi^{-3/2} * \left(m_e/2kT_e\right)^{-3/2} = 6^{n_0}/\lambda_e * \pi^{-3/2}/4m_i * \left(2m_e k^3 T_e^3\right)^{1/2} .$$

$$P = 6^{n_0}/\lambda_e m_i * \left(2m_e k^3 T_e^3/\pi\right)^{1/2} , \tag{9.24}$$

Let us take the following values of magnitudes, typical of a weak-current discharge:

$n_{0e} = 10^{16} m^{-3}; m_i = 10^{-27} kg; \delta = 10^{-19} m^2; E = 10^6 V/m$, therefore

$$n_0 n_i \delta / m_i = 10^{16} * 10^{25} * 10^{-19} / 10^{-27} = 10^{49} \ , \ (m_e k^3) \approx 10^{-50}.$$

The electron velocity is determined as:

$$v = \sqrt{2eE\lambda_e / m} = \sqrt{2eE / mn\delta} = \sqrt{1.6 * 10^{-19} * 10^6 / 10^{-30} * 10^{25} * 10^{-19}} = \sqrt{10^{11}} = 3 * 10^5 \, m/c,$$

$$kT = mv^2 = 10^{-30} * 9 * 10^{10} = 9 * 10^{-20} J \ , \quad T_e = 9 * 10^{-20} / 10^{23} = 9 * 10^3 K,$$

$$P = 0.25 * 10^{49} * 10^{-50} * T_e^{3/2} = 0.025 * (9 * 10^3)^{3/2} = 0.025 * 10^6 = 25 \, kW/m^3 = 25 * 10^3 \text{ w/cm}^3.$$

In case $n_{0e} = 10^{14} m^{-3}; T = 10^3 K$ $P = 25 * 10^{-6}$ w/cm^3 .

As seen from the discussion, even under the maximum values of the parameters, the power evolved in the discharge is not enough for any noticeable temperature influence upon the subject under a characteristic 10^{-5} sec influence time. However, the increase of these parameters by some orders makes the heat generation an important factor.

Liquid Structurization in the process of GDV

K. Korotkov, A. Korotkin

For understanding the process of obtaining information on the structure of liquids using GDV, the hypothesis was put forward that under the influence of an impulse electrical field with reversed polarity, micro-particles present in the liquid start precession movements, because of the polarization. These movements create spatial distribution of heterogeneity in liquid that may be registered by GDV.

Let us calculate this process for a cylinder of radii R, suspended in liquid at rest (fig.9.12). The amplitude of oscillations a<<R . It was demonstrated [Schlihting, 1974] that liquid tearing off from the surface happens only if the way passed by cylinder from the beginning of movement $S_0 \geq 0.351R$ (for ball $S_0 \geq 0.392R$). So, if

$$a \leq 0.35R \ , \qquad (1)$$

then there is no tearing off and pressure distribution follows the theory of an ideal liquid

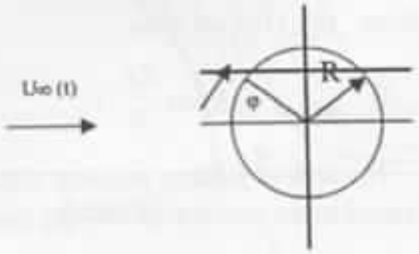

Fig. 9.12. Model for calculations.

and in every moment corresponds to the relative speed of the oncoming torrent. If the cylinder oscillates as

$$S = a \sin(nt), \tag{2}$$

then the instant speed of oncoming torrent follows the equation

$$U_\infty(t) = \frac{ds}{dt} = an \cos(nt), \tag{3}$$

and speed at the surface of the cylinder changes as [Schlihting, 1974]

$$U(x,t) = 2U_\infty(t)\sin\frac{x}{R} = 2an\cos(nt)\sin\frac{x}{R}, \tag{4}$$

where x is counted along the cylinder surface (fig.2.11)

Equation (4) may be written as follows

$$U(\varphi,t) = 2an\cos(nt)\sin\varphi, \tag{5}$$

where $\varphi = \frac{x}{R}$ – angular coordinate describing position at the surface of cylinder.

Pressure gradient at the surface of cylinder will be

$$-\frac{1}{\rho}\frac{\partial P}{\partial x} = \frac{\partial U}{\partial t} + U\frac{\partial U}{\partial x}, \tag{6}$$

where U(x,t) will be

$$-\frac{1}{\rho}\frac{\partial P}{\partial x} = -2an^2\sin(tn)\sin\frac{x}{R} + \frac{4a^2n^2}{R}\cos^2(nt)\cos\frac{x}{R}\sin\frac{x}{R} =$$
$$= -2an^2\sin(nt)\sin\frac{x}{R} + \frac{2a^2n^2}{R}\cos^2(nt)\sin\frac{2x}{R}. \tag{7}$$

From average of both parts (6) and (7) with integral by x we find

$$P_{0_\infty} - P_\infty = \frac{\rho a^2 n^2}{2}\left(1 - \cos\frac{2x}{R}\right). \tag{9}$$

Averaged pressure in the critical point x = 0, denoted in (9) as P_{0_∞}, depends on the average of speed pressure $\frac{1}{2}\rho U_{\infty=}{}^2(t)$, where $U_{\infty=}(t)$ is determined by (3):

$$P_{0_\infty} = \frac{1}{2}\rho U_{\infty=}{}^2(t) = \frac{\rho a^2 n^2}{4}. \tag{10}$$

So, from (9), (10) we have

$$P_\infty\frac{4}{\rho a^2 n^2} = 2\cos\frac{2x}{R} - 1. \tag{11}$$

The task of finding pressure distribution along the surface of an oscillating cylinder is equivalent to the problem of flowing liquid along vibration direction with a speed

$$V_0 = an\frac{1}{\sqrt{2}}. \tag{12}$$

However, the difference is that for an oscillating cylinder, particles of liquid at different sides of the cylinder move to the different directions, and in a case of flow, all particles move in the same direction. So the task may be formulated as calculation of the speed field from the given stationary distribution of pressure for the nearby round contour. At the surface of a contour, pressure is determined by (11).

We can find the solution by solving the Naïve-Stocks equation in cylindrical coordinates (r,φ) for stationary slow current (we neglect non-linear members in the left part) for the infinite round cylinder with boundary requirements at a cylinder surface

$$\mathbf{r = R:}\quad \mathbf{V_r = V_\varphi = 0} \tag{13}$$

$$\mathbf{r \to \infty:}\quad \mathbf{V_r = V_\varphi = 0} \tag{14}$$

Final equations will be as follows:

Round cylinder of radii R

$$\left.\begin{aligned} V_r(r,\varphi) &= \frac{1}{4} Sk\left(\frac{1}{r} - \frac{1}{r^3}\right)\cos 2\varphi \\ V_\varphi(r,\varphi) &= -\frac{1}{4r^3} Sk \cdot \sin 2\varphi \quad , \; r > 1 \end{aligned}\right\} \tag{15}$$

where $r = \frac{r}{R}$, $V_r = \frac{V_r}{an}$, $V_\varphi = \frac{V_\varphi}{an}$, $\mathrm{Sk} = \frac{Ran}{\nu}$, φ – central angle from the direction of vibration; r – dimensionless distance from cylinder center, divided to R. Parameter Sk is analogous to the Reynolds number, but together with (R) it includes viscosity (v), frequency (n) and amplitude (a).

Sphere of radii R

$$\left.\begin{aligned} V_r(r,\theta) &= \frac{9}{8}\frac{Sk}{r^2}\cos 2\theta \\ V_\theta(r,\theta) &= -\frac{243}{64}\frac{Sk}{r^5}\sin 2\theta \quad , \; r > 1 \end{aligned}\right\} \tag{16}$$

where θ — central angle from the angle of vibration; r – dimensionless distance from sphere center, divided to R.

Calculations presented above testify to the forming of stationary currents nearby the oscillating particles. Computer modeling based on these equations demonstrated liquid structurization found far away from the oscillating cylinder (fig. 9.13). The presence of several particles form an interferential field of currents, depending on the characteristics of the liquid and particles. The structure formed determines a quasi-momentary distribution of the electrical field in the volume and at the surface of a liquid, influencing parameters of the GDV-grams.

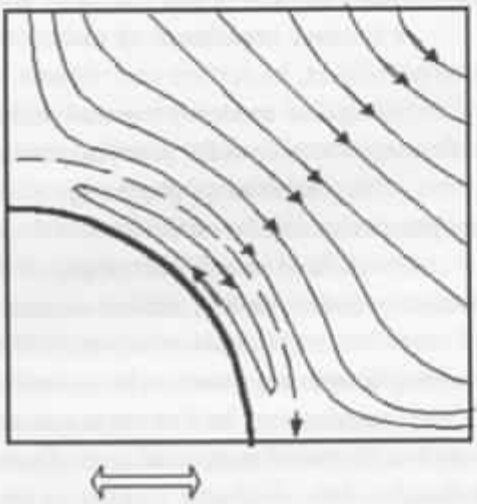

Fig. 9.13. Computer stimulation of the liquid curents nearby the oscillating particle.

These results create a conceptual basis for understanding results of GDV testing for different liquids. Natural biological liquids: blood, urine have some natural microparticles that polarize in an electric field, start oscillating and form an inhomogeneous structural distribution, influencing the GDV process. This is, of course, only one possible mechanism.

Main informative characteristics of subjects found with the GDV12 technique

Materials presented above demonstrate that under the GDV the information about the subject is transferred to an image produced by its influence on the discharge characteristics: intensity, duration, recurrence rate, and spatial distribution of separate avalanche acts, as well as spectral contents of radiation. The main informative characteristics of biological subjects are:

- Factors causing the change of electrical field in a discharge gap (for example, heterogeneity of structure of surface or volume). Under equal concentration of the initiating particles in the areas with maximal electrical field intensity, mostly avalanche discharges appear and develop more intensively as compared to the adjacent areas.
- Space or time heterogeneity of emission characteristics of subject's surface. Both intensity of discharge act (PEE, EEE, in certain conditions IEE and AEE) and discharge recurrence rate (EEE) depend on it. We should note that an important role should be played by electrones kept in surface traps of the upper zone levels.
- Space or time heterogeneity of self-gas emission (or evaporation) of subject's surface. It influences contents of gaseous medium in the gap and, correspondingly, intensity of discharge and spectral contents of radiation.
- Heterogeneity of subject's surface by electroconductivity or its change in time. Intensity of separate acts of the discharge and their recurrence rate depend on it.
- General impedance of electrical chain depending on electrical characteristics of the studied subject, its surface and volume; all other parameters remaining constant.

Analytical models presented in this chapter, together with experimental data, allow the following conclusions for practical realization of the GDV method:

- The character of physical processes within the network of a single discharge act does not practically depend on the form of the applied voltage, but is determined by the redistribution of electrical field in a discharge gap, owing to the accumulation of the surface charge on the boundary dielectrics and studied subject.
- The established notions on the necessity of using high-frequency sinusoidal voltage for forming images are shown to be inconsistent. The discharge might be initiated and, respectively, the images might be formed practically under any type of voltage: constant, sinusoidal, or impulse. Choice of an optimal type of voltage is mainly determined by the conditions of minimal influence of the discharge process on the studied subject.
- The application of a sequence of short voltage pulses appears to be optimal. Because the time for development of a discharge process requires only units of microseconds, duration

of voltage pulse T_U should be at least an order higher. Comparison of the GDV-grams received under various durations of pulses demonstrated that under T_U>15mcs and T_U<5mcs the quality of revealing metal inclusions in the dielectric on the GDV-grams worsens. In the given work the duration is 10 mcsec, which seems to be optimal from the viewpoint of revealing structural heterogeneities of bio-subjects.

- Mathematical analysis of thermal processes on the bio-subject's surface under the GDV shows that under a characteristic time of influence 10^{-5}sec even at maximal values of the applied parameters, the power emitted in the discharge turns out to be insufficient for some noticeable temperature influence on a bio-subject. This is evidence for an undisturbing character of the measurement process. At the same time, the exceeding of these parameters in some orders makes the emission of heat an important factor and might effect functioning of a bio-subject.
- Analysis of structurization of biological liquid under the GDV demonstrates that a stationary heterogeneous distribution of microparticles is formed in a studied volume of liquid. The main reason for this phenomenon is the initiation of a stationary heterogeneous pressure field near the oscillating body in a liquid at rest. The results obtained provide a conceptual basis for the substantiation of the experimentally observed peculiarities of gas discharge glow in the liquid-phase subjects. Liquids used for the research: natural water, blood, and urine have natural microinclusions, which are polarized in the applied electrical field and are the sources of the macro-heterogeneities discussed above. As a result of this process, the liquid from a homogenous state passes to the state of volumetrically heterogeneous dielectric, and notions discussed in this chapter, on the distortion of an electrical field above the surface of such a dielectric are applicable to it.

Investigation of channels of extracting information on the state of biological subjects in the GDV process

Characteristics of informational interaction of the biological subject with the channel of data processing

Any bio-subject is characterized by a great number of various subsystems with multiform and mobile connections and functions. This fact leads to a quantity of possible states. In modern medico-biological practice the state of a bio-subject is described by a great number of heterogenous parameters, each of which characterizes a certain channel of interaction of a bio-subject with its environment. However, these parameters describe the state of a bio-subject ambiguously, because the state of balance, i.e. an individual norm, is provided under various variables of determining parameters. What is more, many parameters are intercorrelated, and this correlation is, as a rule, non-linear. It is important to have an idea of the physical essence of these processes, leading to the formation of some one or another information channel and, consequently, some or other parameters.

Based on the analysis performed, it is possible to distinguish the main informational channels of a bio-subject's investigation in the GDV technique (fig. 9.14). These channels can be conditionally divided into two groups: self-, or spontaneous channels, and channels stimulated by an electromagnetic field. Changes of electro-conductivity or impedance of a subject as a

single whole or its separate parts, structural heterogeneity of volume or surface, gas emission or ultra-weak optical radiation – pertain to self-channels. Various kinds of electron emission, optical radiation and, in the case of liquid-phase subjects, structural heterogeneity induced by the small precession of macro-particles belong to stimulated channels.

These channels are distinguished on the basis of the theoretical analysis described above. Therefore, in the present chapter, we will discuss a set of model experiments, proving the validity of the statements put forward, and reflecting the quantitative sides of the visualization process.

Intrinsic electroconduction of a subject

For an estimation of the influence of volume electro-conductivity of a subject on the visualization process, a direct experiment was performed: gas discharge visualization of glow from salt solutions of various concentrations and electro-conductivity in distilled water. Detailed analysis of this data is given in part II. In fig. 9.15 a schematic graph of relative area of GDV-gram S against the logarithm of resistivity of the material is shown. Three main parts can be distinguished on the curve: AB and BC, where S ~ – ln p (with different inclination angles)

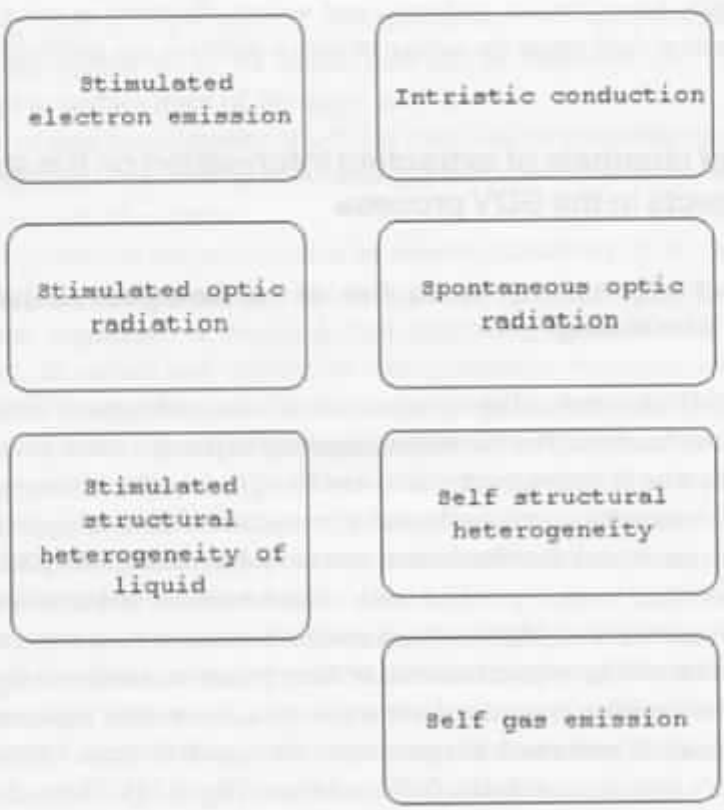

Fig. 9.14. Main informational processes of a biological subject in the GDV technique.

and DE where S – constant. This dependence can be expressed by an empirical ratio:

$$S = \begin{cases} 0, & \rho < \rho_0, \\ -C_1 \ln\rho, & \rho_0 < \rho < \rho_1, \\ -C_2 \ln\rho, & \rho_1 < \rho < \rho_n, \\ S_k, & \rho > \rho_n. \end{cases}$$

where ρ_0 – threshold of GDV-gram formation; ρ_1 – point of inflection, ρ_n – threshold of saturation; C_1, C_2 and S_k – constants. Threshold values and constants depend on the configuration of a benchmark subject.

Thus, the experimental data proved the given notions on the multi-phase character of the visualization process and the non-linear character for dependence of GDV-gram parameters on the volume electro-conductivity of a subject.

For the estimation of electro-conductivity of a subject's surface, a direct experiment with a benchmark subject was performed [Korotkov, Velichko, 1983]. Vanadium dioxide films, undergoing phasic transition: metal-semiconductor (PTMS) under the change of temperature, were selected as a benchmark subject.

The plan of this experiment is demonstrated in fig. 9.16. Vanadium dioxide film 2 is applied to ceralized plate 1, glued to a massive metal plate 3, into which heater 4 is put. Temperature is measured by thermocouple chromele-alumele 5. Calibrated dielectric spacer 6 provides optimal size of spark gap (about 300 mcm) between the surface of the investigated sample 2 and quartz plate 7, to the outer surface to which transparent conducting coating 8 is applied.

While applying voltage between electrodes 3 and 8, exceeding firing potential, avalanche gas discharge appears in the spark air gap. (A sinusoidal voltage with 400 Hz frequency and 1.2-2.1 kV amplitude was used in these experiments). The glow of this discharge is registered by a photomultiplier tube (PMT) 9. Vanadium dioxide film has electroconductivity jump (approximately in 15-20 times) under phase transition metal-semiconductor 17.5 K wide and temperature hysteresis. Characteristics of PTMS were determined according to temperature dependencies of both light reflection factor with the wave-length 0.63 mcm and electro-conductivity using a four-probe method. In fig. 9.17 the dependence of film resistivity VO_2 on temper-

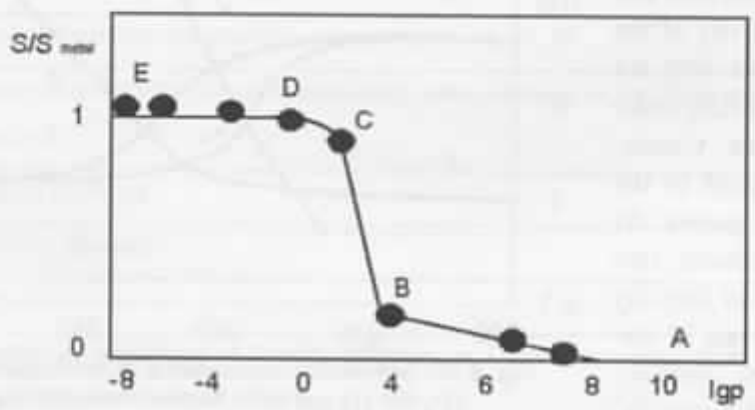

Fig. 9.15. Shematic dependence of the GDV area on relative conductivity of the material.

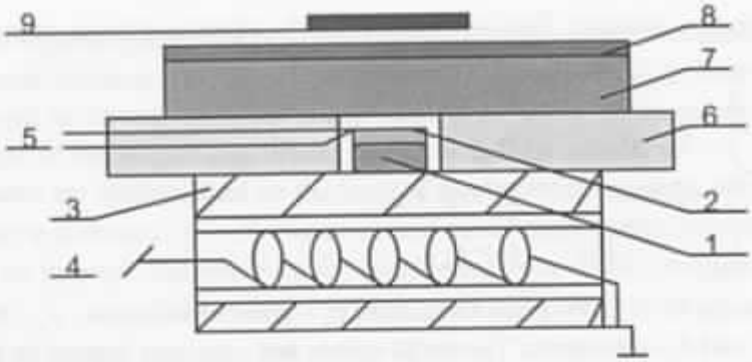

Fig. 9.16. Scheme of the experiment (see details in the text).

ature is shown by curve 1. The energy of activation for electro-conductivity in the semiconductor phase near transition is 0.23 eV.

By investigating three different samples of film VO_2 with the GDV technique, it was revealed that the phase transition is reproducibly found according to temperature dependencies of the glow intensity (curve 2 fig. 9.17). The temperature interval of PTMS for forward trace of the hysteresis loop is equal to 347.5±1.0 K. while for the reverse trace it is 327.5±5.0 K. These values have a good correlation with the data of direct measurements, although, according to the estimation in gas discharge, the area of PTMS is moved to higher temperatures. In control experiments carried out using cerimized plates without VO_2 layer, the value of PMT current in the range of 290-360 K practically did not depend on temperature. Changes of integral characteristics of glow were determined by the change of parameters of glow in every half-period of voltage: with the rise of temperature in the process of phase transition, amplitude, regularity and pulse-recurrence rate increased. This was strongly manifested in half-periods, when negative potential, relative to grounded electrode, was applied to electrode 8.

The observed change of characteristics of discharge under PTMS in the sample with surface limited by a discharge gap, is a direct experimental proof of the role of a subject's conductivity in the development of discharge.

In the discussed experiment, both surface and volume conductivity of the sample increases with the growth of temperature under phase transition. Consequently, the speed of the charge leakage grows. As demonstrated above, this leads to the rise of intensity and reccurence rate of discharge acts. The same result is produced by the in-

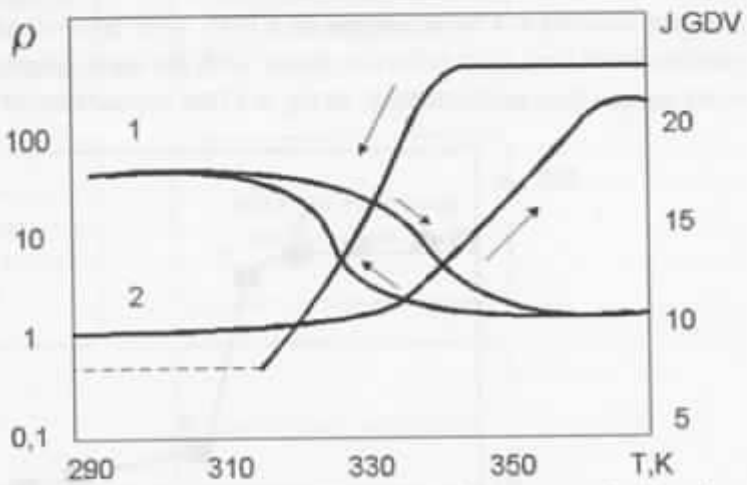

Fig. 9.17. Temperature dependence of electroconductivity of VO_2 film (1) and GDV fluorescence intensity (2). Hysteresis loop is defined by arrows.

crease of speed of diffusion of charges applied to the grounded electrode along the side surface of a ceramized plate with the rise of temperature.

A certain part might also be played by the redistribution of voltage between the gas gap and dielectric layers produced by a change in dielectric penetrability of one of the layers.

Structural heterogeneity of surface and volume

As shown above, the presence of structural or surface heterogeneities distorts the electrical field above a subject's surface, which can influence the distribution of discharge streamers. For experimental testing of this data a series of physical models was produced, which included specially selected heterogeneities-defects. The defects in dielectric were imitated by metal and dielectric threads 300, 200, 100, 30 mcm in diameter and balls 100 mcm in diameter, placed in the dielectric at different depths. The width of the dielectric layer above these defects varied in the number of layers of dielectric film 65 and 230 mcm thick, glued to one another. The glow was fixed on photo-film. After standardized processing (development and fixation), the photo-film was measured with a densitometer, which showed the curves of spacial distribution in the density of the image exposure (equal to the logarithm of the product of exposure time and the intensity of light falling on each point of the photo-film).

The data received [Ban'kovsky, et al, 1982; 1986, Korotkov, Hmirov, 1982] give an opportunity to estimate limit values of both a series of visualized parameters of the investigated subject (table 9.1) and characteristics of the received GDV-grams (table 9.2).

Table 9.1. Limit values of some parameters of subjects revealed with the GDV.

Parameter	*Value*
Minimal dimension of ledge on the metal surface, mcm	3
Minimal dimension of cavity on the metal surface, mcm	15-20
Minimal dimension of metal impurity in the dielectric at the depth of 100 mcm, mcm	10
Heterogeneity of dielectric penetrability of non-metal subject, %	10
Maximal occurrence depth (mm) of the visualized metal impurity in the dielectric (epoxy compound):	
Ball 100 mcm in diameter	2.5
Wire 100 mcm in diameter	4.1
Film 0.8 mcm thick	0.3
Threshold value of resistivity of liquid, differing in GDV parameters from distilled water, Ohm/m	$<10^7$

Table 9.2. Limit values of image parameters, obtainable with the GDV.

Parameter	*Value*
Contrast, %	40 - 100
Minimal size of picture dot, mm	0.05 - 0.1
Magnification degree	Up to 100

Moisture of subject

The presence of moisture both in the bio-subject's emission and in the atmospheric air influences the GDV processes, therefore this question is studied in detail in a series of works [Pehek et al, 1976; Zhevelev et al., 1998].

The processes of emission of electrons in the moist air under atmospheric pressure are investigated in the work [Chernov, 1975]. Emission currents were registered only in heterogeneous electrical fields near cathode, and their magnitude depended on the air moisture. It is significant that the presence of water molecules in the discharge produces not only the formation of a double electrical layer, but also causes both direct and reverse plasma chemical reactions (more than 200) in the discharge [Shustov, Protasevich, 1999; Protasevich, 1989; 1999]. In [Grigoriev, Protasevich, 1998] it is shown that the speeds of condensation (and then coagulation) of water vapor (and water drops) are determined by squared electrical field intensity. Evaporation of moisture from the surface of plants or human skin leads to the decrease of partial pressure of water vapor near the surface of the investigated subject. This causes distillation of moisture from the deeper lying layers to the surface, i.e. makes for the drainage of a subject's surface. Simultaneously, moisture evaporation causes additional cooling of the surface of the investigated subject.

Thus, both processes of moisture exchange of a biological subject's surface and volume processes, mainly caused by dissociation of water molecules in gaseous discharge, exert influence upon the character of a discharge. Moreover, decay products of water molecules also influence the magnitude of ignition potential.

Consequently, moisture turns out to be an important, however not the only informative feature of a subject. As shown in [Jerman, Berden, Ruzic, 1996; Opalinski, 1979] and proved by our experiments, placing a bio-subject (finger, plant) into a rubber covering leads to the decrease of intensity of GDV-gram, but does not influence topographic peculiarities of the distribution of streamers. This statement is proved by the results obtained with the application of evacuated cameras [Korotkov, Ban'kovsky, 1980; Korotkov et al. 1980].

The scheme of this experiment is given in fig. 9.18. A device, consisting of flat optical glasses 2, vacuum-compactly glued with a 1 mm gap, is placed onto the optical window of the GDV camera 1. Tube 3 serves for air exhaust and letting-to-gases. The size of gap was selected by way of quantitative comparison of contrast and brightness of GDV-gram for test-subjects with the gap varying from 0.55 to 1.5 mm. Gaps 0.8-1 mm were optimal. Gas pressure

was kept within the limits of 1000-2000 Pascal. Air, nitrogen, and argon were used. The discharge fully developed in a closed cavity 4, ignition potentials depended on the magnitude of pressure and sort of gas according to a Pashen curve.

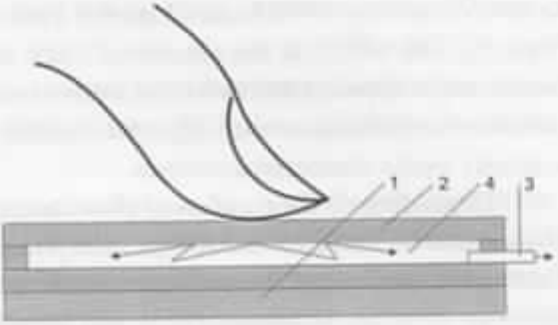

Fig. 9.18. Scheme of the experiment with evacuated chamber: 1 – lens of the GDV Camera; 2 – glass chamber; 3 – pumping tube; 4 – gap.

Use of the evacuated camera completely avoids physical contact of a bio-subject with the discharge area, and especially eliminates the influence of a subject's moisture and of the surrounding atmospheric air. The character of the GDV-gram does not change qualitatively with the evacuated camera (although image area grows), and all peculiarities of topographic heterogeneities of GDV-grams are kept. This result is a direct experimental proof of the minor role of a subject's moisture in the process of GDV image formation, although this factor should be considered as an informative feature.

Spontaneous and stimulated optical radiation in the visible and ultraviolet spectrum

To reveal the role of various components of optical radiation, a large series of tests were performed on experimental investigations of the glow spectrum from different subjects in the GDV process. Interest in this question was stimulated by many works on the Kirlian effect, where it was stated that on color photos of fluorescence a spectrum of colors was observed, naturally depending on the state of the investigated subject. Because of the short time of discharge development, investigation of this spectrum represented a complex technical task, using optical filters, spectrographs, and impulse spectrometers (fig. 9.19, 9.20). It was found that the spectrum of GDV discharge radiation in the air mainly occupied the area from 150 to 800 nm. The most active part of the spectrum mainly consisted of molecular bands of the second positive nitrogen system, as well as of CO, CO_2 and O_2, which were usually observed in low-power discharge in the air. Investigating microbiological subjects demonstrated that intensity of most lines of this area depended on the subject's state [Korotkov, 1998]. In the optical spectrum region, intensity of lines was considerably lower, their position and amplitude depended on the type of subject. Application of different types of spectral devices demonstrated that these lines were the subject's radiation, and not over-reflection.

Based on the measurements performed, a conclusion can be drawn on the significant role for optical radiation of a bio-subject in the visible and UV spectrum. Let us study these processes in more detail.

Some form of luminescence provides the basis of almost all types of radiation from organism tissues in the visible and UV spectrum (fig.9.21) [Kaznacheev, Mihailova, 1981;

Konev, Volotovsky, 1979; Konev, Liskova, 1965; Merill, Hippel, 1939; Ho, Popp, Warnke, 1994; Popp, Li, Gu, 1992]. In the process of GDV the luminescence induced by various physical factors might appear. Ultraviolet and visible rays cause photoluminescence, ionizing radiation stimulates radioluminescence, electrical current produces electroluminescence, and chemical reactions evoke chemoluminescence.

Depending on the duration of glow damping t, photoluminescence can be conditionally divided into fluorescence ($t \leq 10^{-8}$ sec) and phosphorescence ($t > 10^{-8}$ sec) [Ugrehelidze, 1976]. Fluorescent methods of research are used in ophthalmology [Krasnov, Simonova, 1971], stomatology [Mautin, Slutskaya, 1973], and oncology [Melnik, 1968]. The skin of an adult, exposed to UV light with the wave-length of 400 – 410 nm, fluoresces with red light. Fluorescent red points correspond to the openings of hair follicles [Podimov, 1982].

Ultraviolet radiation of tissues and cells of an organism lies in the area of wave-lengths of 190 – 340 nm. Its substrate are proteins, polipeptides, and carbohydrates. Intensity of UV fluorescence of tissues makes up from 10 – 700 photons per 1 cm^2 a second [A.A.Gurvich, 1968; A.A.Gurvich, 1974; 1944] to 800 – 1200 photons a second [Frank, 1982]. UV radiation is manifested in three main biological effects: cytopathic mirror effect [Kaznacheev, Mihailova, 1981,

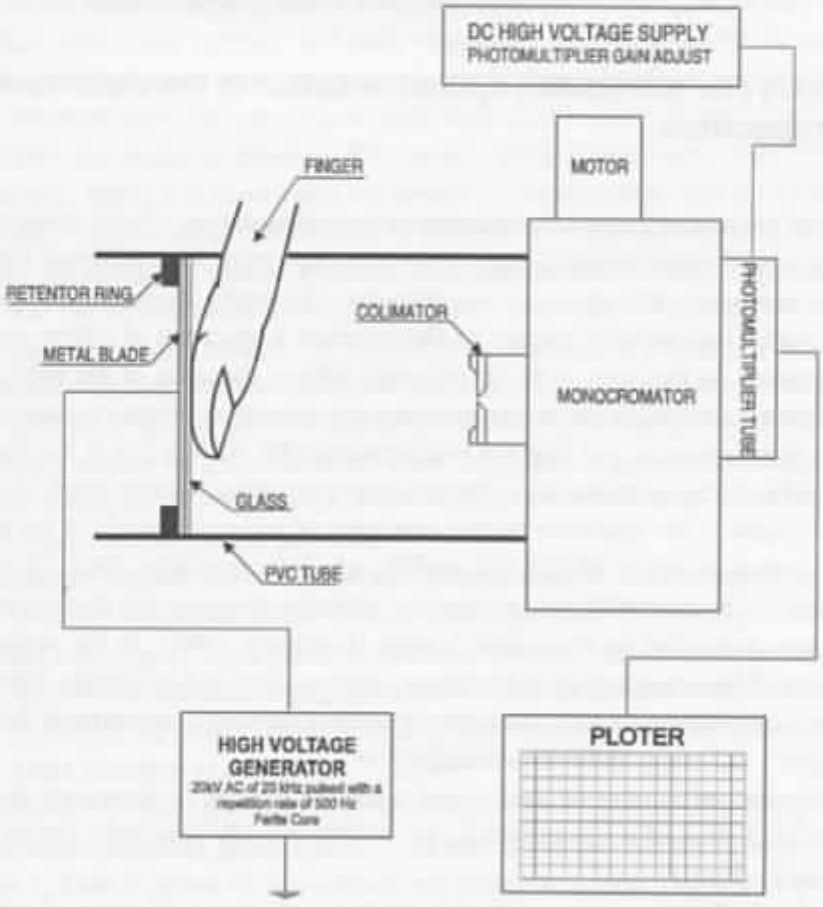

Fig. 9.19. Scheme of registration of the GDV optical spectra.

1985; Kaznacheev, Mihailova, Shurin, 1974; Kolotilov, Bakay, 1978], necrobiotic effect [Zhuravlev, 1974; Zhuravlev, Zhuravleva, 1975], and effect of stimulation of cellular division by endogene UV radiation [A.A.Gurvich, 1968; 1974; A.G.Gurvich, 1944]. It is considered that this radiation is a necessary condition of mitosis [A.A.Gurvich, 1968; Konev, 1965; Konev, Volotovsky, 1979; Konev, Liskova, 1965; Popp, Li, Gu, 1992].

As seen from the given material, under certain conditions ultra-weak fluorescence in the visible and UV areas might contribute to the GDV processes produced by photo-ionization and initiation of electron avalanches. To register the above-mentioned effects using GDV technique, samples of leaves of different plants with a cut side – the so-called "leaf phantom" were investigated [Korotkov, Kuznetzov, 1997; Korotkov, 1998]. A leaf (pine needle) was slightly cut by scissors or a leaf-tip 3-4 mm long was cut, after which the leaf was placed on the visualization electrode and voltage was applied. The fluorescence was observed on a computer screen. Picked and growing plants were investigated. The time of observing fluorescence made up from 2 to 60 seconds.

Gas discharge fluorescence of the whole leaf or needle represented a system of glowing points, located along the periphery of the leaf and in the area of main veins. As a rule, brightness of all fluorescence points was approximately the same. With the increase of electromagnetic field intensity the number of points of fluorescence rose, while having an insignificant growth of brightness.

The image looked different when a part of a needle or leaf was cut. For 3-5% of the investigated samples of needles this fluorescence received a character of glowing outburst, which length exceeded the length of the cut tip, i.e. made up 5-7 mm. This outburst appeared in about 0.3-0.5 sec after applying voltage and remained within the whole period of taking GDV-grams, i.e. up to 60 sec.

For leaves in about half of the cases, fluorescence points appeared along the cut side. The brightness of these points exceeded the brightness of "normal" fluorescence tenfold. They appeared in a few points along the section line of the leaf, regardless of whether a side of the leaf was slightly cut or a leaf-tip was cut. The dynamics of development of fluorescence looked as follows. Applying voltage within 0.3-0.5 sec there was no fluorescence observed. After that bright streamer channels 5-7 mm long appeared, being stable in certain points within 20-40 sec. Replacing a leaf by a metal plate of corresponding size enabled observing an analogous picture of bright streamers, however the streamers appeared immediately after applying voltage and existed stably at certain points during the whole time of exposure. The details of this experiment were discussed in [Korotkov, Kuznetzov, 1997; Korotkov, 1998].

To understand the observed effects, it is necessary to apply the results of the analysis made in this chapter. GDV fluorescence is determined by discharges appearing at the points with heightened intensity of the electrical field, which is stimulated by surface or volumetric heterogeneity of conducting subject, as well as by the area of emission activity of the subject or modified gaseous medium. Intact plant leaf is covered with a thick layer of epidermal cells and wax cover from the outside, and its inner structure represents a system of channels and cellular structures, filled with cytoplasm, sap, and galipot [Raven et al, 1986]. Thus, with quite a good approximation the leaf can be represented as a system of conducting structures, covered with a dielectric cover.

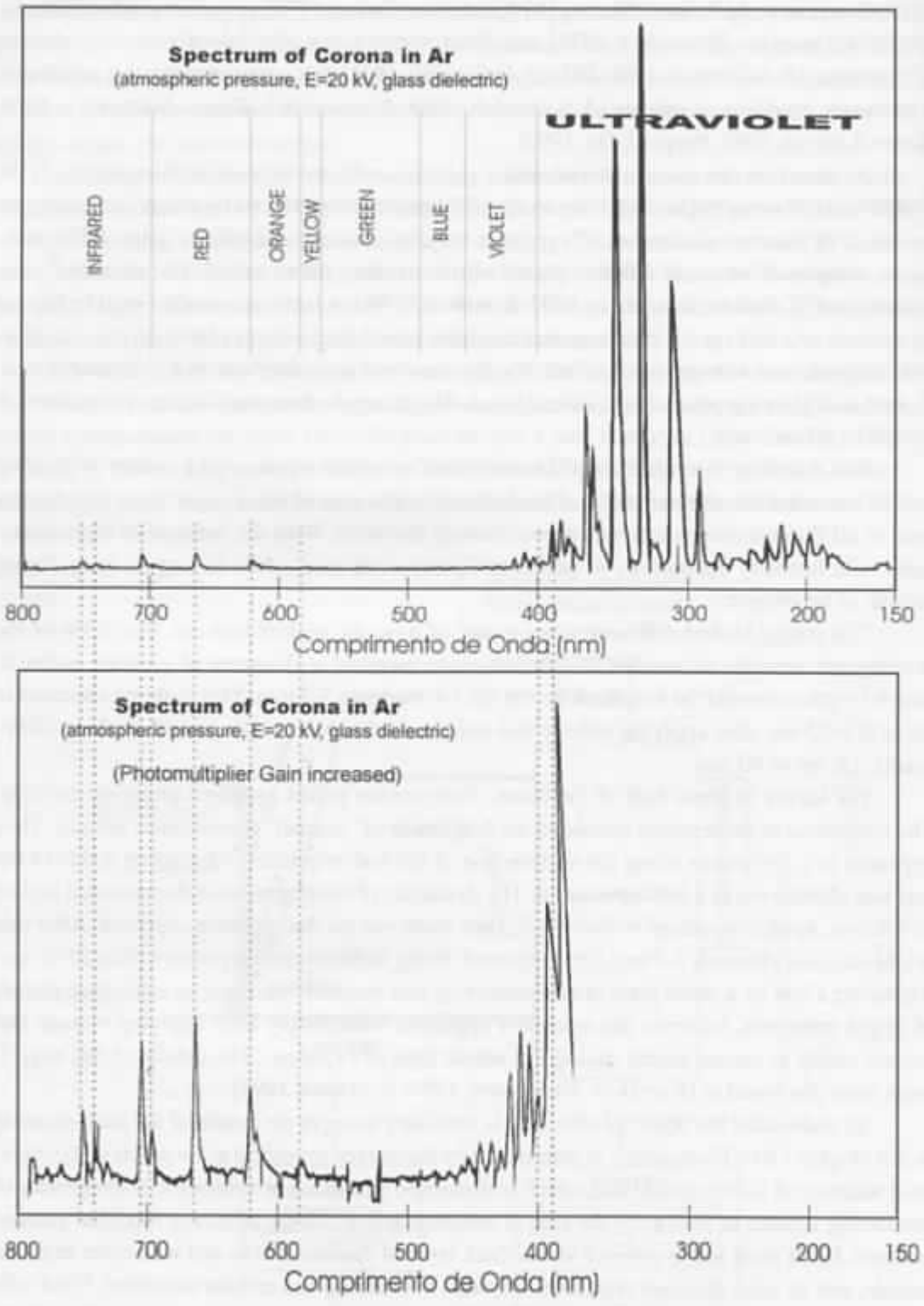

Fig. 9.20. Spectrum of the GVD glow of human finger in two different scales (data of W. Pickler, Brazil).

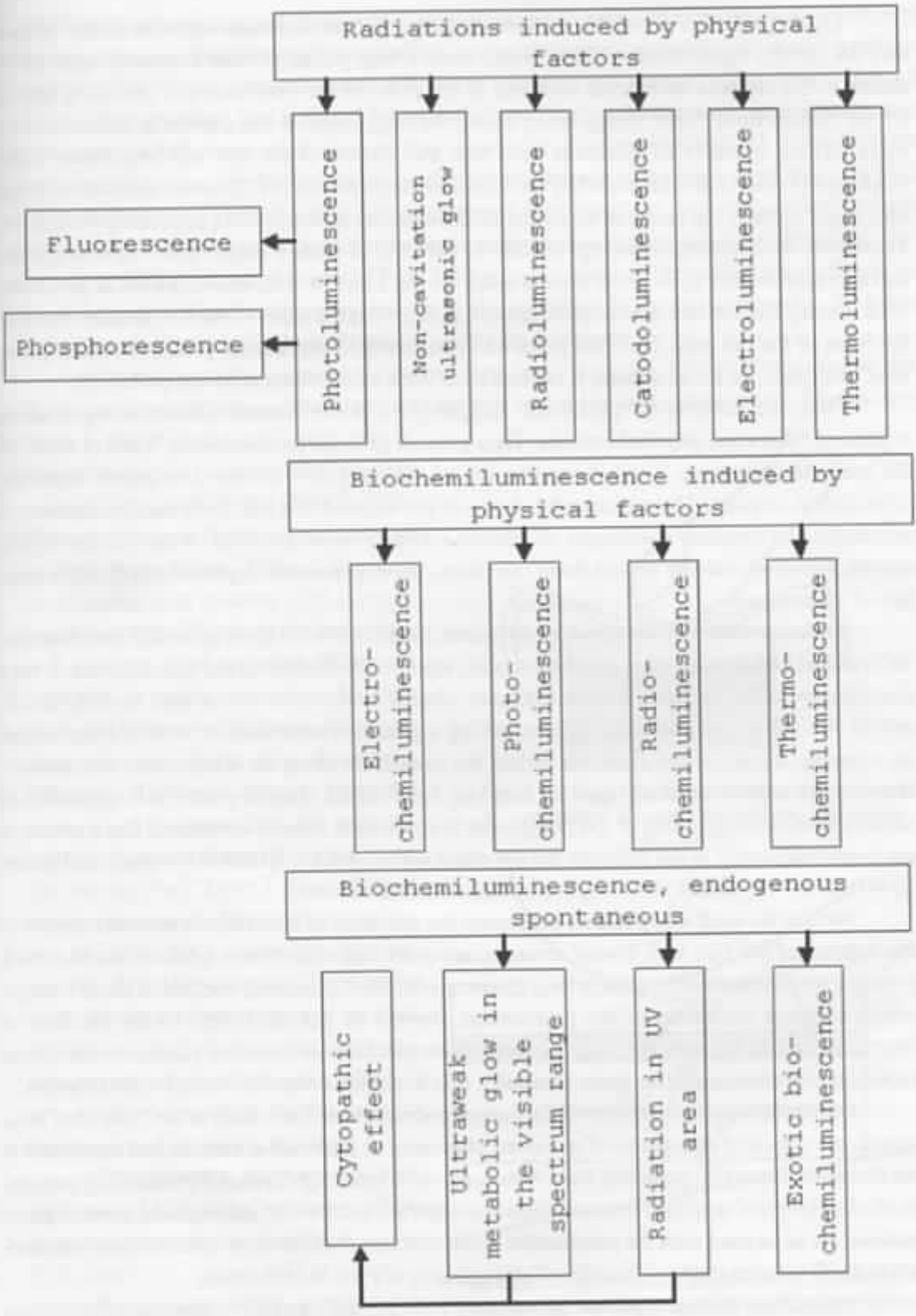

Fig. 9.21. Classification of glow from biological tissues in visible and UV spectral range.

Cutting a leaf or a needle, a series of damaged cells becomes apparent in the cut part and the cellular liquid exudes. Thus, within quite a long period of time a conducting structure shows in the cut part, connected with one of the poles of the generator and providing quite a strong current flow. Other things being equal, the magnitude of this current is defined by two main factors: intensity of electrical field near the surface of the leaf and impedance of the discharge chain. As demonstrated by the calculations [Slivkov, 1972], for a 1 micrometer ledge on a metal surface, the factor of electrical field multiplication is 10-100, depending on its form. Therefore, the discharge develops mainly in the area of such a ledge. This explains the observed experimental glow from the cut sides on the basis of well-known physical processes. With a sharp leaf-tip two discharge streamers, going from the sides of the cut, usually resemble the form of the cut part. This fact gives an opportunity to discuss the presence of the "phantom," although, as far as shown, it is associated with well-known physical processes.

Thus, the majority of "phantoms" images given in the literature and obtained by us are explained by normal physical reasons. They give no grounds to discuss the "field of form" of the leaf and "phantoms," and reconstruction of the cut part's contour is a purely topologic coincidence, stipulated by a successful choice of the location of a cut. Only the development of avalanche and streamer discharges of various intensity from the sides of the cut can be discussed. However, having solved these questions, the experiments implemented reveal a number of other issues.

As demonstrated by numerous experiments, the glow of a cut tip of grounded metal conductor in plastic isolation, all other parameters being equal, is localized near the side of the cut. It has a characteristic diffusive form, and no streamers, similar to the streamers of pine needles, are observed. We will see an analogous picture, putting a grounded metal subject without sharp ledges, for example, a coin on the electrode. Bright but even glow along the whole outer side appears. How can we explain the discharges 5-7 mm long from the cut sides of plants? It is impossible to explain them by evaporation of gas component from the leaf. Even if we assume that a stream of gas is emitted, owing to the diffusion the gas cloud will be quickly spread in the space, and during 20-40 sec we will be still observing formed fluorescence channels.

We put forward a hypothesis proposing the presence of a self active emission center in the volume of the live leaf. Under certain conditions, this radiation is quasi-coherent, which provides its distribution for quite a long distance with small damping, and lies in the UV range, which supports excitation of the pronounced channel of gas discharge. Under the flow of electrical current through the leaf, the generation mechanism becomes similar to the forced radiation of a semiconductor laser. Naturally, this hypothesis requires further substantiation.

One more important question: if the fluorescence spectrum lies mainly in the "light blue" area, what is the source of emergence of red areas, often used as informative features and mentioned in the literature? Naturally, particular lines in the long-wave area might appear if produced by processes of a bio-subjects' activity. However, there is a suspicion that most of red exposure areas on photo material are associated with the peculiarities of the structure of photo-film. This question was studied in detail in the example of Brazilian Kirlianography of Prof. N.Milhomens.

In Brazil the method of Kirlian photography is successfully applied by hundreds of physicians and practitioners. And all that is due to one person, Prof. Newton Milhomens, who created his own

unique approach and original diagnostic system. Prof. Milhomens takes pictures of fingers using color photographic film, processed in a standard way in commercial photolabs, and applying ordinary generator. The pictures obtained amaze with plenty of colors: red, orange, yellow, green, blue – all colors of the spectrum! And in Prof. Milhomens' system each color has a special diagnostic value [Milhomens, 1996]. From where does such an abundance of colors originate? As shown by instrumental investigations, the fluorescence spectrum mostly belongs to the blue – light blue area? Why these results are not proved by other Kirlian cameras? Detail study of Prof. Milhomens's standard, performed by us in his native land, gave an opportunity to answer these intriguing questions.

Fig. 9.22 displays the layout of Prof. Milhomens's camera. The patient places finger 1 on the photographic film 2 and presses, squeezing the soft layer 3. The operator pushes the button, applying voltage to electrode 4. Exposure makes up 4 seconds.

With the help of accurate experiments, Brazilian researcher Wilson Pickler found that a discharge appeared both on the finger surface and on the backside of the photo-film in the air cavity 5. Fig. 9.23 shows the structure of photo-film. Layer 1, sensitive to light blue radiation, is located on the outer surface. Discharge photons fall onto this layer and create a photo-image. Filter 2 prevents the penetration of photons with a wavelength less than 500 nm to the lower layer 3, creating a red exposure. When the photofilm is tightly pressed to the electrode of Milhomens's camera, all colors except for blue-light blue disappear. When the discharge appears from the back side of the photo-film, the photons, both direct and reflected from the plate, fall onto the "red" layer 3. Most of these photons are absorbed by antihalation layer 4, therefore for a visible red illumination significant exposures are required for 4 sec. Under smaller exposures red light disappears. And all this is obtained on a certain type of photofilm only, which is apparently determined by the ratio of thicknesses of emulsion layers.

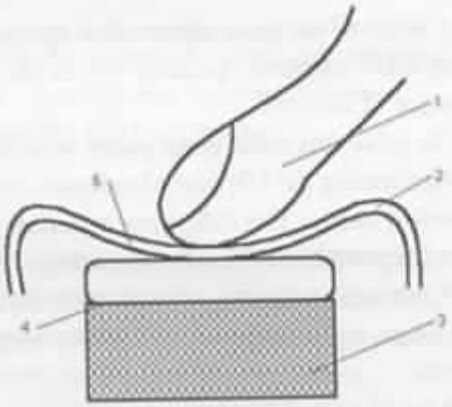

Fig. 9.22. Prof. Milhomens's camera: 1 – finger; 2 – photofilm; 3 – soft dielectric; 4 – electrode; 5 – air gap.

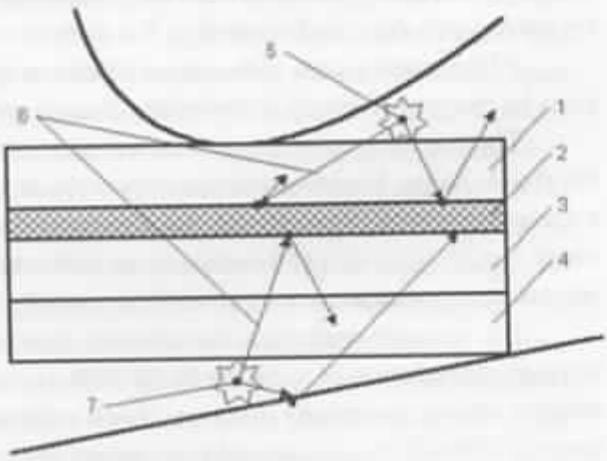

Fig.9.23. Structure of the photofilm: 1– blue layer; 2 – blue filter; 3 – red layer; 4 – cover; 5 – main discharge; 6 – photons; 7– secondary discharge.

Consequently, there are no "red" photons in Milhomens' camera – all exposure appears from the effects of the blue ones!

How do the colors correspond to the state of a patient? Electrons and ions

can not penetrate through the photofilm, thus only photons remain on the back side. It is obvious that the presence of the finger creates a specific distribution of the field near the surface, depending on the the finger's characteristics. In every point the intensity of discharge is determined by the magnitude of field and, consequently, depends on the parameters of finger's areas. Therefore, it is natural that the photofilm exposure is connected with the patient's state of health.

By way of long empirical research Prof. Milhomens revealed the correlation of colors and geometrical characteristics of images with the state of patients. The technique became wide spread and received certain clinical proofs in Brazil [Filho 1987, Coutinho 1989, Auri Silveira da Silva 1987].

Choosing most informative radiation spectrum for the extraction of information on bio-subject's state in the GDV process

Choice of the most informative spectral radiation range is one of the main questions for creating GDV systems, because this is an important moment in the construction of optical schematics of devices.

To solve this issue glass plates were placed on the GDV Camera's window with coverings transforming the UV part of radiation into visible or with the evacuated screen with coverings studied above. The following materials were used as coverings:

- Luminophor K73 – flow coating of water mixture, dried and sintered at T = 580 °C.
- Surface-avalanche multiplier (SAM) in the form of a regular net of discrete figures of special shape and orientation, formed by magneto-vacuum spraying of aluminium and photolithography.
- SAM with K73.
- Evacuated screen with the layer of television mica.
- Evacuated screen with the layer of magneto-soft ferrite (ferrite powder is mixed with the powder of easily-melted glass in the proportion 1:1, turpentine mixture is applied to the glass by watering, is dried and sintered at T = 590 °C.
- Evacuated screen with a layer of silicon (polisilicon 1 mcm thick is sprayed onto the glass by magneto-vacuum spraying of silicon target in the argon medium).

These coatings perform a transformation of radiation from the range of 250-400 nm into the visible range. For investigation of the influence of registration of various spectrum ranges, a comparison was implemented for parameters of GDV-grams of the test-subject, distilled water, NaCl 0.9% and 0.45% solutions, as well as biological liquids (urine of people of different age and sex), taken in various conditions.

The research performed demonstrates that introduction of various coatings leads to the increase of brightness of radiation by 10-17%, however the ratio between parameters of various subjects remains practically constant. This is evidence for the fact that the radiation in spectrum range of 250-400 nm, stipulated by the second positive system of the brain, does not carry information specific for the bio-subject. This conclusion is confirmed by the results of investigation of microbiological cultures, presented in the work [Korotkov, 1998]. Thus, common glass optics and standard television systems can be used for the creation of visualization systems.

Chapter 10. Biophysical approach

Biological subject as the object of electrographic research - Self gas emission of the subject - Methods and principles of extracting information from the biologic subject state using the GDV technique

Principles studied in the previous section describe peculiarities of the GDV process for non-organic subjects, and can be fully applied to organic systems. Yet, visualization of the latter demonstrates its own specific character. This GDV process can be studied in order of increasing complexity; hence, first to be explored is the analysis of medico-biologic converters.

A wide array of measuring and recording devices to examine the organism's state is in current use in modern medicine and biology. There is a wide expanse of existing methods and techniques for measuring the various medico-biological indices, as well as for recording and analyzing ongoing physiological processes in the organism. The results which represent the biologic subject's state obtained from this diagnostic evaluation are typically displayed as figures and diagrams. Visual images remain a very popular method for presenting the results in biological practice. When passing and reflected wave-fronts interact with the biologic subject, the resultant forms the elements of the inner biologic subject structure which is displayed on the monitor. Representative biological imaging devices using this principle include diagnostic radiography (x-ray), ultrasound, nuclear medicine imaging (radioisotopes), etc. Novel software manipulations allow for greater arrays of display presentations, analysis, and formatting of these images for critical assessment. Similarly, once the GDV technique collects its data, the resultant picture is processed and analyzed by computerized software manipulations for easy interpretation. Sophisticated software systems allow diverse processing of the medico-biological pictures, highlight informative elements in the picture for further analysis which makes the identification and further study of individual elements of the anatomic biologic subject structure possible.

A key feature inherent in all of these systems is their capability to identify and integrate the various elements of the biologic subject anatomic structure, as if they were virtually 'looking inside the organism'. However, the GDV technique does not provide direct visualization of

anatomic structures or their functions. The created image as generated is actually a biologic subject conform transformation, and is derived from the interaction between GDV and the biologic organism. This fact implies that existing methods for medico-biological image processing cannot be directly applied to the GDV technique, and a new approach sympathetic to the unique characteristics under study will be required.

Presentation and formatting of results for optimal interpretation depend upon the medical and biologic purposes sought through the GDV approach. Distinguishing the medical purpose (indication) for which the GDV technique is to be used is appropriate. These indications include:

- medical monitoring of the patient;
- health status evaluation;
- timely detection of pathological changes and conditions;
- prediction of future development of pathologic processes;
- identification of the organism's reaction to applied therapies;
- monitoring patient status during therapy;
- monitoring the state of rehabilitation achieved in the process towards recovery.

Each distinct indication thus requires a particular form for presenting results. Consequently, the general organism state can be rendered through a qualitative or quantitative format; pathologic changes often require detailed examination of the pathologic organ or system in question, such as examination of the thyroid gland or coronary vessels for dysfunction, etc.

There are additional difficulties connected with the biological subject examination. Biologic subjects are characterized by numerous parameters describing physiochemical properties of its internal environment and physical properties as it interacts with the external environment. In their whole, these parameters define a 'functional level' of the organism resulting from various physiologic systems with complicated interrelationships. Therefore, simultaneous estimation of the composite is the preferred representation.

Another aspect requiring close attention is the reliability of measurements, i.e. the metrological aspect of medico-biological research. Each measurement process utilizing its associated sensor can be characterized by its own defined methodical errors, and must be taken into account for completeness. The analysis of such methodological errors, their estimation as a component of the total systemwide uncertainty cannot be managed without precise knowledge about the biologic system's peculiarities. The nature and relevance of these errors which arise when the measuring converters are applied in diagnostics becomes of special importance to overall integrity.

The diagnostic settings depend upon the intent of the evaluation: overall biologic subject condition, or a particular functional ability. The organism's state or its functional ability is estimated by a 'functional level', given as a set of fundamental variables including physiologic processes or medico-biological indicators. The measuring converters capture information manifested by certain physical processes and variables of generating fields. The resultant output carries information on the subject state parameters through conversion into electrical signals. These signals are initially analyzed by different devices and create an authentic representation of the state - symptom complex.

To correlate with the diagnosis, the symptom complex is logically analyzed [Popechitelev, 1997]. The following requirements are established for the measuring converter and the diagnostic methods based upon it:

- proper selection of medico-biologic indices and method which achieve high information potential regarding the subject's state;
- straightforward subject and technical instrument preparation for proper measurement;
- user-friendly and readily available technical instruments to perform the investigation according to the designated technique;
- concordance between algorithms and computations of these medico-biological indices with the experimental data to create reliable interpretations of the results;
- flexibility of this system to combine with other methods (fusion of data).

The medico-biological exam can be adapted to an overview assessment of the whole organism, or it's constituent separate organs and functional system; moreover, analysis of the internal environment including its constituent biologic tissues, and externally through **biologic samples** and substances circulating or residing in the organism can be obtained. The GDV technique is used for investigation of practically all biologic subject classes. Therefore, special demands are made when particular applications are being worked out.

Biological subject as the object of electrographic research

At present numerous electrographic methods have been designed to address these needs. These methods enable investigators to carry out diagnostics, prediction and correction of the functional state of the human organism. This occurs through critical study of electrical activity of organs and tissues, and correlations between the electrophysiologic and clinical-anatomic characteristics has been established.

Among the most informative and widely used medical methods are *electroencephalography* (EEG) and *electrocardiography* (ECG), [Human Physiology, 1996], as well as electromyography (EMG), electrogastrography, electroaculography, etc. In modern reflexodiagnostics and reflexotherapy, the method of *electroacupuncture* (EAP), utilizing techniques of the conductivity of biologically active points (BAP) of the human body becomes more and more important. [Belhover et.al., 1986; Zubovsky, 1992].

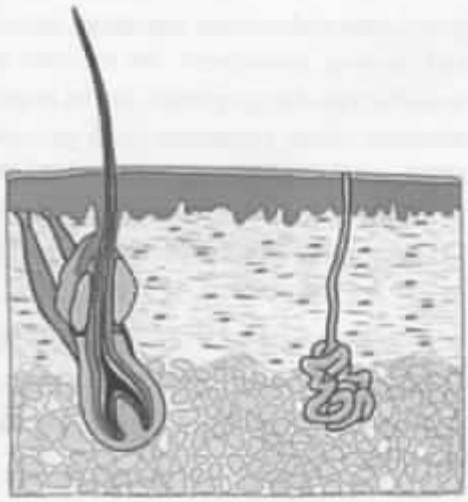

Fig. 10.1. Structure of the skin.

The GDV approach investigates a stimulated or induced organism reaction and, hence, it is close to the method of induced potentials [Human Physiology, 1996], to the Nakatani and Voll system [Velhover, 1986], and to Dr. Motoyama's technique [Motayama, 1999]. All these methods combine the following: a certain potential is applied to different places of the body and the current amplitude changes caused by the organism's reaction are traced. Due to the unique, highly specialized skin structures and their properties, these collected reactions can reflect aspects of the organism and are worth an in-depth evaluation.

Skin structure and its properties. Skin is a *multifunctional complex organ*, serving as a barrier between the environment and the inner organs (protection and exchange functions). Skin participates in water-saline, thermal and gas-exchange of the organism with the environment. It represents a three-component tissue system, formed by epidermis, dermis and subcutaneous fat, which taken together make up a morphological and functional unity (living, functional unit). (table 10.1, fig. 10.1)

Electrical characteristics of skin. Electrical conductivity and resistance measurements can characterize the skin's functional status and provide an opportunity to estimate the activity of both the central and peripheral nervous system. Impedance value depends on both the intensity of sweat and fat secretion, the concentration of mineral salts in the tissues and extracellular fluids and on the blood supply of the skin's vessels (the basis of the reography technique). *Hidrosis* is the principal factor determining the skin impedance. The more sweat, the less resistance; a dry horny layer is thus a good dielectric.

The resistance of dry, undamaged skin of a healthy person ranges up to 10^5 - 10^6 Ohm. Mainly horny and bright epidermis layers are characterized by high resistance to electric current. Their dielectric properties are determined by the two factors: lipid content and low humidity. The outer layer of epidermis is dry as a result of constant water evaporation. The point where a sharp decrease in electroresistance (nearly down to zero) takes place is situated on the outside surface of the skin's granular layer, dividing the epidermis into two key parts: the dry outer and the moist inner aspect.

An observed phenomenon is direct connection between sweating and the human emotional state and nervous regulation process [Human Physiology, 1996]. Together with emotional and nervous excitement, the increase of sweating activity of the glands influences the electroinductive skin properties and its impedance, which can be displayed by way of potentials and decrease ohmic resistance (skin-galvanic reflex, SGR). Being connected with emotions, this effect was also called psycho-galvanic reflex. SGR is widely used in clinical research as an indicator of objective disorders of emotional and nervous activity [Kozhevnikov, 1970; Samoylov, 1986]. A biophysical chain involved in the development of these reactions might be shown as follows [Motoyama, 1999]:

senses → cerebral cortex of the brain hemispheres → limbic system → autonomic nervous system (ANS) → sympathetic nerves → sympathetic nerves near sweat glands → depolarization of the sweat gland cells → increase of negative electrical potential

Such a reaction of the sympathetic nervous system is considered to be more systemic than local. It is opposed to the skin cells' reaction to mechanical stimulation or application of electric potential, followed by a local positive charge. This charge relates to moving ions through the

cellular membranes. Dr. Motoyama associates the arising ionic currents with the Chinese energetic meridians and based on this principle he gives proof to the concept of Qi energy.

Skin as an organ of sense. According to function, the skin receptors pertaining to the somatovisceral system are divided into mechano-, thermo-, hemo-receptors and nociceptors, i.e. pain receptors. The general feature of receptors of dermatovisceral systems is that they do not form sensory organs, but are spread over the entire body [Skin, 1982; Human Physiology, 1996]. Skin can be characterized by point sensitivity. It was calculated that on average 1 cm^2 of skin contains 2 warm, 12 cold, 25 tactile and 150 pain points [Velhover et. al., 1986].

Nervous receptors and fibers provide direct connection of skin not only with the nervous system, but also through the latter with inner organs, changes of which produce an effect on the skin condition (somatovisceral dermatome). A vital part of the change in skin reactivity is played by the overall nervous system status, since the brain and epidermis have common embryonic origin. A number of sources indicate the influence of the CNS upon the skin in the normal state. Many skin diseases can also be a reflection of psycho-physiologic pathology. Dermatoses, eczyma, hair growth and a variety of other nervous system dysregulation can be observed.

Therefore, the composite measured data reflecting vital activities of the tissues, organs and systems of the human body is projected on the skin. Skin responses reveal information which can be fixed and decoded by the various corresponding diagnostic devices including the GDV instrument. In particular, the most sensitive and reactive parts of the human skin are located on the palms and feet, where the skin and, *pro tanto*, its functions differ greatly from other parts of the body (table 10.1).

To best investigate the human psycho-physiologic state by the GDV technique a direct study of fingers and toes is typically made. In this regard, the gas discharge develops on the contacted border between the dielectric surface and the pad of the corresponding finger or toe (an analogue of the core test-object). In fact, in this setting the information derived from the actual human status is transferred indirectly via the extremity fingers or toes. The main informative characteristics of skin which influence discharge parameters may be distinguished by exploring the estimated coverlets (surface properties) of the fingers and toes as seen by the device (table 10.2).

Thus, to evaluate the influence of skin as an organ upon the GDV parameters, it is necessary to estimate the role of the following factors:

- structural heterogeneity of surface and volume;

Table 10.1. Characteristic features of human palm and foot skin structure [Michailova, 1970, Kotovsky, 1989].

Structure	*Palm, foot*	*Other parts of the body*
Epidermis (thickness), mm	> 1.5	0.03 – 1.5
Horny layer (bright layer), mcm	600	10-15
Desquamation (rejection of the horny scales), g/m^2/24 hours	3,5	0,1 – 2,1
Number of papillae in derma	Many (h < 0.2 mm)	Less
Subcutaneous fat development	Strong	Weak
Sweat-glands, cm^2	> 300	120-200
Oil glands	Absent	Present
Nerve endings, cm^2	To 300	100

Table 10.2. Main skin characteristics of fingers, influencing the GDV fluorescence results [Skin, 1982].

Function	*Parameter (biological)*	*Parameter (physical)*
The skin surface structure (epidermis)	Folds, burrows, wrinkles	Heterogeneity of the surface and inner layers
Desquamation (rejection of the horny scales)	Horny scales	Particles on the surface of the subject analyzed
Water-salt metabolism (sweating, perspiration)	a) moisture b) salts, metabolites, medicinal substances	a) moisture b) heterogeneity of chemical composition
Sweat and fat secretion	Electroconductivity	Electroconductivity
Sensory system (receptors)	Electroconductivity	Electroconductivity
Biologically active points (BAP)	Electroconductivity	Electroconductivity
Gas exchange	Carbon acid	Heterogeneity of gas evaporation

- surface and volumetric electroconductivity (taking into account BAP's chactacteristics);
- degree of moisture and surface pollution;
- gas composition of the environment over the surface;
- self gas emission of the subject.

Self gas emission of the subject

The main process of gas exchange achieved through the coverlet is CO_2 emission and O_2 absorption. Total gas exchange through the coverlets makes up 1-2% of the lungs gas exchange. The intensity of this process depends on the body part, external conditions, state of the person. Table 10.3 represents a series of data on the gas exchange indices. As demonstrated by this data, the structure of the gas medium near the person's skin depends considerably on the level of vital activity.

Table 10.3. Indices of coverlet gas exchange [Levshankov at al., 1983, Pilyugina, 1963].

Investigated subject	CO_2 emission, $cm^3 m^{-2} hour^{-1}$	O_2 absorption $cm^3 m^{-2} hour^{-1}$
Healthy person tongue	1470 + 36	No data
Healthy person lip	780	No data
Healthy person forehead	162 + 8,4	No data
Healthy person palm	40,2	No data
Healthy person average value	211	108
Heart disease patients (forehead skin)	101	61
Acute eczema patients	323	221
Toxicodermia patients	195	126
Dermatitis patients	205	165

Apart from CO_2 and O_2, volatile organic compounds produced by the skin contribute to perspiration and are worth bearing in mind. The spatial heterogeneity of the subject's gas emission thus makes a significant contribution to the spatial heterogeneity of GDV pictures and it's diagnostic capability.

Extracting information from the biologic subject by analyzing gas discharge signals

In the GDV process the subject under investigation is placed within the circuit of impulse or high-frequency electric current. Current closure takes place either by placing the electrodes upon the subject's surface, or by the volumetric connection of the subject with the ground pole of the voltage generator. The influence of the subject's complex impedance upon the flowing current becomes measurable, and reflects unique aspects of the skin appendage and by inference, the human body. In such cases, analysis of the electrical processes as applied to kirlianography is produced with the assistance of a wide range of models [Kozhakinov et. al., 1986; Romaniy and Cherny, 1991]. Characteristics of the flowing electrical current and its influence upon the processes of biologic subject's vital activity, as a function of the frequency range and power, can be studied. It can be shown that during the investigation of the contact between a human being or animal with the voltage source, short impulses or sinusoidal frequencies of more than hundreds of kilohertz produce currents which flow along the outer surface of the coverlet. They have no effect upon the inner organs and systems structure or function (the so-called skin effect), and these voltages are deemed safe for vital activity.

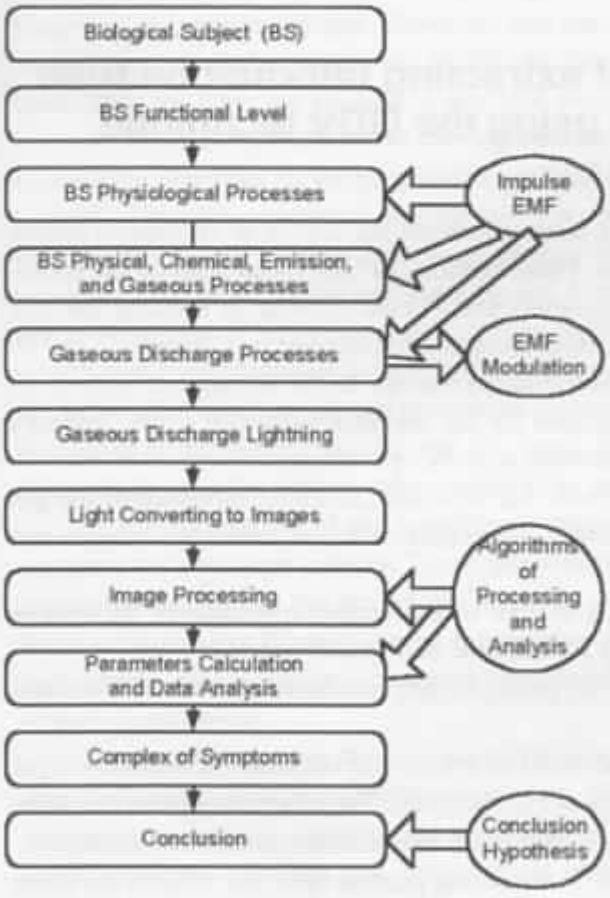

Fig. 10.2. Model of information transfer in the GDV technique.

In the GDV approach the EMF is considered a 'generating field' which causes biologic subject's response by modification of the gas discharge parameters and the generated optical radiation. In this way, the GDV mitigates the EMF and the biologic subject properties (fig. 10.2). The biologic subject condition can be characterized by its functional level and, from the GDV technique viewpoint, the de-

termining role is played by physiologic processes and medico-biological indices. Modification of these levels alters the initial GDV parameters by varying the following processes:

- biologic subject impedance;
- biologic subject surface parts impedance;
- biologic subject structural properties;
- biologic subject emission properties.

Variations of these processes manifest themselves actively on the biologic subject's outer coverlet (skin) at the expense of reflexogenous areas and biologically active points. Through variations in electromagnetic field due to emission or gas release, these processes influence the resultant gas discharge which modifies these parameters - current and optical radiation of the discharge. Analysis of the characteristics of the two-dimensional fractal probabilistic image results in a set of parameters being formed, which is the parametric description of the discharge radiation field. To create a diagnosis it is necessary to introduce hypotheses on the connection of the calculated parameters with the biologic subject properties. These contentions can be addressed on the basis of experimental data subject to generally recognized ideas.

Methods and principles of extracting information from the biologic subject state using the GDV technique

The above informative features of a subject indicate the choice of method to extract information on the biologic subject condition. These methods include visual observation, photoregistration, capturing of various glow parameters and electric current. In defining the best method for work with live biologic subjects, three main conditions must be fulfilled:

1. Maximum acquisition of specific information relevant to the investigated subject. In other words, creation of conditions and devices for the maximal influence of the subject's parameters upon the gas discharge characteristics must be optimized.

2. Non-invasiveness of the measurement, i.e. minimal disturbing influence of the gas discharge processes' electron-ion bombardment, ultraviolet radiation, molecular oxygen and ozone production.

3. Miscellaneous conditions including ease of measurement, ergonomy of the sensors and applied electrodes, and complete safety for both the patient and operator.

Taking these conditions into account, the principles and possibilities of the GDV method may be formulated as follows:

1. To realize a GDV image, the method must involve contact whereby it is necessary to put the subject under investigation into a high-intensity electrical field. The subject becomes a part of the electric circuit; consequently, when a discharge takes place an electrical current flows through it.

2. To describe the influence of the GDV measuring process upon the subject, the effect exerted upon the biologic subject must be lowered. This can be achieved by reducing the time for making the measurement and decreasing the flowing current assessed. Taking into consideration the first condition, it is optimal to use a single short voltage impulse.

The duration of this impulse is determined by the subject's characteristic response time, i.e. the speed of the processes transferring information about the subject. Theoretical considerations estimate that this time amounts to microsecond units, and have been acknowledged through experimental models. As an investigated subject, microbiological cultures were used (the results of their investigation are stated in the work [Gudakova et. al., 1988, 1990]). Applying single microsecond impulses the luminescence characteristics were connected with the culture vital activity process. Using nanosecond impulses no connection of such kind was observed; the luminescence was almost the same for all the cultures. Consequently, from the viewpoint of informativeness, it is optimal to apply voltage impulses of micro- and milli-second duration. GDV generators make use of a 10 mcsec impulse. In some cases it is advisable to use a single impulse. However, for the visualization of human fingers it turns out to be more 'informative' to apply a burst containing 10 impulses passing with the frequency of 1000 Hz.

3. As demonstrated previously, the general character of these particular physical processes does not change regardless of the voltage applied. Both low-frequency sinusoidal, impulse or high-frequency voltages can be applied. 100 kHz frequencies correspond to a microsecond duration of a single mode. So, comparable results can be achieved after either high-frequency or impulse voltages. However, one can exploit a pulse burst to increase the reproducibility of results by employing digital circuits which control the quantity of impulses per burst. Thus the latter are favored in practical use.

4. Two factors limit current flowing through the subject: a) insertion of dielectric layers between the electrodes for the measuring circuit and the biologic subject; b) limitation imposed by controlling the output current of the generator. The reduction in intensity parameters, i.e. amplitude and time of influence, usually leads to an increase in the signal's informativeness. When general principles are applied, results can be anticipated. For low discharge intensity, a subject's contribution to the process of its initiation appears to be considerable and demonstrated by the characteristic of fluorescence; however, in high discharge intensity, the key role is played by gaseous processes. At the same time, using small parameters typical of the initial discharge stage is inconvenient because of its stochastic character and, *pro tanto*, little reproducibility of results. Therefore, it is necessary to enter the field of stable discharge by not reaching intensive stages.

5. Consideration of the conditions mentioned makes the process of GDV totally harmless for a biologic subject. Test experiments carried out with plants and also with such a sensitive subject as the sea-urchin's sperm, have shown the maintenance of activity of these subjects after 20 consecutive expositions. At the same time, if one puts an alive plant leaf into the discharge area for a long time period (15-30 minutes), the oppression of vital activity is observed.

6. As obvious from the analysis of physics of the visualization process, the method of spatial characteristics' registration is important, but not the only one. Measurement of both the luminescence integral intensity and the discharge current comes out to be informative. These are proportional quantities and, hence, usage of one or another is determined by the concrete conditions of the experiment.

7. It is necessity to follow the subject's state changes in an uninterrupted fashion during a predetermined time interval. The method of discrete shooting of the GDV signal where a

measuring pulse is being applied for a certain timeframe is preferred. The following sequence of measurement is thus chosen for use: a) measuring the pulse duration amounts to 10 microseconds; b) applying 1000 Hz frequency pulse burst to the subject within a second, creating a general effect of 10 milliseconds.

The subjects' relaxation time after the measurement should exceed it no less than an order of magnitude. For the theoretical situation being described, this would be 100 milliseconds. It is obvious that if we increase this period to one second, the measuring process effect will become even less. In this way, it is preferable to investigate processes who's typical time change be no less than one second. In experiments, this parameter was changing in a wide range: 15 seconds when monitoring psychophysical state of an operator, 30 seconds when studying the processes of plant leaf respiration, 10 minutes when observing the dynamics of gas discharge fluorescence of a sportsman in the process of training, and 60 minutes when following the microbiological culture development.

Factors which can contribute nonfavorably to a subject measurement include physical parameters directly linked to gas discharge. This primarily is due to ultraviolet radiation and charged particles, especially ozone. They are good in small quantities, but in large, vice versa. This recognition supports an application of ultra-short voltage impulses, as suggested by the GDV technique. Comparison of the exposure obtained by an operator using various voltages can be made, as in the following scenario:

Let the operator work 6 hours, receiving 6 patients an hour, i.e. he turns on high voltage 36 times during the workday. The typical parameters in the technique proposed by us are: 10 mcsec impulse duration, 1000 Hz impulse flowing frequency, 0.5 sec time of one photography session. Thus the general time of discharge existence totals 10*1000*0.5 sec = 5 millisec, or during the whole workday, 180 millisec, i.e. 0.18 sec. As one can see, this time period is extremely small, and the UV irradiation dose is much less than the ambient air standard. In addition, during the gas discharge, one must recall that ozone is generated in the air which in low concentrations is healthy for the individual; it can, therefore, provoke negative reactions in high amounts. The operator working with the GDV equipment has to aerate the room periodically. This is a standard requirement for physiotherapy rooms.

Fortunately, as an added safety feature, the GDV device has a forced lock-out of the circuit if the ozone concentration exceeds a certain level; after a predetermined time of a few minutes sufficient for the ozone to dissipate satisfactorily, the lock-out is lifted and the equipment is functional.

It is important to note that clinical tests have indicated that the complex of influencing factors inherent in the GDV technique can become beneficiary to the human organism. This realization has results in the GDV technique being applied as a therapeutic method, producing a positive informational influence on the patient's state. This GDV correction is being introduced into the public practice, and is an area under active investigation with its full capability yet to be defined.

Chapter 11. Mind-Body Connections

Right-left analysis – The puzzle of the left-hander – The sexual brain – Is there any difference in Male and Female BEO-grams?

A problem which has puzzled Humanity since ancient times is the interrelation between the psyche and the body, or soma. There is no absolute concordance of opinion in psychology concerning which phenomena are psychic ones, and which are somatic, and even concerning the interpretation of the notion soma.

The problem which worries the Humanity since ancient times is the interrelation between the psyche and the body, or soma. The mind-body connection has been a source of inquiry since ancient times. There is no absolute concordance of opinion in psychology concerning the fact which phenomena pertain to the psychic ones, and which to the somatic, and even concerning the interpretation of the notion soma.

As mentioned in the work by Shostak and Litaev [1999], in a strictly correct sense according to the modern normative anatomic publications, the soma (from "soma" in Greek) is the body or trunk and represents a totality of all cells of the organism except for the reproductive ones, i.e. head, neck, trunk, tail, and the extremities. Thus, from the physiological point of view functions performed by these organs pertain to somatic functions. From the viewpoint of an orthodox physiologist, even the psyche as a function of the brain (head) corresponds to the somatic functions, as well.

However, much more often when we speak about functions of the human organism, we divide them into psychic and somatic functions. The latter, in its turn, into muscular-skeletal system and autonomic nervous system. By the former we usually mean the work of support-locomotion system (skeletal muscle, joints, ligaments, and bones) in order to maintain the body position and its movement in space. When we speak about autonomic nervous system, as a rule, we mean functions regulated by its sympathetic, parasympathetic, and metasympathetic sections. These are functions connected with the activity of the inner organs (or visceral systems), particularly, of the smooth muscle system found in them, as well as of the inner and outer

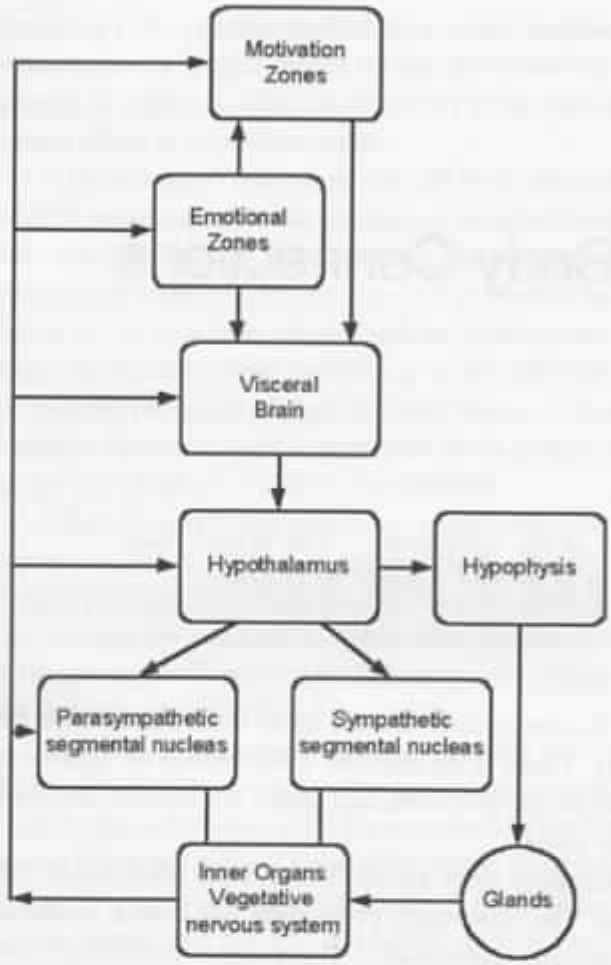

Fig. 11.1. Principles of mind-body connections (after [Shostak, Litaev, 1999]).

secretion glands, related to maintenance of stability of the organism interior medium, and, finally, to implementation of adaptation-trophic adaptive influences on all tissues of our body.

It follows from this that both from morphologic and functional viewpoints the human organism represents a single whole, consisting of the psyche, the somatosensory nervous system motorics, and the autonomic nervous system vegetatics, constantly interacting with one another. Interruption of this interaction leads to disorders of the organism activity, and at times, death.

From the standpoint of organism vital activity the final effect might show up through any of these three components: and namely **somaticmotor, autonomicvegetative, and psychic functions.** However, analyzing the mechanisms of each of these components, we should never forget their interrelation and interaction.

In general psychovisceral interaction (psychovegetatics) is schematically represented in fig. 11.1. As follows from this scheme, in a healthy organism the state and activity of the inner organs directly depends on the psychic sphere. The most important issue for our discussion is the volitional effects on the autonomic functions. This is realized not only according to the mechanisms of unconditional and conditional reflexes, but according to direct influences of the motivational-emotional sphere, implemented through the autonomic vegetative nervous system and the system of endocrine inner secretion glands, as well as through other biologically active substances: *prostaglandins, kinins, biogen amins, zitomedans*, etc.

Under usual conditions only a few of visceral functions, and not to the full degree, may be voluntary regulated. These are, for example, breathing, accommodation of eyes, miction, and defecation. However, human experience indicates that many other functions might be controlled voluntarily after special training. This problem is being intensively investigated, although the theoretical background is not yet formed in full. One of the most significant components in developing such an ability by a human is the actualization of feedback. Either by means of training of the corresponding channels of the human's interceptive analyzer, or by using special technical devices (visual, acoustic, tactile signals) the human finds a method of volun-

tary influence on the intensiveness of metabolism, hemodynamics, thermal condition, and other functions. Today this principle is already applied in medical practice. We are referring to biofeedback and first of all to the work of Elmer and Alyce Green.

Through activity of the inner organs, the state of the organism inner medium exerts a pronounced influence on the psychic processes, using mechanisms such as follows.

Firstly, deviation of parameters of the organism inner medium from the physiological norm brings forth the corresponding needs, formation of motives, and prompts behavioral activities adequate to them, including those effecting forms of deviant behavior.

Secondly, the same reasons launch mechanisms of both positive and negative emotions.

Thirdly, the condition of the inner organs exerts pronounced influence on the psyche, both through afferent nerve signals and through the production of biologically active psychotropic substances, such as neuropeptides. This is even mentioned in a number of proverbs: "A full stomach is deaf to learning", "The way to a husband's heart is through his stomach", and many others similar to these.

Fourthly, visceral systems, homeostatic vegetative functions maintain properfunctional states of the brain structures, directly connected with the psychic activity, on a proper level Thus, these effects provide evidence of natural, indissoluble connections, a mutual conditionality of the psyche, the somatic systems, and the autonomic systems vegetatics. When this interaction is out of balance, pathological states (psychosomatic diseases) are inevitable to occur. On the other hand, from the times of empirical medicine this interaction is used for a purposeful influence on each of these types of vital activity. Therefore so enduring were the words of a Roman poet Juvenal: "Mens sana in corpore sano" - a sound mind in a sound body.

Activities of the right and left brain hemispheres, referred to as bilateral connections with the opposite parts of the body, determine the specificity of psychophysiological activity of any particular human in many respects. Hands are significantly represented in sensorimotor brain spheres (fig. 11.2 [Carter, 1998]). Fig. 11.3 demonstrates how a human would look, if the

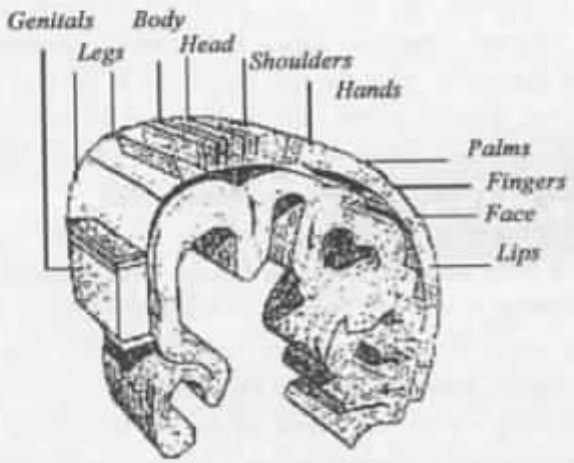

Fig.11.2. Sensor areas of the brain.

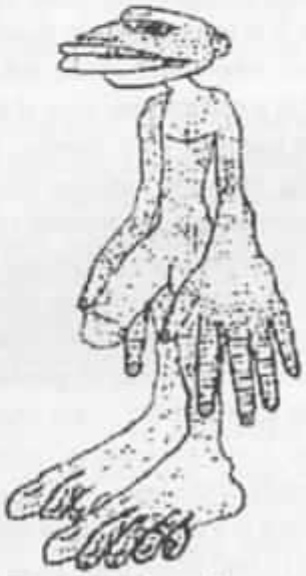

Fig. 11.3. "Sensor homunculus".

size of the body organs was proportional to the sphere of their representation in the brain. The brain receives a large quantity of information from the hands and fingers, much larger than from the other organs. Therefore, in accordance with the systems principles of brain functioning, the hands represent information, distributed in the brain, i.e. information on functioning of all the body systems and organs. Along with the concept of energy meridians, this is one of the explanations why it is possible to obtain data on functioning of all the organism systems through the fingers of the hands. And a large part of this data is connected with the specific character of functioning of the brain itself, in particular, of its two hemispheres.

Right-left analysis

The human brain is a marriage of two minds. Each of its twin hemispheres is a physical mirror of the other, and if one hemisphere is lost early in life, the other may take over and fulfill the functions of both. Normally, though, the two are bound together by a band of fiber that conveys a continuous intimate dialogue between them. Information arriving in one half is almost instantly available to the other via the corpus callosum, and their responses are so closely harmonized that it produces an apparently seamless perception of the world and a single stream of consciousness. At the same time, each half of a mature brain has its own strengths and weakness, its own way of processing information and its own special skills [Unestahl, 1996; Carter R. 1998].

The left brain is analytical, logical, precise, calculating, communicative, time-sensitive, and capable of conceiving and executing complicated plans.

The right brain is a dreamer, it processes information in a holistic way rather than breaking it into parts and it is more involved in sensory perception and abstract cognition.

There is truth, too, in the idea that the right brain is more emotional than the left. In particular, it is responsible for fearful and mournful feelings and for general pessimism. This is why people who suffer severe left-brain strokes quite commonly behave as though what has happened is a catastrophe, even if the disabilities they suffer as a result are relatively mild. Patients with bad right-brain damage, by contrast, sometimes appear to be entirely unmoved by it, maintaining an overly sanguine attitude optimistic, what-the-hell sanguinity in the face of what would otherwise be quite dreadful suffering. Sometimes this sublime disregard for their condition is taken to such extremes that people with right-hemisphere injuries fail to notice frankly disabling conditions like paralysis or even blindness – a condition known as ***anosognosia***.

Despite the irrepressible cheerfulness of an unopposed left brain it takes the combination of both hemispheres to produce a fully rounded sense of humor. The combination of right-brain alert and left-brain cheerfulness is still not enough to make something funny – humor also needs meaning in order to work. Meaning emerges from the pulling together of all the threads of the joke, including context, assumptions, and knowledge of our own prejudices. Humor is a diffuse, fuzzy sort of thing – a matter of taste, often, and something you do not expect to find in even the most sophisticated computer unless it has been programmed in by a human. In this it is typical of the type of functions that engage both hemispheres.

Finding your way around in space, for example, is very much a right-brain activity. Face recognition does not require thought – again, like all right-brain activity, it just happens. The right hemisphere is also good in grasping wholes, while the left brain likes detail. The tasks that each hemisphere takes on are those that fit its style of working: holistic (right brain) or analytical (left brain). For example, right-brain strengths include the ability to make out camouflaged images against a complex background and to see patterns at a glance. The left, by contrast, is good at breaking down complicated patterns into their component parts.

You see that we can really attribute to the right brain a more feminine role: emotional, gentle, pessimistic, and intuitive; while to the left brain a more masculine: logical, analytical, controlling and optimistic to the level of craziness. To use another simile: overall the two sides of the brain are like an old married couple who long ago fell into doing things according to a 'his 'n' hers' division of labor. The partner that can communicate takes the dominant role, speaking and acting, most of the time, for both and doing much of the day-to-day business of thinking, calculating, and dealing with the outside world. The other stays largely in the back ground, quietly doing its moment-by-moment chores and constantly using its singular talents to sniff and taste the social environment for signs of anything that may be a threat or a benefit. They keep each other perfectly informed of what is going on in their own spheres through a continuous, intimate conversation. So natural to them is this pattern of working that they can carry out the most complex tasks together in a perfectly integrated way.

Most of the time the marriage of our two brains is completely harmonious. Conscious decisions, although they may seem to be made by the dominant partner alone, are in fact fully informed by the findings of both hemispheres. Sometimes, though, the conversation between them falters. The dominant hemisphere may ignore the information supplied by its partner and make a decision based purely on what it thinks. The result may be an emotional disquiet that is difficult to explain. Conversely, the non-dominant partner sometimes bypasses the executive control of the other side and triggers an action based purely on instinct. These are the sort of things we look back on (usually with embarrassment) and say: "I didn't mean to do it – I just couldn't hear myself." Quite often these are the intuitive actions that enable a human to survive and make a decision in a complex situation.

Not understanding a feeling does not stop us from acting on it. Much human behavior is based on right-brain hunches. We see millions of things happening around us from minute to minute and only a tiny percentage of them is consciously registered. The rest enter the brain fleetingly as momentary blips of energy, leaving no impression. Some of them are probably just noticeable enough to create a momentary emotional response in the right brain, but not significant enough to create conscious awareness in the left. Such half-seen stimuli may account for the odd, uncalled-for flicker of irritation or the little cloud of inexplicable melancholy that most people experience from time to time.

Not that we like to admit this. The idea that our actions may be irrational is peculiarly unacceptable to the left hemisphere. A series of experiments showed that people hardly ever admit to making arbitrary decisions. In one of the experiments, for example, a selection of nylon stockings was laid out and a group of women were invited to choose a pair. When they were asked why they had made their particular choice all the women were able to give detailed and

sensible reasons, citing slight differences in color, texture or quality. In fact, all the stockings were identical – the women's 'reasons' for choosing them were actually rationalizations constructed to explain an essentially inexplicable piece of behavior.

These ideas should be considered when analyzing BEO-grams. The asymmetry becomes apparently clear from BEO-grams distributed in two rows after printing or studying Preview in "GDV Printing Box," the same as from GDV Diagrams. Prevalent activity of BEO-grams of one of the hands is reflective of the opposite hemisphere activity, which influences first of all the psychological state. Very often we see difference in intensity and area of BEO-grams of the left and right hands, and all the features mentioned above may be applied for describing a patient's condition.

So we should remember the main rule:

Right Hand – Left Brain, Left Hand – Right Brain.

At the same time, physiological functioning of the pared organs in most cases has direct representation. That means, left lung is presented at the left little finger, and right lung – at the right one; left kidney at the left middle finger, and so on.

Intense asymmetry is observed quite rarely, and it is often a sign of a pathological condition. These cases should be treated very carefully.

Symmetry of the observed defects on the right and left hand fingers is a significant diagnostic characteristic. Physical problems exist on the physiological level when they are presented at both hands in corresponding sectors. A defect at only one of the fingers is mainly associated -with functional psychophysical redistribution of energy.

Intense asymmetry is observed quite rarely, and it is often a sign of a pathological condition. These cases should be treated very carefully.

The puzzle of the left-hander

More than 90 per cent of people in the world are right-handed. It has been the same throughout the history of man - studies of tools used since the Stone Age, pictures drawn by ancient man on cave walls and analysis of the fractures on baboons' heads presumed to have been made by human hunters all show that the vast majority of people have used their right hands in preference to their left for skilled single-handed tasks. Right-handedness is strongly associated with the left-brain dominance. But what of the 5 to 8 per cent of people who use their left hands? Are they cerebral mirror-images of the norm? Not quite, is the answer. Whereas 95 per cent of right-handers have language firmly lodged only in their left hemispheres, left-handed people vary much more in the way their brains are organized. About 70 per cent of them have language in the left hemisphere only. Of the other 30 per cent, most of them seem to have language in both hemispheres.

Is left-handiness pathological? Culturally, it has always been treated as such and almost every language has some derogatory term derived from the word for left. 'Gauche' - French

for left - is used in English to mean awkward, and 'Amancino' in Italian means deceitful as well as left. The Bible offers one of the most striking indictments: in Matthew's vision of the Judgement it states that God will set the sheep on the right, the goats on the left, and then dispatch the former to life eternal while consigning the latter to everlasting fire. Most of the tools of our world are constructed for right-handed people.

Not surprisingly, given this authoritative prejudice, parents of left-handed children often went to great lengths to encourage their offspring to use their right hands. The fact that many succeeded — and now appear to be right-handed despite having cerebral arrangements that predispose them otherwise — has confounded subsequent research on the subject. For example, in Russia from old times it was common to teach children to be right-handed.

Handedness is well established by the time a baby is born – in fact, the first signs of it can be seen at just fifteen weeks' gestation when most babies start to show a distinct preference for sucking their right thumbs. The current consensus about left-handedness is that some of it is simply genetically determined and of no particular significance, while in others it is because of some pre- or perinatal disturbance that arrests the normal development of left-brain/right-hand dominance. It might be something like mild brain injury, which affects left hemisphere growth at a crucial time; or it might result from the failure of neuronal apoptosis, or of some neurons to navigate to their proper place. About 20 per cent of twins are left-handed – a far greater proportion than among the general population – and some researchers have speculated that some singleton left-handers – perhaps all of them – are the sole survivors of what started out as a twin pair. The shift in cerebral dominance may have been caused by mild damage sustained when competing with the twin for limited resources in the uterus, or the result of whatever trauma or uterine deficit it was that killed the other twin.

On BEO-grams we do not see any particular signs of left-handedness – only the features, specific for the particular person. And from the above-stated analysis it is clear that it is not the hand, but the brain hemisphere dominance that rules the game. But, of course, it would be interesting to pay attention to this factor.

The sexual brain

The main structural differences so far observed between men's and women's brains are:

- The hypothalamic nucleus $INAH_3$, in the medial preoptic area, is on average 2 to 2.5 times larger in men than in women. This nucleus is responsible for male-typical sexual behavior. It contains more cells that are sensitive to androgens (male hormones) than any other part of the brain. Some studies [Fisher, 1997] have found a correlation in women between assertive (male-typical) and excessive heterosexual behavior and small breasts, low voice, and hirsutism. The physical characteristics generally signify unusually high androgen levels, and it may be that the women's behavior is caused by their hormones stimulating $INAH_3$.
- The corpus callosum — the band of tissue through which the two hemispheres communicate – is relatively larger in women than in men [Katz, 1997]. So is the anterior commis-

sure – a more primitive connection between the hemispheres that links only the unconscious areas of the hemispheres [Melzack, 1997].

This fact may explain why women seem to be more aware of their own and others' emotions than men – the emotionally sensitive right hemisphere is able to pass more information to the analytical, linguistically talented left side. It may also allow emotion to be incorporated more easily into speech and thought processes. Women also have more tissue in the massa intermedia, which connects the two halves of the thalamus.

• Men lose their brain tissue earlier in the aging process than women, and overall they lose more of it. Men are particularly prone to tissue loss in the frontal and temporal lobes [Rose, 1993]. These areas are concerned with thinking and feeling, and loss of tissue in them is likely to cause irritability and other personality changes.

Women tend to lose tissue in the hippocampus and parietal areas. These are more concerned with memory and visio-spatial abilities, so women are more likely than men to have difficulty remembering things and finding their way about as they age.

• Imaging studies show that men and women use their brains differently, too. When they do complex mental tasks there is a tendency for women to bring both sides of their brain to bear on the problem, while men often use only the side most obviously suited to it. This pattern of activity suggests that in some ways women take a broader view of life, bringing more aspects of the situation into play when making decisions, for example. Men, on the other hand, are more focused.

But sex – human sex particularly – is not all about thrusting and ejaculating. In humans it gives rise to a complex package of feelings and thoughts that we label love. Romantic love is born out of the evolutionary success of pair bonding as a reproductive strategy. Our brains have evolved to feel pleasure in sexual bonding and discomfort at separation. It is brought about by an even more elaborate than usual interplay of hormones and neurotransmitters. So far, only the most preliminary movements in this chemical concerto have been charted. We have a good idea of the substances associated with the various stages of falling in love, but it is not yet known precisely which brain areas each of them activates.

The feelings of euphoria associated with early stages of love seem to be brought about by a combination of dopamine and a chemical called phenylethylamine (PEA). These probably work on the reward pathways leading from the limbic system to the cerebral cortex. The drive to make love comes from testosterone (in men and women) and estrogen (in women) working on the hypothalamus. Bonding – both sexual and between parent and child – seems to be brought about largely by the action in the brain of a hormone called oxytocin.

Countless psychological studies have shown that people in the throes of this hormonal storm are more than usually divorced from reality, particularly when it comes to making assessments about the person they love. They are typically blind to the other's faults and often wildly over-optimistic about the future of the relationship. Looked at coldly, romantic love is a chemically induced form of madness and a terrible basis for social organization, as the divorce rate in the Western world demonstrates.

But how pleasant it is to be a little crazy in this world! Romantic love can not be the only basis for family life, however it is the love that sometimes helps to avoid turning family life into a variety of business.

Is there any difference in Male and Female BEO-grams?

All the given data demonstrate that the difference of sexes is not just the difference of bodies, but difference in internal structure. In general we can say that there are two different species of human race living on the Earth: females and males. They are different in appearance, behavior, physical construction, hormonal production, and even in tiny structures of the brain.

At the moment our experience does not allow us to distinguish sex by BEO-gram. Clinical trials on randomized groups demonstrated statistical difference between energy activity of different systems for women and men. For example, for a group of middle-aged people the main difference was found for activity of digestive tract and spine, not to mention reproductive system. But we do not know, whether this is a common trend or specificity of this particular group.

The fact is that a BEO-gram is an imprint of the biological field, which is formed by co-operative processes beginning at a cellular level and finishing with the level of organs and systems, having a prevalent effect on consciousness and psyche processes. These processes are quite the same for men and women. We may predict a difference of yin-yang energy, but at present have not been able to document this. We may suggest the statistic distribution of men and women by types, although we have not made a strict analysis.

The fact is that a BEO-gram is an imprint of the biological field, which is formed by co-operative processes beginning at a cellular level and finishing with the level of organs and systems, having a prevalent effect on consciousness and psyche processes. These processes are quite the same for men and women. For example, numerous experiments have shown that the states relating to various phases of love and falling in love are well registered on the GDV-grams. This is the strongest psycho-emotional state, deeply touching the energetics of the organism. Attraction, passion, and love are not just the chemistry of the body and a play of hormones; these are a contact of energies and tender whisper of souls. Is it possible to measure the skin odor or wave of eaves of the beloved woman?..

Chapter 12. Oriental philosophy and medicine approach

R. Alexandrova, V. Nemtsov, K. Korotkov

Only in XX century, with the emergence of quantum theory and especially with the development of synergetics [Hagen, 1985; Prigogine, 1986], did non-linear thought become usual for Western people (perhaps not counting some genius insights of Heraclit or moninism ideas of XVI century, which had not been developed in their time). Greek-Roman tradition postulated dominance of mind – in that, everything is governed by the Logos, which led the man to feeling himself the world's master, and by the end of XX century put Humanity on the verge of an ecological catastrophe. However, in the East and, first of all, in Chinese-Indian philosophical tradition, non-linear thought was the primary tradition since ancient times.

As opposed to the Greek Logos, the Tao does not create from the opposed endeavors (elements), but follows spontaneous rhythm of the world. In Ancient China it was considered that everything comes and goes away in due time, as in a cycle in which one moment "yin" takes in power, at another – "yang", and on the brick of the Great End the way back starts: they change places. In addition, there is nothing unilateral and single valued, everything is simultaneous – both "yin" and "yang", everything is centrifugal and centripetal, being at rest and at run at the same time. European culture is dialogic, and in its striving for the truth – abstract principle – the ideas come through a creative dispute. In China every sage follows his own Tao. Chinese culture is monologic, and the truth is not only necessarily comprised ethical principles but is also practical.

In contrast to the Greek-Roman world, which started opposing the Spirit and the Substance (in Christianity – opposition of the Soul and the Body) quite early, the Chinese had never separated them. For the Chinese the world was a continuous consecution from the emptiness on the one end to the deepest substance on the other, and, therefore, in China the Soul did not become an invisible antipode of material body.

European discursive thinking, based on the principle of binary oppositions, according to its immanent approach can not but separate the whole into parts and contrast these with one another. But here the harmonic unity and integrity of the existence collapse, and the human alienates from both the environment and his inner essence, and as a result he loses his integral sense of the world.

The Tao-Buddhistic world is principally "non-dual". "Tao-Buddhistic thinking is characteristic of the following features: non-linearity, singularity, synchronism, arising from non-casual type of connection; non-duality, stipulated by interpenetration of "yin-yang"; non-duality of levels of the unified, universal, imperishable and single, unique, metastatic... An integral approach... is conditioned by realization of principal unity of macro- and microworld". An integral worldview is typical of the Confucianism. Great Chinese Neo-Confucian Chju-Ci (1130–1200) considered the Cosmos to be an organism, capable of reproduction through birth and possessing consciousness present in any object. Structures of the human and the Cosmos are single-typed and single-natured, as well as the structure of consciousness, and since the main principles of social life are set by the Cosmos, it possesses the same ethic features. Sinn philosophers tied together the social, the moral, and the cosmic in a single whole not only to humanize the whole existing, but to endow the human with the cosmic meaning.

Chiness philosopher Cjan-Cay (1020-1077), having developed the theory of "chi", returned Confucianism its philosophical basis. If "chi" initially meant "gas" or ether", the Neo-Confucians consider "chi" within the limits of a much more complicated and abstract idea – as the main substance of the Universe. As soon as all things consist of "chi", people and other subjects are part of vast body of the Universe (Cosmos). Cjan-Cay supposed that the emptiness is not an absolute vacuum, it has "chi" particles dispersed in it [Osborn, Vanloon, 1997].

Wonderful analogies to these ideas are represented by modern physics [Kapra, 1994]. In the term Tao the idea of field is implicitly present: Tao, being empty and shapeless, gives birth to all the shapes and forms. Explicit idea of the notion of field is contained in the term of "chi". Likewise quantum field, "chi" is perceived as a non-material, slipping away from perception, form of the substance existence, simultaneously present in the whole space and capable of concentrating in the form of various material bodies. "Chi" concentrates and disperses with a rhythmic periodicity, giving birth to the forms, which again dissolve in the Darkness. As the quantum field theory puts it, "chi" field does not only lie at the heart of all material subjects, but also implements their interconnection, taking form of the waves. According to the Chinese philosophers, "chi", compensating in the form of a tangible matter, does not have its own essence, but all the other subjects interact with one another with the help of waves and oscillations, nature of which depends on the "yin-yang" rhythmic oscillations. Thus, separate subjects possess their own rhythmic characteristics, which are entwined into the general pattern of world harmony [Needham, 1956].

In common with the Western Emptiness, physical vacuum is not just the state of absolute non-fullness. On the contrary, according to the highest achievements of physics by the end of XX century - Standard Model of elementary particle physics, the physical vacuum contains in itself the opportunity of all the forms of particles to exist. The quantum field theory considers all the interactions as the processes of exchanging virtual particles ("chi" in Chinese philosophy) [Kapra, 1994]. In ancient China the notion of "chi" was also used to mark the life energy, or the energy animating the Cosmos. The ideas of "life channels" of "chi" circulation in the human body became the basis for Chinese medicine. Biologically active acupuncture points and meridians uniting them, the paths of motion of "chi", form network system of the level which is higher than the nervous system level. This network might be regarded as the projection of energy system of a higher hierarchy level upon the other regulative systems of the organism. Penetrating into every-

thing, "chi" energy provides organic interaction of all animate and inanimate world, as well as of humans and nature itself.

The method of Gas Discharge Visualization enables to fix the image of energy emanation from any body of both animate and inanimate objects, found in the field of high tension. GDV-gram is a kind of energy-informational "pattern" of any natural body. Chinese hieroglyph "ven" is a polysemantic "pattern". In the "yin" inscriptions on the stones (XIV-XII cent. BC) it represents a pictogram of a man with a tattoo on the breast, and in early written sources it is used meaning a "line", a "picture", or an "adornment" [Rubin, 1970]. In the opinion of a renowned German sinolog Wilhelm Rihard, for the Chinese, "ven" is not just a theoretical or forming principle, it is what enables things to take shape. The line takes shape, but slips away from it, constantly changing, since the line's main property is potentiality, possibility and necessity to transform; the line is quasi-playing with the shape, it does not end anything, does not create anything, which would last and maintain in an eternal flow of Changes. The health of a person is provided by a dynamic interaction of "yin-chi" and "yang-chi", which are charged by an exogenous energy of Yin and Yang. Any disease is the result of "yin-chi" and "yan-chi" disbalance, which results in the transformation of energy-informational "patterns", visualized with the help of the GDV-grams.

To normalize yin-yang misbalance Traditional Chinese Medicine acts according to the principle of minimal intervention into the natural course of events. Lao-cze maintains that "All the subjects in the world are born within the existence, and the existence is born in non-existence... Non-existence penetrates in everything and everywhere. That is why I know the benefit of non-activity" ("Tao te zin", paragraphs 40, 43). The methods of traditional Chinese medicine make use of "Vey Uvey" principle, which means action beyond active action, self-natural action, generated by natural necessity, wise action, conforming to the nature of subjects. This principle of traditional Chinese medicine corresponds to the synergetic ideas of modern philosophy and medicine: effect of "accretion of the little".

A thousand-year experience of traditional Chinese medicine (TCM) application is based on a detailed analysis of energy distribution through the body meridians. In XX century it was found that the acupuncture points on the body differ by a reduced impedance. TCM conceptions are hardly gaining acceptance in the West. Everything, which can be measured, exists objectively! However, all attempts to find morphological correlations of acupuncture points failed: they do not differ principally from the surrounding tissue. Moreover, the research demonstrated that apart from the system of points and meridians of TCM, a number of "constellations", differing by the changed electrical properties or specific sensitivity, might also be measured on the body. Basing on the totality of these points the system of Dr. Voll was created, auriculodiagnostics is carried out, and numerous other microacupuncture systems, including hand-foot system [Park Jae Woo, 1993], are used. Systems of meridians are found with animals, as well [Kazeev, 2000]. Consequently, having accepted the concept of acupuncture points, it is necessary to accept the idea of energy circulation, although this idea requires a lot of work for its substantiation from the viewpoint of modern scientific paradigm.

The fingers and toes have initial and final points of all meridians, depending on the direction of energy flow. They are called "Jing" in Chinese, "Sei" in Japanese, and "well" in English

(fig. 12.1). It is known that these points most sensibly reflect the state of a corresponding meridian. The latter, in their turn, are distributed in pairs according to the Yin-Yang principle, having strong correlation in a pair. This means that if one meridian in a pair starts dominating, the other one tries to reduce this dominance, restoring the initial balance. If this cannot be reached, a misbalance arises, which leads to dysfunction.

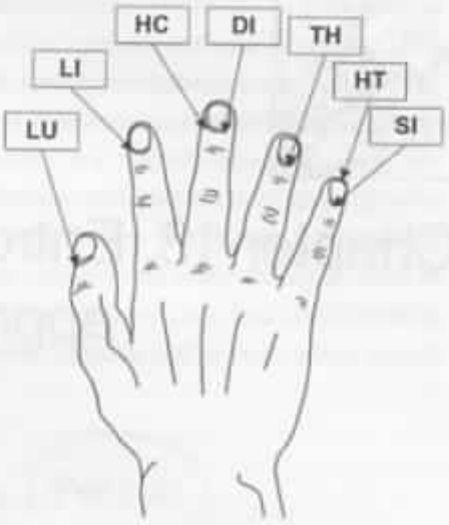

Fig. 12.1. Meridianal points on the fingers.

The notion of meridians is used in some GDV software programs for the interpretation of GDV-grams' data.

The idea of energy circulation is the basis of classical Indian medicine and philosophy, as well. It is founded on the conception of chakras – energy whirlpools, situated along the spinal column. In Ayurvedic medicine, detailed notions concerning the connection of chakra' activities with the physical state of various body systems, organs and psycho-physiological typology are elaborated. Distribution of energy within the chakras, free flow of energy along the energy axis - Sushumnas define human state and nature of inter-relation with the environment. In this way, the notions of traditional Chinese and traditional Indian medicines are quite close: in both cases the question is related to energy or "chi" circulation. The main difference lies in the fact that the Chinese physicians have always directed their efforts to the maintenance of energy flows in the organism. On the other hand, Indian philosophy and medicine has considered a human as a part of the Universe, and the highest objective has been to reach a clear condition - nirvana, which has been practically achieved by a particular state of chakra balance. Therefore, the Indian tradition has always paid great attention to the interaction between human's energy field and the environment. We can say that Chinese medicine and philosophy have been accented inside the human, while Indian - outside.

The idea of energy meridians has been accepted by Western medicine through the opportunity to measure acupuncture points, however, the direct measurement of the state of chakras has not yet been accepted. It is interesting to note that as we have seen from the above, these systems describe the same phenomena from different viewpoints. So there are no grounds to doubt in the reality of chakras, which in fact gives an opportunity to use all of the notions developed throughout thousands of years. As it will be demonstrated below, in the chapter on the organism's field structure, modern biophysics has developed the idea behind the nature of acupuncture points and chakras from the viewpoint of biological field conception.

Chapter 13. Entropy-synergetic approach

European and oriental conceptions of holistic medicine and principles of synergetics - The principle of entropy and its application to the GDV-graphy - Information-energy exchange - Application of probabilistic parameters for the description of GDV-grams. GDV entropy

European and oriental conceptions of holistic medicine and principles of synergetics

R. Alexandrova, V. Nemtzov, K. Korotkov

A human being is a complex non-linear system consisting of a large number of various functional structures. The principle of functional blocks put forward by A.Ugolev [1987] is reasonable for different levels, from molecular and sub-cellular to the level of the whole organism. Combination of standard blocks, which are in complex quantitative correlation in various sections of cells and organs, provides their specialization, and redistribution of such blocks provokes modification of functional effects. Systems of nervous and humoral regulation maintain informational balance in the organism, modulating and compensating signal effects of one another. A notion has been formulated of a "communicative-regulator integrative device," functioning in two ways: a conducting one, when electric signal transfer takes place (nervous cells), and a humoral one, based on the transport of various bioregulators (nervous, mesenchyme, and epithelial cells).

In the initial stage of adaptation to any new environmental factor, a stress-reaction takes place, which is mediated by stress-realizing systems: a neurogenic determinated activation of hy-

pothalamo-hypophysis-adrenocortical and adrenergical systems occurs. To prevent excessive stress reaction, having immediate adaptation to stress, stress-limiting systems activate simultaneously, both central (ergic, opioidergic, serotonergic) and peripheral, local (prostaglandin, antioxidant) systems. Long-term adaptation is implemented by activation of genetic device followed by synthesis of the corresponding albumens and nucleic acids, which results in a "system structural trace" and in the increase of power of definite functional systems. Nervous and endocrine systems transfer signals "from the center to the parts", bringing out effector cells, tissues, and organs of the balance state. Tissue-specific peptide complexes, singled out quite recently and representing a result of proteolis of various tissue-specific ferments, maintain tissue homeokinesis, and function according to the principle "from the tissue to the organism" as a peculiar "peptide buffer" correcting signals of higher regulating systems [Human Physiology, 1996].

Thus, the integral organism reaction to any influences is formed, taking out homeokinetic oscillations beyond the normal limits. Any disease, in spite of organic clasure (locus minoris resistenciae), also gives rise to the general organism reaction and changes of functions of many organs and systems, sometimes obvious, sometimes subclinical. In this connection, a clear interest in holistic notions arises in modern medicine, mostly stimulated by penetration of synergetics ideas into biology.

Synergetics is a part of non-equilibrium thermodynamics, describing behavior of open dissipative systems. Open systems interact permanently with the ambient space, exchanging substance, energy, and information, and change continuously. Synergetics creates a new image of an open and complex-organized world, not a "grown" one, but rather a "growing" one: a constantly arising and changing world. The whole world may be

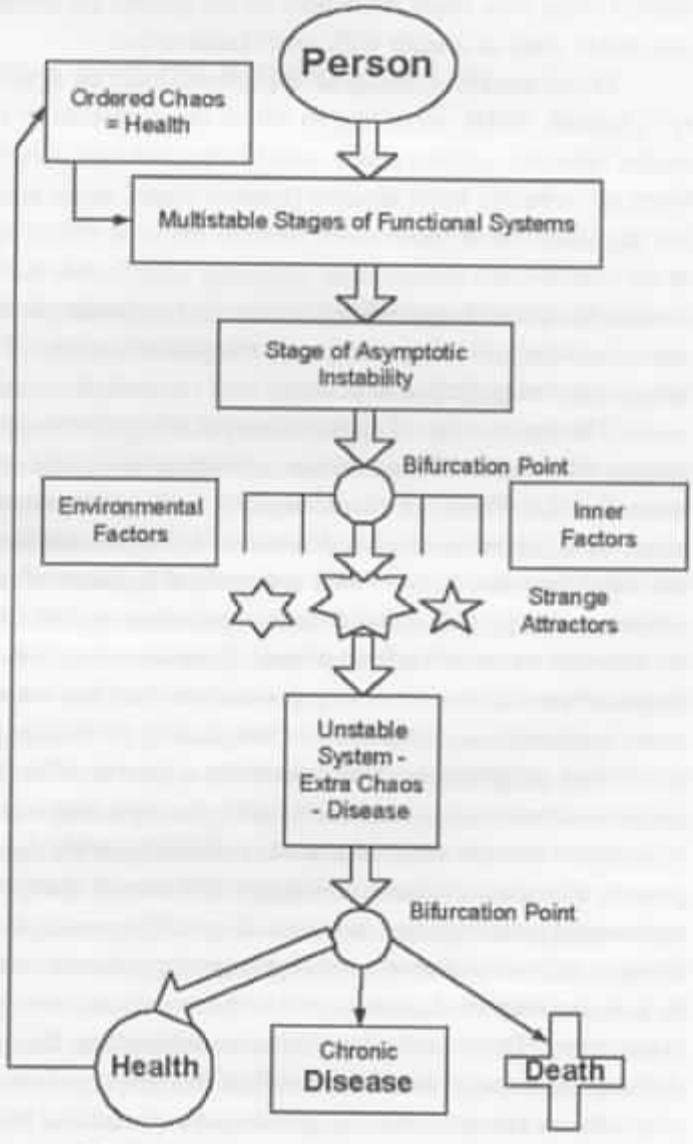

Fig. 13.1. System approach to the human health.

represented by a hierarchy of mediums having different non-linearity, and the way to the complex is the way to the mediums having new characteristics [Prigogine, Stingers, 1984].

The organism, in turn, may be depicted by a hierarchy of autonomous self-organizing systems, between which (and also between endogenous structures) there are non-linear connections. The system is described by a spectrum of key moments - bifurcations, in which points stochastic selection chooses one of the stable branches of further development, through which the information is transferred to the next bifurcation (fig. 13.1). Bifurcation points are crucial, critical moments of system development, and bifurcation zones are notable for their principal abruptness. For non-linear systems, the presence of special critical states is characteristic. In the point neighborhood of these states, the growth of fluctuations increases - random deviations of instantaneous values of the system parameters from average equilibrium values. In these critical areas even small influences on the system are enough for it to overleap from the previous stable state to a state with other parameters.

Development of many acute diseases may be described in terms of "catastrophe theory" [Arnold, 1990], according to which the evolution of a system proceeds in the "blow up" mode: bronchial asthma attack; acute lungs oedema; paroxysmal rhythm disorders, some acute types of ischemic heart disease (sudden death, acute coronary deficiency), and other cases. For the initiation of these states, several extreme effects upon the organism are not necessary at all; sometimes a microscopic, clinically undefinable state fluctuation is enough to lead to the avalanche-like increase of life-threatening symptoms. In the examples given, the fluctuations result in disbalance of system functioning on a macrolevel. In favorable cases, the same fluctuations may bring forth a new, more well-ordered structure.

The opportunity of spontaneous initiation of chaos is the most important moment in the process of system self-organization: a macroscopic order arises, preserving microscopic (molecular) disorder. There are two tendencies in the understanding of micro-order: the birth of the chaos from the order, which is determined by the second law of thermodynamics, and the birth of the order from the chaos, which is described by thermodynamics of open systems. Synergetics stresses an inseparable unity of these two tendencies. The dynamics of living systems, which can be shown in terms of "ordered chaos," gives a number of fundamental advantages in the struggle for existence and, foremost, an opportunity to function in a wide range of oscillations of homeokinetic parameters and, therefore, to adapt easily to changing conditions.

Any pathology is characterized by a growth of the degree "harshness" in the process of interaction between systems constituting the organism: a quantitative rigidity develops, growing from health through the predisease to a clinically sickly state. As soon as the danger of pathologic process increases, a clearer periodicity and loss of changeability take place. For example, with myocardial pathology the variations of systol frequency decrease, with arterial hypertension patients experience a rise of arterial pressure that becomes more monotonous and the amplitude of its daily oscillations decreases, and with leucosis patients the number of leucocytes becomes less changeable. These particular clinical manifestations demonstrate one of the principal bases of disease - increase of the "harshness" of interstructural interactions.

Every function of a biological system is realized in the form of a definite trajectory of an algorithmic aim, consisting of successive elementary processes. Synergetics makes use of the

term "attractor" as a spatial representation of the aim, to which a number of conjugate functional algorithms are directed. Each of the functions, realizing an attractor based on the principle of dominance on a scale of the whole organism, is formed in its turn, on the grounds of attractors. According to these ideas, pathological states may be characterized by the fact that some attractors become indefinitely more important. "Strange" attractors, i.e. unstable attractors arise, so that the phase trajectories of some functional processes do not converge to a single point, but wander in some zone of phase space, which results in a chance of their interaction, and is clinically characterized by one or another disease manifestation.

Thus, health is the state of balancing between chaos and order, and the theories of chaos and non-linear dynamics become more and more helpful in diagnostics and treatment of diseases.

The principle of entropy and its application to the GDV-graphy

D. Korotkin, K. Korotkov

One of the universal instruments for description of system functioning of biological subjects and, particularly, the human organism, is the application of a synergetic-probability approach, coupled with the use of the generalized notion of entropy. This notion is widely applied in thermodynamics to identify the measure of energy necessary for dispersion of a non-uniform thermodynamic system and in statistical physics as a measure of probability of the system's being in the given condition. In 1949, Shannon introduced entropy into information theory as a measure of uncertainty of an experiment's outcome [Shannon, 1988]. The notion of entropy is one of the fundamental properties of any system having probabilistic behavior, providing new levels of understanding in the theory of information coding, linguistics, image processing, statistics, and biology [Yaglom, 1960].

Entropy is connected directly with the notion of information, which mathematically characterizes the interrelation of several events and becomes more important when the functioning of biological subjects is investigated [Stonier, 1990]. The necessity of taking into account the processes of exchange of both energy and information is acknowledged, while describing the functioning of the biological organism as an open dissipative system. The influence of outer information upon the organism might be estimated through the modification of entropy conditions.

In accordance with the Nobel Prize laureate I.Prigogine's conceptions, in the process of growth and development of the organism a decrease occurs in speed of entropy production, pertaining to a subject mass unit. Reaching standard state, a summary modification of entropy may be considered equal to zero, which corresponds to a mutual compensation of all processes related to the inflow, removal, and transformation of substance, energy and information. I.Prigozhin formulated the basic property of stationary states of open systems: having fixed outer parameters, the speed of entropy production stipulated by irreversible processes' flowing, is permanent in time and minimal by magnitude dS/dt min. Thus, according

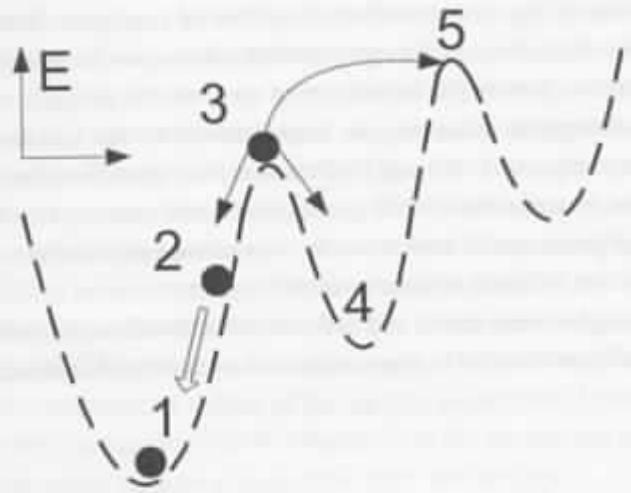

Fig. 13.2. Energy levels of the biological system.

to the theorem of Prigozhin, a stationary state is characterized by minimal dispersion of entropy, which, for the alive systems, can be formulated as follows: maintenance of homeokinesis requires minimum energy consumption, i.e. the organism tries to operate in the most economical energy mode. Deviation from a stationary condition - disease - is concerned with additional energy consumption, compensation for inborn or acquired biological defects, and entropy growth.

There may be several stationary conditions in the dynamic system, which differ by entropy production level dS_i/dt. The organism state may be described as a set of energy levels (fig. 13.2), some of which are stable (levels 1 and 4), the others are unstable (levels 2,3,5). Having constantly functioning external or internal influence, a spasmodic change from one state to the other may occur. Any inflammation is characterized by an increased consumption of energy: the body temperature rises, the speed of exchange processes increases. Deviation from a stationary condition with minimal energy consumption results in the development of inner processes, striving to bring the system back, to level 1. Under long-term factors' activity the system may pass over to level 3, at the so-called bifurcation point [Prigogine, 1984], from where there are few outcomes: return to the stable level 1, change to another stable equilibrium state 4, characterized by a new energy-informational level, or a "leap" onto a higher, but unstable level 5.

An organism corresponds to a few levels of relative health or chronic disease with various levels of system functioning. An acute disease relates to a non-stationary condition with an increased entropy production, i.e. an uneconomical type of organism functioning. In compliance with the theory of catastrophe of V.I.Arnold [1990], with acute diseases or acutely developing pathological syndromes (the most acute start of hard pneumonia, asthmatic status, anaphylactic shock, etc.), it is necessary to transfer the organism from a "bad" stable state to a "good" one by one leap. The role of small influences, for instance, acupuncture and homeopathic medicines, giving a positive energy-informational effect, increases in the phase of calming down exacerbation and remission of chronic diseases.

To understand the multistability of complex non-linear systems, such as a human organism, the probabilistic nature of its constant development and self-organization require seeking the "system-forming factors" [Anohin, 1980] to which entropy might be attributed.

We have elaborated the method for calculation of the GDV-grams entropy and created software for that. Experiments have shown that this parameter is an informative characteristic of the organism state and may be used for the estimation of condition and determination of patients' therapy direction. Let us study the principles of this approach in more detail.

Entropy and information in the theory of probability

Let us represent a few facts of the probability theory and discuss the notion of entropy and information, mainly following wonderful classical books [Yaglom, 1960 and Brilluen, 1959].

Entropy

The basic notion of probability theory is the notion of *experiment* which may be repeated many times under the same conditions and may produce different results, or *outcomes*. Let us assume for simplicity that the number of different outcomes is finite and denote them by $A_1,...,A_N$. Moreover, let us assume that, if we repeat our experiment many times, the frequency of outcome A_j turns out to be proportional to positive number p_j and, moreover, $p_1 + ... + p_N = 1$. Then we say that outcome A_j has *probability* $p(A_j)=p_j$. We recall the simplest possible experiment: tossing the coin. It is normally assumed that there are only two possible events: the "head" and "tail;" under standard conditions probabilities of these events are equal to S.

The notion of entropy naturally arises if we ask the following question: *Is it possible to give a natural measure of uncertainty of outcome of experiment A?* For example, in the coin experiment the coin may be forged in such a way that the "head" event has probability 0.99 and "tail" event - only 0.01. It is natural to suppose that the measure of uncertainty of this second experiment should be essentially smaller than the measure of uncertainty of experiment with a non-forged coin. If the probability of "head" equals 1, there is no uncertainty in the experiment outcome at all, and the measure of uncertainty of such experiment should be minimal (it is natural to put it equal to zero). In general, it is intuitively clear that the experiment with all probabilities p_j equal to $1/n$ contains bigger uncertainty than does an experiment with any other values of p_j.

What are the other requirements which we would like to impose on uncertainty measure?

Consider two independent experiments a and b. Denote possible outcomes of experiment b by $B_1,..., B_M$ and corresponding probabilities by $q_1 = p(B_1),..., q_M = p(B_M)$. Consider experiment ab: outcomes of this experiment are formal products $A_j B_k$ with assigned probabilities $p_j q_k$. It is clear that the uncertainty of experiment ab should be greater than the degree of uncertainty of, say, experiment a, because experiment ² introduces additional uncertainty. It is natural to require that uncertainty of ab should be equal to the sum of uncertainties of independent experiments a and b:

$$\varepsilon(\alpha\beta) = \varepsilon(\alpha) + \varepsilon(\beta) . \qquad (13.1)$$

To be able to get a universal numerical value of $\varepsilon(a)$ we should require that it does not depend on the nature of outcomes A_j, i.e. it should be only the function of probabilities p_j: $\varepsilon(a) = \varepsilon(p_1,...,p_n)$. Moreover, consistency requires the invariance of $\varepsilon(p_1,...,p_n)$ with respect to an arbitrary transposition of numbers p_j. Finally, we would like $\varepsilon(p_1,...,p_n)$ to be always non-negative and a continuous function of probabilities p_j (since small variation of p_j should intuitively lead to only small variation of uncertainty of experiment).

It turns out that the measure of uncertainty of experiment satisfying all these requirements does really exist; supplementing them by some more technical condition [Yaglom, 1960] it is possible to claim that a solution is also unique up to an arbitrary positive multiplier and has the form

$$\varepsilon(\alpha) = - C \Sigma p_j \ln p_j \ , \qquad j = [1.N] \ . \tag{13.2}$$

where $C > 0$ is an arbitrary constant. Value $\varepsilon(a)$ is called the *entropy* of experiment a. It is worth making one technical comment: the events with very low probabilities give very little contribution to ε. This is not completely obvious since ln p —> ∞ as p —> 0. However, it is easy to prove that the product $(p \ln p)$ tends to 0 as p tends to 0.

The notion of entropy in probability theory as a universal measure of uncertainty of experiment was first introduced by Shannon in 1949 within the framework of signal transmission theory. Since then, this notion has played a very fundamental role in different application areas of probability theory like coding theory, linguistics, image processing, statistics, and so on. We do not mention here the applications of the notion of entropy in physics and biology, which will be considered in the sequel.

Let us summarize once more the main properties of the entropy ε (13.2):

• The entropy ε is a continuous symmetric non-negative function of probabilities $p_1,\ldots, p_N$ invariant with respect to any transposition of numbers $p_1,\ldots ,p_N$.

• The entropy takes its minimal value $\varepsilon = 0$ if and only if one of the probabilities amounts to 1 and all the others amount to 0, i.e. the experiment a does not contain any uncertainty.

• For fixed N the entropy takes its maximal value for experiment with equal probabilities $p_j = 1/N$; then

$$\varepsilon(\alpha) = C \ln N \ ; \tag{13.3}$$

• Obviously, the entropy of an equal probability experiment infinitely and monotonically increases with increasing of N.

• Entropy of product of two (or more) independent experiments satisfies the addition law (13.1).

• Function ε satisfies the following functional equation: which is closely related to the addition law (13.1).

$$\varepsilon(p_1, \ldots, p_N) = \varepsilon(p_1 + p_2, p_3, \ldots, p_N) + (p_1 + p_2)\, \varepsilon(p_1 / (p_1 + p_2), p_2 / (p_1 + p_2)) \ . \tag{13.4}$$

Information

The object having a very close relationship to the entropy is ***information.*** The notion of information naturally arises in the following context. Suppose we have two experiments a and b which are *not* independent i.e. probability of outcome A_jB_k (we denote this probability by $p(A_jB_k)$) does not equal to the product of probabilities $p(A_j)$ and $p(B_k)$. Instead, we have the relation

$$p(A_jB_k) = p(A_j)p_{A_j}(B_k) \ . \tag{13.5}$$

where $pA_j(B_k)$ is the so-called conditional probability of outcome B_k, which equals to probability of B_k under condition that outcome A_j was realized. If experiments a and b are independent, the realization of outcome A_j can in no way influence experiment b and $p_{A_j}(B_k) = p(B_k)$.

Now it is natural to ask the question: *Is it possible to give a numerical value to the measure of uncertainty of experiment β under the condition of realization of experiment α?* The answer turns out to be positive again; this measure of uncertainty is given by ***conditional entropy,*** which may be written in the form

$$\varepsilon_\alpha(\beta) = \varepsilon(\alpha\beta) - \varepsilon(\alpha) \ . \qquad (13.6)$$

It is the function of probabilities $p(A_j)$ and the matrix of conditional probabilities $p_{A_j}(B_k)$.

It turns out to be possible to prove that conditional entropy always satisfies the inequality

$$0 \le \varepsilon_\alpha(\beta) \le \varepsilon(\beta) \ . \qquad (13.7)$$

Therefore, we can define a non-negative value

$$I(\alpha,\beta) = \varepsilon(\beta) - \varepsilon_\alpha(\beta) \ , \qquad (13.8)$$

which shows how much the uncertainty of experiment β decreases if we know the result of the experiment α. Value of $\beta(\alpha, \beta)$ is called ***the amount of information about experiment β contained in experiment α.***

It is possible to verify the following properties of information defined by (13.8):

- Information is symmetric:

$$I(\alpha,\beta) = I(\beta,\alpha) \ , \qquad (13.9)$$

i.e. the amount of information about experiment β carried by experiment α always equals to the amount of information about experiment α carried by experiment β.

- Information is zero: $I(\alpha, \beta) = 0$ if and only if experiments α and β are independent.
- If experiments α and b coincide, information reduces to the entropy of experiment α:

$$I(\alpha,\alpha) = \varepsilon(\alpha) \ . \qquad (13.10)$$

- Therefore, the entropy $\varepsilon(\alpha)$ of experiment a may be interpreted as the total amount of information which we obtain after carrying out experiment α (if experiment α does not contain any uncertainty i.e. $\varepsilon(\alpha) = 0$, we do not gain any information after realization of the experiment, in full accordance with an intuitive notion of information).
- If α, β, γ are three arbitrary experiments, the following inequality always takes place:

$$I(\beta\gamma,\alpha) \ge I(\beta,\alpha) \ , \qquad (13.11)$$

i.e. the information about experiment α carried by combined experiment $\beta\gamma$ is always greater or equal than the information about experiment α carried by experiment β alone.

The listed properties make intuitive justification for use of the word "information" for variable $I(\alpha, \beta)$. An additional, empirical, justification will be given in one of the sections below.

Random variables

Here we shall briefly describe the notion of random variable, which will be exploited in analysis of BEO-images. Let us associate to every outcome A_j some number $f_j = f(A_j)$. Function f, defined on the set of outcomes, is called a *random variable* (to be more exact a discrete random variable). It is clear that, as a result of the experiment, random variable f takes values $f_1,...,f_N$ with probabilities $p_1,...,p_N$ respectively. Now we can define the *mean value* f_0 of random variable f:

$$f_0 = \Sigma\, p_j f_j , \quad j = [1.N] , \tag{13.12}$$

the *dispersion f*:

$$m_1 = \Sigma\, p_j |f_j - f_0|^2 , \quad j = [1.N] \tag{13.13}$$

and the *higher centralized moments*:

$$m_j = \Sigma\, p_j |f_j - f_0|^{j+1} , \quad j = [1.N] \tag{13.14}$$

The important generalization of the notion of discrete random variable is the notion of *continuous random variable*, when the "number" of events A_j becomes continuous and random variable f may take any value of some interval $[f_{min}, f_{max}]$ with continuous probability density $p(f)$. The formulas for mean value, dispersion and higher moments for the continuous case look as follows:

$$f_0 = \int fp\,(f)\, df, \qquad [f_{min}, f_{max}] , \tag{13.15}$$

$$m_j = \int |f - f_0|^{j+1} p(f)\, df, \quad [f_{min}, f_{max}], \; j = 1,2... \tag{13.16}$$

$$\varepsilon = - C \int p(f) \ln\{p(f)\}\, df, \quad [f_{min}, f_{max}] \tag{13.17}$$

Notice, that, in contrast to the discrete case, the entropy given by this formula may be negative for certain distributions (if, say $f_{max} - f_{min} < 1$ and on the whole interval $p(f) = 1/(f_{max} - f_{min})$).

As one of the applications of the notion of entropy in this context, let us consider the following problem: to find the density distribution $p(f)$ on the interval $f \in]-\infty;\infty[$ which has maximal entropy among all distributions with zero mean value and fixed dispersion equal to σ^2. The answer is given by Gaussian distribution

$$p(f) = (1 / \sqrt{2\pi}\sigma)\, e^{-f^2/2\sigma^2} \tag{13.18}$$

– the distribution which we most often probably meet in reality.

Entropy in physics and the time arrow

It is well-known that on a micro-level all fundamental laws of physics (classical and quantum mechanics, field theory, general relativity) are invariant with respect to the inversion of the time direction. On the macro-level in our real life it is, however, very difficult to imagine some processes going in the opposite direction. The process of expansion of a gas in vacuum, or dissolution of a piece of sugar in a cup of tea obviously have a non-reversible character. One of the few theories that distinguish the direction of the time arrow as the complimentary macroscopic physical law is the second law of thermodynamics, exploiting the notion of thermodynamic entropy.

The thermodynamics and statistical physics study macroscopic objects, i.e. objects consisting of a huge number of micro-objects like atoms, molecules and so on. The explicit description of macroscopic systems by means of fundamental laws of micro-physics (like quantum mechanics or quantum field theory) is therefore very difficult, if not impossible, because of the very big number of microscopic degrees of freedom. In general, to make predictions about the macro-behavior of a system, we would have to know all its micro-parameters. Therefore, at present the explicit description of general macro-objects is not possible at all, unless we assume that the macro-state of an object satisfies some additional requirements.

One possible (and very strong) assumption is the assumption that the object is in an *equilibrium state*. The equilibrium states were objects of study for classical thermodynamics. It turns out that all macroscopically relevant information about equilibrium states of macro-objects may be encoded into a very few parameters: mass, energy, density, pressure, number of particles, temperature, and entropy. The meaning of all of these objects except entropy is intuitively very clear. The notion of entropy was introduced into thermodynamics much earlier than in mathematics. Boltzmann in 1899 defined thermodynamic entropy of equilibrium states of macro-objects as

$$\varepsilon^{TD} = k_B \ln N \qquad (13.19)$$

where k_B is a very small number called the Boltzmann constant, and N is usually a very big number equal to a number of microscopic states available for our macro-object. Immediately we see the formal coincidence of Boltzmann's formula (13.19) to entropy (13.3) of experiment with N equally probable outcomes after choosing an arbitrary constant C in (13.3) to coincide with Boltzmann constant k_B. The experiment α may be formulated as follows: "To determine a micro-state of our macro-system," under the assumption that all N possible micro-states have equal probabilities. It turns out that if the total energy of the system is fixed, the micro-states of the macro-systems in equilibrium do really have equal probabilities, the so-called *microcanonical ensemble*, and therefore Boltzmann entropy does give the proper answer for such systems.

However, the definition by Boltzmann has obvious limitations. Boltzmann's definition does not tell us anything about calculation of entropy for systems where the energy can fluctuate (the so-called *canonical ensemble*), and, therefore, different micro-states may have different probabilities p_j. It was Gibbs in 1902 who generalized the Boltzmann's formula (13.19) to the case of the canonical ensemble as

$$\varepsilon^{TD} = -k_B \Sigma p_j \ln p_j, \quad j = [1,N] \quad . \tag{13.20}$$

which already completely coincides with the general entropy formula of probability theory (13.2) after choosing $C = k_B$. Moreover, if we go to the continuous limit and parameterize our micro-states by some continuous variable f, formula (13.20) admits the continuous limit leading to (13.17) after our usual identification of C with the Boltzmann constant. In physics the formula (13.20) for thermodynamical entropy is called the *Boltzmann-Gibbs* entropy formula.

It is the notion of thermodynamical entropy, used in the Second Law of thermodynamics, which determines the direction of the time arrow in the macro-world. There are many different formulations of the Second Law; the simplest version describes behavior of the entropy of a system under an *adiabatic process*. The process is called adiabatic if the system does not get or give away any heat during the process. Then the simplest version of the Second law is:

As a result of adiabatic process the thermodynamic entropy of the system cannot decrease

$$(\delta\varepsilon^{TD})_{adiabatic} \geq 0 \tag{13.21}$$

If, however, the system can be transformed from initial to final state via infinite chain of very close equilibrium states, the process is called *reversible*. Under a reversible process the entropy always stays constant:

$$(\delta\varepsilon^{TD})_{adiabatic,\ reversible} = 0 \tag{13.22}$$

Of course, both adiabatic processes mentioned in the beginning of this section – the expansion of gas into a large volume and dissolution of sugar in a cup of tea are irreversible. And it is the Second Law which prohibits the inversion of these processes without influence from the outside. Therefore, the Second Law does really determine the direction of the time arrow in adiabatic processes.

Entropy and information in biological systems

In spite of the enormous complexity of biological systems in general and the human in particular, the notion of entropy turns out to be very useful in description of certain aspects of such objects.

As a first example we consider the following psychological experiment. Suppose we have N lamps; and lamp number j flashes with probability p_j. The human should point out as quickly as possible which lamp has flashed. What is the mean time of human reaction if the experiment is repeated many times?

The answer turns out to be rather unexpected: the average reaction time is proportional to the entropy (13.2) of our experiment, and not to the number of lamps N, as one would naively think [Hyman, 1953].

Moreover, we can repeat the experiment under another condition: we can ask the human to point to the flashed lamp as soon as possible, very quickly, so that sometimes he can even make mistakes. Then we get two probabilistic experiments: experiment α, whose outcomes

are flashes of lamps, and experiment β, whose outcomes are human reactions. It turns out that the average time of human reaction in this case is proportional to information $I(\alpha, \beta)$!

The conclusion we can make from these experiments is that the speed of signal propagation in human nerves is proportional to mathematically well-defined amount of information contained in the signal!

Another indication of the relevance of the entropy notion in biological systems is a well known fact that in any population of biological species most of their physical characteristics (like say weight, or length) have gaussian distribution density. As we know, the gaussian distribution (13.18) maximizes the entropy if the dispersion is fixed. Therefore, we conclude that the principle of maximal entropy (and also the constancy of dispersion) has direct application to the evolution of biological populations!

Of course, it seems very tempting to generalize the notion of entropy and information to the level of biological subjects, or, say, mankind as a whole, looking at evolution of our civilization, or even the whole universe as a huge random experiment. Such attempts were made by many authors (see, for example [Stonier, 1990]). Nowadays many authors speak about an "information field" as a fundamental phenomenon, about the information significance of biological life, etc. Not denying the importance of such approaches (we will study it in more detail in the next chapter), we should admit that at the present moment there is no possibility to give fully satisfactory theoretical substantiation to these notions.

At the same time, as shown by the studied examples, the notion of entropy can really be used for effective description of certain aspects of an individual person's life. Maybe because of that it is possible to measure some characteristics of human behavior experimentally and then quite satisfactorily interpret them as the "total entropy of the human being." In the sequel we introduce such a variable. Then, based on the results for calculation of this variable in different types of humans, we will demonstrate that this notion can really have pretentions of an experimentally measurable entropy of the human state or measure of "uncertainty of the current human state." To give experimental proof for these ideas we use analysis of GDV-grams. But let us first recall the main principles of energy exchange of the organism and introduce an important notion of **information response**.

Information-energy exchange

We are accustomed to the fact that biological organisms exist at the expense of energy consumption. Air, water, nutrients, and microelements are all necessary components of biological life. Intensity of metabolism and energy production of the organism under conditions of mental and physical activity is investigated by physiologists in detail [Human physiology, 1996]. It has been demonstrated that metabolic rates depend on sex, age, intensity of activity, and to a first approximation might be characterized by production works, emitted heat and energy, stored in the form of depositing nutrients and structural transformations.

At the same time, not less important components of a biological system's existence are informational signals. It is generally acknowledged that the organism realizes functional self-regulation at the expense of signals, coming from all systems and organs, which leads to continuous regulation of their work by a vegetative nervous system [Anohin, 1980]. It is necessary to pay more attention to the role of weak factors, influencing the organism from exterior space and under certain circumstances causing informational reactions.

For simple organisms these are mostly signals connected with behavioral activity: searching for food, partners, anxiety, and pleasure. For more complex organisms, particularly, humans, these signals determine many peculiarities of life and behavior both on the conscious and subconscious levels.

General and specific sensory physiology studies general principles, based upon sensory capabilities, i.e. the work of separate **sensory systems** and their result - subjective **perception** by a human. Subjective perception takes into account factors of the environment, caught by the sensory organs. Such factors are called sensory stimuli. Under their influence receptor cells generate potentials, activating afferent nervous fibers. The impulsation of many afferents is brought to sensory centers of the brain, where information processing takes place.

Sensory stimulus might lead to the rise of subjective **sensation**. For example, electromagnetic oscillations with the wave-length of 400 nm arouse a sense of "blue color." A person says: "I see blue sky." Interpreting sensations on the basis of previous experience and current mood, a person comes to **perceptions**. A perception of blue sky is different for inhabitants of Northern latitudes and for those inhabiting hot, Southern regions.

The law of "specificity of sensory energies," formulated 150 years ago by Johannes Müller states that the character of sense is determined not by stimulus, but by the irritated sensory organ. This is one of the most important laws of subjective sensory physiology. Sensory organs are usually subdivided into three main groups [Human physiology, 1996]:

1. Organs and receptors, stimulated by the environment, called **extroceptors**.

2. Other organs determine the length of muscles, tendon tension, angles in joints, and other parameters of body position and movement. These are called **proprioceptors**. Vestibular apparatus might also be referred to this group.

3. Finally, sensory information is received from the inner organs, as well. Efferents coming from them are called **interoceptors**.

One of the main notions of psychophysics is the notion of sensory threshold. It is defined as the minimum stimulus by intensity, capable of causing a certain sense. Sometimes it is interpreted as the lowest threshold, reachable at optimal conditions of stimulation and adaptation. For example, threshold values for hearing depend on the sound frequency, for eyesight – on the time of adaptation. In the subthreshold range another type of threshold is determined – "hardly visible difference". This is a quantity, in which one threshold should differ from the other, so that their difference is perceived by a human. In 1834 E.Weber demonstrated that a minimum discernible change of intensity of stimulation dj makes up a constant part of its initial intensity j. This is the law of Weber, expressed by equation:

$$\delta\varphi / \varphi = Const$$

The given rule is implemented in a wide range for many sensory modalities, being a useful measure of relative sensitivity of sensory systems. It is impossible to mathematically compare the sensitivity of eye to the light power with the sensitivity of ear to the level of sound pressure. However, non-dimensional coefficients of Weber for these modalities can be compared with one another. Investigation of the dependence of a sense's intensity on the quantity of stimulus is an important task of psychophysics. Experimental research over many years revealed certain regularities, among which the psycho-physical law of Fechner and law of Stevens are most well-known [Stevens, 1975].

In recent decades, the high effectiveness of treatment methods based on influencing an organism by weak, subthreshold factors, has been demonstrated. These methods include several electromagnetic signals of weak intensity; light, including laser radiation; aeroions in small quantities; as well as homeopathy and phytotherapy. Clinically demonstrated effectiveness of such weak signal influence techniques enables us to study a relatively new class of psycho-physiological interactions, which can be denoted as informational.

By **informational-significant signals** we will mean influences on the organism, which are characterized by an intensity of stimulus lower than the absolute threshold of senses, but which, never the less do initiate development of chains of psycho-physiological processes (reactions) of the organism.

In usual physiological notions subthreshold signals are considered to be insignificant for functioning, and they have never been a subject of investigation of psychophysics. It is obvious that the known laws on the correlation of reaction of the organism and intensity of stimulus are inapplicable to such subthreshold signals. In such cases it is therefore expedient to speak about development of informational reactions.

These specific informational reactions **R** develop according to the following laws [Ponomarenko, 1999]:

1. $\mathbf{W_R >> W_F}$: Energy of reaction is many times higher than energy of co-efficients. Effects are developed at the expense of free energy of the organism, i.e. that part of the inner energy, which is used for biological oxidation and transport of metabolites.

2. $\mathbf{R = f(L)}$: Directivity of reaction is determined by the area of influence L; depending on the area of stimulus application, the organism reacts differently. Experimental facts particularly indicate the importance of notions of reflexogenious zones and biologically active points.

3. $\mathbf{R = f(\nu)}$: Reaction depends on the frequency of co-efficient.

4. $\mathbf{R \neq f(t)}$: Reaction does not depend on the time of influence, i.e. it starts developing from the moment of influence and continues developing when the influencing effect has already ended.

In this way, we can say that external signals can be initiators of specific reactions, flowing at the expense of free energy of the organism itself. This principle is the basis of modern vibrational, wave, physical, or informational medicine, medicine of low intensity. The factors used in these methods influence the organism not through the energy that they contribute to the organism or chemical substances, but owing to regulatory influence on electron-ion processes. Therefore, more and more often a development of quantum medicine is discussed, although it is evident that such statements require a thorough conceptual elaboration and experimental substantiation.

We can discuss a few ways information signals can be processed and analyzed (fig. 13.3). Part of signals directly influence physiological processes by means of a thin regulation of quantum bioelectric and chemical processes within the organism. In modern chemistry it is generally acknowledged that the effect of catalysts is based on inclusion of additional electron-ion bonds and processes. Apparently, calalysts might be not only physical substances, but also physical agents: photons, electrons, and fields. All these factors bring to activation and launch inner processes of the organism, which strive to transfer the organism into the most energy favorable

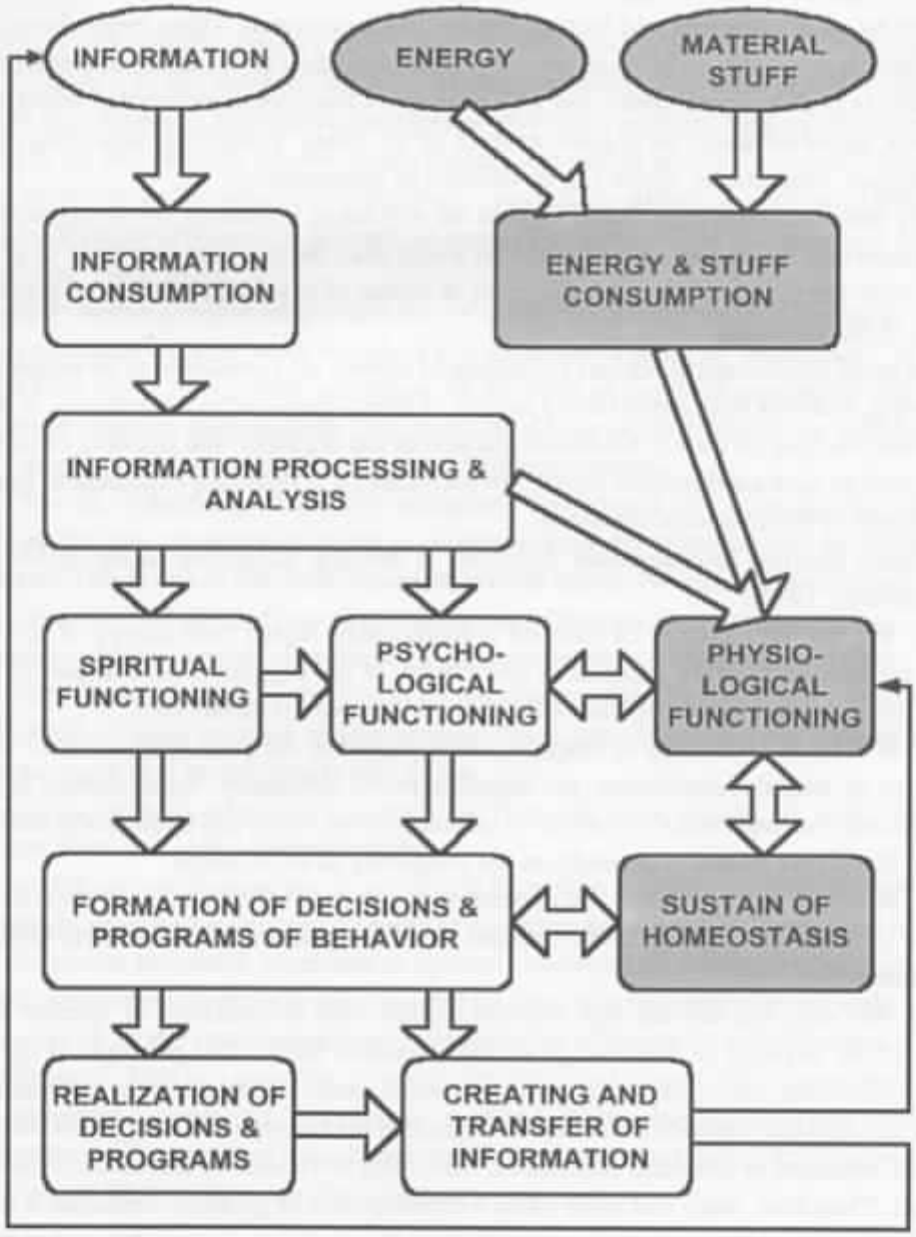

Fig.13.3. Principles of Energy – Matter – Information exchange in the organism.

state according to the principles of fig. 13.2. The organism always prefers the state which is most energy favorable under the given level of adaptation possibilities.

Effects of psyche influence and, on the highest level, complex influences of spiritual organization are added to self-regulating processes for humans (see fig. 13.3). All these processes directly or indirectly tell upon the physiological level, providing an optimal level of functioning under proper direction. It is impossible to determine a priori which of the weak informational influences will appear to be resonant , and which will cause maximum catalytic effect, i.e. adequate informational response. Hence, from a practical viewpoint it is most useful to apply a wide range of influencing factors, from which the organism chooses the most optimal in an autoregulation mode.

Practice of the recent decades of the twentieth century has shown the high effectiveness of medical influence of weak subthreshold factors, but the importance of information in the life of humans and animals goes beyond just influence upon their state. Informational signals play a determining role in the process of organism development, turning it from an embryo into an active functioning representative of the given species. This is especially important for the development of humans.

Some few years ago in the mountains of Greece, hunters found a herd of jaal-goats, among which they saw a small man-like creature. In a massacre, after destroying the rest of the herd, the hunters managed to catch this creature. This turned out to be a boy of 10-12 years old, who behaved himself like a small goat. He walked on his four legs only, ate grass, and when he was brought to the city, he hid under a bed and in no way wanted to get out. The only food that he agreed to take except for grass was pizza. All attempts to bring him back to the human society failed. And in a few years he died of yearning for missing his native mountains. There are a lot of such known "mauglies," brought up by animals. In all cases they remained animals, having failed to turn into humans.

Such facts indicate that in the process of development of a human, as well as any other living beings, the determining role is played by information signals, received by an infant from the very moment of birth. Statistical investigations of many years demonstrate that at the early stages of development the type of behavior is mostly determined by influences of the environment, and after a number of years the influence of genes is more and more strongly manifested. Thus, we can assume that consumption of not only energy, but also information, i.e. signals, coming from the environment and causing specific informational reactions at the expense of inner energy of the organism itself, play the key role in the development and existence of a human. Consequently, we can discuss the emergence of a new scientific direction – informational biology and informational medicine.

Informational response of biological subject

Let us study a simple experiment: a fire-engine speeds along the night city streets, producing loud signals. It passes by a house, and all the tenants of it hear this signal. They react in a different way: the majority do not pay any attention to it and even do not notice it; a 9-year-old boy starts dreaming of his future as a fireman and imagines how he will become famous; a motorist starts getting worried about how he has parked his car and is anxious if it is damaged by the

rushing firemen; a young fireman's wife passes into a stressful state and is beside herself with worry, until her husband calls and calms her down. We see various reactions to one and the same sound irritant, since this signal has a different meaning for these people.

Question: what is interesting for us in the estimation of this situation?

Answer: we are interested in the estimation of response of various people to the influencing signal.

Question: are we able to evaluate the quantity of information, contained in the very signal?

Answer: we are able to count the quantity of information in a fire-engine signal, for instance, having coded it in a binary system.

Question: does it play any role for estimating the reaction?

Answer: it does not play any role for estimating the informational reaction of the people mentioned above.

Question: then, by what means is this reaction determined?

Answer: it is determined by means of all previous experience of the given person, his state at the given time moment (a sleeping person is able to react to the signal, but on the subconscious level), both physical and mental-psychological states, and also by way of a behavioral model and level of expectations, accepted by the given person.

Question: is it possible to take all these factors into account accurately?

Answer: it is not possible, since the number of factors, involved in the study, is incalculable.

Let us study a conceptual approach to the description of informational processes in biological subjects, taking into consideration the questions previously presented.

Informational channel

According to Shannon's theory of information, for biological subjects we can introduce a notion of informational channel, which includes the following main components:

Information source → Information transmitter → Transmission channel → → Receiver → User (addressee).

For example, in the case of a sensory system this chain will look in the following way:

Sensory stimulus → Action potentials of receptors → Nervous fibers → → Synapses of neurons in CNS → Central nervous system (CNS) in general

In this case information is coded in a nervous pulse sequence in accordance with a method analogous to frequency modulation. Frequency of neuron impulsation is the universal information carrier.

In neurophysiology the characteristics of information include, for instance, quality, intensity, frequency, location, length, and duration of a stimulus effecting the sensory organ. These characteristics are transmitted in a nervous fiber in the form of a sequence of action potentials (nervous pulses).

Let us examine the channel of information transmission where human consciousness is the user. We can analyze the properties of this information channel.

Informational signals

Every second a human organism receives a large number of external signals. These signals are transported by material carriers, having various physical natures. Let us give some examples:

- Optical radiation is transmitted by photons of various energy;
- Sound is distributed by air molecules;
- Smell is transported by molecules of certain substances;
- Mechanical influences, irritating skin surface, cause tactile senses;
- Electromagnetic signals are transferred by electromagnetic fields.

This list might be continued, but it is already obvious that any processes of the physical world might represent the carrier of informational signals. However, only a part of the received signals is significant for the organism.

We will give the name of informational-significant signals to those received by the organism which trigger inner psycho-physiological processes. Therefore, the significance of any informational signal might be estimated according to the reaction of the organism to that signal. From millions of irritants the organism selects a small part and reacts to these signals by a cascade of inner processes, taking place at the expense of free energy stored by the organism. Thus, the inner organism resources are the energy source of informational response.

At the same time let us stress that one and the same signal might be the source of both an informational response and an energy process. In the present study we are interested only in the informational component.

A certain (rather relative) classification of informational signals might be done:

- internal and external signals, perceived by the organism from the external space and generated by inner systems and organs, particularly, thoughts; and processed at the conscious and unconscious levels;
- energy-informational and purely informational signals, differing in intensity and character of effects, evoked in a biological subject: as mentioned above, stimuli of various intensity cause effects of a qualitatively different nature;
- resonance and non-resonance signals for the given organism.

This classification might be continued and enlarged, however it is important to mention that from the viewpoint of the developed conception the character of an influencing signal is not principal: we consider estimating the subject's reaction to be important, regardless of the nature of an influencing signal. The notion of informational response enables us to carry out this estimation quantitatively.

As demonstrated above (formula 13.8), the quantity of information is determined through the change of the subject's state entropy. Let us introduce the notion of information quantum and on the assumption of constancy of source's entropy express it as follows:

$$dI = \gamma / d\varepsilon \ , \qquad (13.23)$$

where $d\varepsilon$ – unit measure of entropy of the receiver's state.

The main characteristics, resulting from formula (13.23):

1) Information quantum differs from zero in the case of the receiver's state change under the influence of a received signal.

2) Information quantum does not depend on the nature of the signal, transferring information, or on the nature of the information carrier.

Let us take an integral from both parts of the equation (13.33) on the time interval from t_1 to t_2:

$$\int_{t_1}^{t_2} d\,I = I_R \int_{t_1}^{t_2} d\,t = \gamma \int_{t_1}^{t_2} d\,\varepsilon \quad , \tag{13.24}$$

$$\Rightarrow I_R(t_2 - t_1) = \gamma \int_{t_1}^{t_2} d\varepsilon \quad , \tag{13.25}$$

$$I_R = \frac{\gamma}{t_2 - t_1} \int_{t_1}^{t_2} d\varepsilon \quad . \tag{13.26}$$

Let us call the value I_R a parameter of informational response. This value estimates the changes occurred with the given subject in a definite time interval under the influence of the informational signal. Let us call parameter γ the coefficient of informational dependence.

In the study of informational signals, expression (13.26) diverts the emphasis from the source and carrier to the reaction of the subject perceiving information, and provides a practical method for estimating this reaction. In the GDV technique these calculations are reduced to a practical level and embodied in the GDV software. This enables us to estimate informational contents of some or another experiment, according to experimental data, for example, of the channel of information transmission from one person to the other.

Application of probabilistic parameters for the description of GDV-grams. GDV entropy

GDV-gram of finger or water drop represents a figure with radial distribution of density (fig. 13.4), which is characterized by a certain diagram of density distribution. This picture may be demonstrated as function *F(x)* where *x is* an angle within the interval [0,360°]. Parameter *F(x)* may be represented by maximum length of the image radius, median length, brightness, or average values for radius. For a real GDV-gram this function is mostly defined by the nature of the initial image processing, at the same time physical principles of image formation enable to standardize these procedures. As shown by the analysis of numerous experimental materials, a central kernel of GDV-gram and diffusive fluorescence around it might be singled out. The central kernel is connected with the illumination of the canals of electronic avalanches, diffusive fluorescence is conditioned by a sum photon emission of the subject. Having removed this

Fig. 13.4. GDV-gram of water drop processed at 250.

Fig. 13.5. Same GDV-gram processed at 200.

emission from the image, we will preserve only central quasistable kernel, which makes the following image processing easier. Let us save the sum area of the remote image as a separate coefficient BEγ. As produced by the experiments, having brightness range of 0-255, the central kernel takes the range of approximately 0-225-240, depending on the source. Fig. 13.5 presents the image in the range of 0-200, i.e. under diffusive noise removal.

As we can see from many examples of GDV-grams, function $F(x)$ is quasichaotic. This suggests the idea to consider function $F(x)$ as random variable, and calculate associate statistical parameters [Korotkov, Korotkin, 2001]. Let us introduce the integral function:

$$Q = \int F(x)\,dx,\ [0, 2\pi] \tag{13.27}$$

and pass from function F(x) to the normalized function f(x):

$$f(x) = F(x) / Q \tag{13.28}$$

Denote maximal and minimal values of function $f(x)$ by f_{min} and f_{max} respectively. Let us build a graph $P(f)$ of density distribution of values of function $f(x)$ on the interval $[f_{min}, f_{max}]$. Let us also introduce the normalized distribution $p(f)$ by the formula

$$p(f) = P(f) / \int P(f)\,df,\ [f_{min}, f_{max}] \tag{13.29}$$

Obviously function $p(f)$ satisfies the normalization condition

$$\int p(f)\,df = 1,\ [f_{min}, f_{max}] \tag{13.30}$$

Now we are in position to introduce standard statistical characteristics: the mean value f_1, dispersion m_2 and higher moments m_j.

The entropy definition arising in this context is:

$$\varepsilon^{BEO} = -\int p(f)\ln\{p(f)\}df,\ [f_{min}, f_{max}] \tag{13.31}$$

We call entropy ε^{BEO} - **the *BEO-entropy.***

Question: is there any reasonable correlation of function $f(x)$ behavior at certain distances? Are there any repeatable features or elements for the BEO-gram along the circle? The answer is given by auto-correlation function (we assume $f(x + 2\pi) = f(x)$).

$$K(y) = \int (f(x) - f_0)\,(f(x+y) - f_0)\,dx\,, \quad [0, 2\pi] \qquad (13.32)$$

If $K(y)$ *is* close to 0, correlation at distance y is absent; if it has clear peak, it does exist. The characteristic of this function is auto-correlation angle, i.e. the angle at which the function K(y) crosses the axes.

Of course, the proposed statistical interpretation of function F is some approximation to the real process only: in practice there may be certain correlations between the amplitude at different points (probably, there exist both short-range and long-range correlations). Nevertheless, for us the main role of BEO-entropy notion will be just practical: it will allow to introduce natural classification of BEO-gram by "degree of misbalance". Namely, for highly inhomogeneous BEO-grams (which, according to experimental data in turn correspond to unstable human state) the random variable $F(x)$ has high degree of uncertainty, which should lead to relatively high value of BEO-entropy ε^{BEO}. On the contrary, homogenous "quiet" BEO-grams correspond to random variable $F(x)$ with low degree of uncertainty, which should give rise to relatively low values of ε^{BEO}.

The developed principles were realized in a series of programs and tested in practice. The testing has shown a high importance of notion of entropy for the description of GDV-gram. Moreover, the results obtained afford all the grounds to assume that notion of BEO entropy is directly related to the studied above notion of negative entropy of biological subject. Namely, values of ε^{BEO} turn out to vary depending on age and state of human in exactly the same way as we would expect. This question is discussed in more details in part two of this book.

Chapter 14. Fields of biological subjects

Radiation of biological subjects - Transition from a cell to a biological system - Multilevel character of synchronization - Principle of holographic structures - Spatial-field structure of the organism - Structural synchronization in a group of organisms - Levels of organization of space-field structures - Hierarchy of synchronization levels - GDV bioelectrography as a method of registration of field structures

An important role in our notions is played by a concept of biological and informational field. Let us give the main definitions.

***Field** is a method of consideration, when each force creates a "field" around it (i.e. force consists in creating a field), distributed according to the method of a continuum and influencing every body placed in this field (as well as being influenced by every body. Empty in itself, space possesses only the one capacity to contain fields. According to the three types of forces known today, we distinguish gravitation fields, electromagnetic fields, and fields of nuclear forces. Since every energy at the same time represents a mass, and every mass – energy, any field represents a certain mass. Thus, the field theory equates the mass, represented by the energy of an electrical field created by an electron, with the mass of the electron, so that both coincide with each other in the field. Energy and matter merge into a notion of field, which covers both the former and the latter. Matter is nothing else than singularities of the field (field nodes).*

***Field** is a method of consideration, under which every point of space might be associated with a value of some function characterizing the given field. In this sense it is possible to speak about informational space or an informational field for a certain type of information presentation.*

Biological Field is a combination of different types of fields, including electromagnetic, acoustic, gravitational, molecular, and other fields of known and unknown origin, responsible for informational interaction of the particular subject with the environment and other subjects.

The conception of biological fields was introduced in the mid-1930s by an eminent Russian scientist, A.Gurvich. The idea lies in the fact that, in addition to the physico-chemical level, a complex of fields distributed in space is connected with every biological subject. First of all, this is an electromagnetic field, although it is actively discussed that some other fields may exist (microlepton, torsion, vector, etc.). Electromagnetic fields are generated by movement of electrical charges. A large variety of electrical processes continuously takes place in the organism, from the cell level to the level of separate systems and organs. Each of these processes relates to electromagnetic fields. Fields of several systems and organs in the organism are coherent, i.e. synchronized in their activity. This brings us to the conclusion that, being put together, they form a summary field, possessing interference or, in other words, holographic properties. The idea of coherence of electromagnetic fields is being actively developed in modern biophysics, for the most part by the research group of German physicist F. Popp. An interference or holographic field possesses very interesting characteristics - it carries information on the subject - its creator - in its every particle. This means that if such a field is recorded on a hologram, and then the record breaks, every splinter will carry information on the whole subject. Is this not a magic mirror from Anderson's fairy tale?

These notions of an interference field, quite difficult for common perception, were developed in the 1940's and subsequently led to the creation of lasers and holographic equipment. At the same time, these ideas might have been more fully used for research into the biological organism. Let us suppose that the field level is the basic level of the biological systems' operation. This level was embodied in the most primitive biological subjects, long before the vegetative and central nervous systems originated. This level defines functioning of the system as a whole, including the level of coherence of interaction of different parts. It is fully applicable to the plant kingdom, and, as we do understand today, is concerned with the animal kingdom as well.

We propose the concept that the acupuncture points represent a projection of wave quantum fields on the skin surface [Korotkov, Kuznetsov, 1996]. At the same time, from the very principle of field structures it is obvious that the field spreads outside of the organism, theoretically to an infinite distance. Thus, information on the organism's state may be theoretically obtained at quite long distances from the organism. This principle is acknowledged by the healers' activity. The organism's field structure defines processes of morphogenesis, i.e. the development of an organism in the process of development, as well as determining the existence of the organism as a uniform system. Disorders at any level first of all tell upon the loss of control of the organism upon its separate parts, which in turn leads to systematic diseases. The ideas of Gurvich were thereafter developed in the conception of morphogenetic fields by Sheldrake, and later resulted in a holographic conception of the brain and organism structure. These notions, however, have not become wide spread in biology. Yet it is most strange that the measurement of electric parameters of the organism is, at the same time, one of the most powerful instruments in medical practice. No modern medicine exists without the electrocardiogram, electroencephalogram, or electromyogram. These are electrical processes, each of which corresponds to one or another electromagnetic field!

If we accept the idea of the field of an individual organism, an individual human being, we can move on the idea of the collective field by starting at the level of family and progressing

to the work collective, nation, religious confession, and ending up with the level of the whole Humanity. Each of these levels is associated with some field spatial structures or others. Thus the information exchange and the influence of one person upon the other, apart from everything else, also takes place on the field level. Along with the electromagnetic field we can mention other fields, such as gravitational, acoustical, fields of smells, objective distributions of one or another characteristic in space. The role of these fields in the organism's life requires fundamental consideration. These considerations also relate to the notions of the so-called torsion or vector fields, which are being actively developed in modern physics.

Some few years ago we put forward a conceptual model for the structure of biological subjects and their interaction with each other and the surrounding world, based on the ideas of the organism's fields' structure [Korotkov, Kuznezov, 1996]. The notions formulated enable one to present a new view on the functioning of many aspects of biological subjects: their interaction with each other, and various manifestations of biological effects; such as the "program" of forming an embryo, a society "consciousness field," innovative creativity, volitional manifestations of human consciousness, telepathic contacts, influence of people on one another, etc. Let us state the main principles of the model.

Radiation of biological subjects

A phenomenon of ultra-weak radiation of cell structures was experimentally discovered in the first half of the twentieth century by A.Gurvich [1944] and studied in detail in the works of V.Kaznacheev and L.Michailova [1988]. It was shown that ultra-weak radiation of photons was typical of the majority of biosystems, with the exception of some types of protozoa, algae, and bacteria. A.Chizhevsky [1976] and V.Vernadsky [1989] have been the first to demonstrate the correlation of the planet living substance and radiation cosmic flows with considerable practical material.

"Around us, inside ourselves, everywhere and all over, without a break, eternally changing, coinciding, and colliding, there comes the radiation, having different wave-lengths. These range from the waves whose length amounts to ten million parts of a millimeter to the long waves, estimated in kilometers. All space is filled with it. It is difficult and maybe even impossible for us to image this medium, the cosmic medium of the world in which we live and in which, at the same time and place, we distinguish and measure more effectively an enormous mass of radiation, as our research methods improve. Eternal change of radiation and constant filling of space with it makes the cosmic medium devoid of matter and the ideal space of geometry differs widely... Due to this, the substance of the biosphere is charged with energy, it becomes active, gathers and distributes energy, received in the form of radiation, and finally makes it free in the Earth medium, capable of producing work" [Vernadsky, 1989].

In the mid-1960s leading Russian biofisicist V.Kaznacheev put forward a hypothesis that "the quanta of electromagnetic field can represent the most significant material carriers of information flows in biosystems. Perhaps ultra-weak radiation of quanta serves as a regulator of exchange

processes inside the cell in general. Biosystems, in response to outer influences, are capable of implementing reactions connected with multiplication, supression, and also accumulation of electromagnetic signals. Cells and cell populations are functioning as specifically organized devices, emitting and absorbing photons. These devices can be considered as open systems which emit and absorb photons from the external electromagnetic environment, as well as "virtual" photons, received in the process of absorbing material-energy flows of the environment" [Kaznacheev, 1991].

V.Kaznacheev put forward a notion of the biosystem as a "non-equilibrium photon constellation (ensemble)," existing at the expense of constant energy inflow from the outside. This constellation carries out bonds in the cells, which are necessary for the co-existence of protein-nuclein structures." Quantum information is stored in molecular compounds of cellular structures. It can, therefore, be considered as determined that the biological cell is a radiator of a wide range of oscillations, aside from all other characteristics. We will not narrowly specify to which range of wave-lengths these oscillations pertain; whether electromagnetic, or acoustic. For us it is important that the cell emits a wide spectrum of waves, which can be basically characterized by a large total number of frequencies, phases, and amplitudes. Each of these parameters depends on time and varies to a great extent.

Transition from a cell to a biological system

It is widely known that when cells form a biological system their behavior becomes principally different from the behavior of any single member of the system. Examples of such systems might be a yeast suspension, a colony of microorganisms, and, especially, a complex biological organism. We can assume that one of the main reasons for the observed difference of the characteristics of the system from the properties of separate cells lies in the mutual synchronization of radiation, making up this system of cells.

There is an example of synchronization of clock pendulums. Placed on a single movable support, the clock movements will act absolutely synchronously. This is the principle of resonance synchronization. For the resonance to take place, the presence of interconnections of system elements are necessary, through which synchronizing influences are transmitted. In the case of mechanical systems, such as a clock, this influence is a mechanical impulse, transmitted from one clock to the other through a movable support. In the case of synchronizing electronic systems, electromagnetic impulse provides such influence. In the case of biological systems we will not name a specific form of this influence, but will bear in mind that this influence is a necessary condition for the synchronization to occur.

The same process can be considered from another viewpoint. When biological cells form a system and this system reaches a certain level of complexity, it achieves a principally new quality and an explosive bifurcational process of self-organization originates in it. From a number of independent cells it turns into a cellular ensemble, interacting with the environment as a single whole. This transition has a spasmodic character, and since the given system is an

open one, it can be described in accordance with the principles of synergy. The system passes into a new level of organization. The process of entropy decreasing, or negentropy formation, takes place in the system, at the expense of energy and information exchange with the environment. The latter statement is based on notions which were developed in the second half of the twentieth century and which produced a breakthrough, unknown to the general public, but significant in physics.

From the end of the nineteenth century the paradox of heat death arose in physics, i.e. the paradox of the second law of thermodynamics. It claimed that an increase of entropy takes place in all processes of the Universe, which should lead to the diffuse rise of space temperature and, correspondingly, to the heat death of the Universe. This paradox, formulated at the end of the nineteenth century was solved only due to the works of the school of the Noble Prize winner Ilya Prigogine. He created a new direction of science called **synergetics**, studying the processes in the open systems, which under certain conditions might become the processes of self-organization [Prigogine, 1986, 1991].

Summarizing the principle of synergetic behavior in complex systems, we can assume that in biological systems transition to a new level of structural organization is accompanied by resonance synchronization of cellular radiation. This enables one to formulate the first postulate of the present model.

The main condition of functioning in any complex biological system is cellular resonance synchronization. This synchronization is carried out through the effects of both inner synchronizing influences, i.e. influences coming from separate parts of the given system, and outer ones.

Multilevel character of synchronization

We can suppose that synchronization has a multilevel character in biological systems:

- Inner, self-influences for the given system;
- Influences from the other similar systems, i.e. from its own level of organization;
- Influences from higher level systems;
- Influences from lower level systems.

Such a multi-level effect is a necessary criterion for the existence of a biological system, its vital activity is coordinated through these processes. Without inner synchronization it would fall into chaos and a disorganized state ended its existence as a single system. An example of such disorganization is the development of cancer cells, which start multiplying without any coordination with other organism systems and finally lead all others and, correspondingly, themselves to death. Thus, hereinafter we will use a multilevel scheme of structure for biological subjects and the Universe, taking into account that all these levels are interdependent, interrelated, and exert influence on each other both from the upper levels to the lower and from the lower to the upper. Moreover, as shown above, a necessary criterion of biological system existence is inflow of energy and information. In the given model synchronizing influences, flowing to the system from different levels, are correlated with the notion of information.

Principle of holographic structures

Analysis demonstrates that a biological system can be considered as a complex organized set of sources of field radiation, synchronized by frequency and phase. Such sources are called coherent. It is known that superposition of fields of coherent sources forms an interference picture in space. **In other words, a space-field interference structure organized in a certain way appears to be connected with a biological subject.** Such structure is principally volumetric, and the well-known optical holograms are a projection of the given structure onto a photo-material surface in an optical range. However, such spatial structures might be formed not only in an optical, but additionally in any other range of wave-lengths.

Therefore, we postulate that as a result of the functioning of complex biological structure, an interference interaction arises from coherent field radiation by separate elements of the system. For every stable biological system such structure is quasi-stationary, i.e. it changes in time relatively slowly and keeps its configuration in the system of coordinates, related to the given subject.

These notions are not something principally new. At the end of the 1970's a physicist-theorist D.Bohm and neurophysiologist K.Pribram put forward a conception of universal cosmic holograms, or holoversum [Bohm, 1980; Pribram, 1981]. In this conception, which received a wide response in the scientific world, the integrity of the Universum is discussed, with the human and its consciousness as an essential part. The connection between them is defined as unique informational and field holograms, determined by peculiarities of system organization in the human brain.

Along with the standard transfer of nervous impulses between the central nervous system and peripheral receptors or effectors, Pribram paid his attention to the slow-wave potentials between synapses, taking place even when nervous impulses are absent. These slow wave potentials start in the cells with broadly branched dendrites and short or absent axons. While nervous impulses are functioning in a binary "yes/no" mode, slow potentials exist permanently. Pribram proposed that a "parallel functioning" is principally important for the organization of brain activity, and the interaction of these two systems leads to the emergence of wave phenomena, conforming to the holographic principles.

Spatial-field structure of the organism

Within the framework of the given hypothesis we can assume that all former cell population centers, having transformed into some or other organs in the course of development, are drawn into the process of resonance synchronization. Obviously, because of the absence of exact instrumental methods of their identification, weak-character field manifestation, and mutual interference, it is very difficult to attribute these resonance wave centers to specific spatial-morphologic structures of the organism. As a working hypothesis, linking the given notions with esoteric studies and illustrating validity of the applied technique without prejudice to the contents, these centers can be formally connected with the notion of chakras, used by many ancient schools.

We can connect these resonance centers with the seven (or twelve, which are not principal) chakras, known from emperico-esoteric knowledge. In this case the chakras themselves receive quite concrete physical meaning, or rather a more specific scientific interpretation. They can be considered integrated manifestations, generalized by the "traces" of resonance wave centers, which are the most important ones formed in the process of development of individual organs of a biological subject. Their role, as we can suppose, does not result in the rudimentary and residual manifestations, but is demonstrated by the supply and maintenance of the functioning of separate organs and their groups.

It is worth emphasizing that the studied hypothesis develops the notions on chakras in only one specific aspect. It proposes general synchronization, or coherence, for field structures of every chakra.

Perhaps it is this phenomenon which lies at the basis of the living organism development from the stage of an impregnated cell, explaining the "executive mechanism" of a differentiation process. In order that cytodifferentiation of a particular organ begins in a certain place in an embryo, initial cellular structures should "know" where they are, i.e. possess information on a three-dimensional spatial interposition. It is evident that no electrochemical or other "isotropic" mechanisms can be held to be responsible for the explanation of this phenomenon. Field structures, in their essence, are volume-spatial, principally giving a physical base for the explanation of how does the mechanism of "plan," "sketch" of origin, and development of an embryo work.

In the first stage of embryo development, during the phase of weakly differentiated cell populations, the spatial-field structure of an embryo blastula has a simple spherical character. At this stage, separation of cells for the realization of the next step of organism differentiation on account of spatial symmetry of this structure can be implemented in any place in the sphere of the given radius in this population. After the emergence of the area of the differentiated subpopulation and the rise of its own field structure (owing to the mechanism of resonance synchronization), these two structures already set a spatial axis, decreasing the freedom of choice for the place of the next sub-populations' origination. This fully sets out the spatial position of the organisms topological structure. We can assume that in each of these stages the forming field structures participate, in some way or another, in the process of the structuring of populations of differing cells for the formation of embryo organs.

It is quite possible that, changing during the process of organism development, principally the same structures are kept in all the further progress of biological life for a given individual organism. These field structures can be associated with the chakras.

In the present work, the holographic, or interference principle is applied to the level of the integral organism. From this, in particular, it follows that the studied wave structure might be directly connected with the system of acupuncture points and channels. Attempts over many years to find the special nature of these points have not been crowned with success. From the viewpoint of the given hypothesis this becomes understandable:

acupuncture points are not modified cells, as it was once believed, but only the projections of main elements of a spatial-field volumetric structure onto the skin surface.

For example, consider a projection of the extremums of the standing wave front. It is possible to fix the optic wave front, carrying full information on the subject, on photo-material,

as well as in the case of acupuncture channels where a momentary "shot" of a spatial wave is fixed on the skin. Hence, it becomes clear why no morphological elements were found under acupuncture points. These elements simply do not exist.

A number of conclusions follow from the postulation regarding the holographic character of a wave field of a biological subject. These conclusions are valid for any complex organized biological systems. Indeed, acupuncture points are found both with animals and plants, but for convenience we will carry out further discussion as applied to the human being.

First conclusion: ***Biological subjects can have more than one, in fact infinitely many, spatial-field volumetric structures, thus there might be many systems of acupuncture points and channels.***

This conclusion is confirmed by the present notions. There is the classical Chinese system of acupuncture points and channels. There is an Indian system of energy centers (chakras) and there are systems of Voll, Acabane, Reodaraku, and Su-Jok, developed in recent years.

Second conclusion: ***Main elements of the given spatial-field structure might be found in any arbitrarily small part of it.***

This statement is well confirmed in the example of acupuncture channels. It is known that practically all points are observed and represented in or on the ear, on the eye iris, hand, toe, back, etc. In principle, any part of the skin surface can be used to find the points corresponding to all systems and organs of the organism. However, the smaller the part we use for identification, the smaller is the accuracy of the result.

This principle lies at the heart of a holistic approach to the understanding of the Universe, naturally inherent in the sacred philosophy of the ancient East. A wonderful illustration is a description of the necklace of Indra, the God described in the ancient Sanskrit text "Avatamsaka-Sutra:" "In the heaven of Indra such a miraculous pearly chain is spread that if one looks at a stone, all other stones are reflected in this chain. The same way, any subject in the world does not exist on its own, but is connected with all the other subjects and, in principle, with all those existing in the world." Similar descriptions can be found in the philosophy of Jainism, Zoroastrianism, Japanese Kegon, and Chinese Hva Yang. In the Chinses texts this principle is given by the formula: "All in Everything; All in One; One in One; All in All."

Third conclusion: ***Spatial-field structure is not connected with the body limits and is extended beyond its limits. We approach the notions of the complex field structure - multi-layer aura around the body. The idea of the aura is widely known both in Eastern and Western esoterics. This aura is nothing else but an interferential field structure, distributed in space.***

Fourth conclusion: ***Such a structure has principally no limits and exists in all space, although resolution of its structural elements might be changing as it moves away from the subject.***

This extension in space gives an opportunity to understand why diagnostics or influence on a subject is in principle possible at practically any distance from the subject. The spatial-field structure carries quite complete information on the subject which generates the field, and using this information it is possible to reproduce a picture of structure of this subject. Such an approach is widely used in modern holography. The same principle enables us to understand the phenome-

non of telepathy without introducing notions of some material carrier for the transferred information. To realize a telepathic contact, synchronization of a percipient with an information-field structure is needed. Mechanisms of such synchronization should be studied specifically.

Structural synchronization in a group of organisms

In the previous section we introduced our main notions on the functioning of biological systems of the organism. Now let us study a group of biological organisms forming a system. All the considerations given above are also applicable to this group. Each separate organism of this group might be characterized by its own radiation, having a certain number of frequencies and phases. Within the process of synchronization, these organisms can together form a new single system, which will have its own space-field structure. All the postulates and conclusions given above are fully applicable to this structure. It is another level of organization in relation to the structure of each particular person. This highest level structure is formed through the effects of their radiation and, at the same time, sends its own synchro-signals to every system.

Now let us pay attention to the experimentally determined fact that all the people on the Earth, regardless of sex, race or age have principally the same field structure - the structure of energy channels. This fact was established in ancient China and India and experimentally confirmed by the finest modern research. Of course, this structure is a kind of modeling, based on the principle of averaging, and it varies according to the state of every person, but is statistically reproducible with high accuracy. (Note that the given notion pertains to any biological system, whether cultures of microorganism, plants, or animals. Here, however, we are mostly interested in the space-field structure of the human, which has been studied most of all). Some groups of people can form a single space-field structure. According to the general principles of holography, the structure of this system will be analogous to the structure of each particular person. A natural question arises: what is the necessary condition for this structure to be formed? From the principles under study, it is obvious that the structure of each following level appears when the synchronization process takes place on the previous level, i.e. in the given case, when a mutual resonance synchronization is observed from the radiation of separate structures relating to particular persons.

The first level of such synchronization is the level of a small group of people. As we see in practice, such synchronization can be compared with the deepest individual processes such as love, relationships between children and parents, brothers and sisters - especially marked in identical twins, as well as true friendship. When such structure is being formed, every component system stops being independent, and becomes a cell of a more general space-field structure. An effect on any element of this structure, as well as on all this structure as a whole, therefore influences all the components of its system to varying degrees. It becomes clear that deep feelings are not simply sophisticated manifestations of sexual attraction, but are the reaction of an organism to the formation of new space-field structures. The formation of these structures is organically

typical of a human, because of a number of reasons we will discuss shortly. This is why such deep feelings give rise to a great uplift, trembling, so many emotions and spiritual activity.

A human can be an element of many similar structures at the same time. It can be a loving husband or wife, a good son or daughter, or a wonderful friend. Depending on a role performed at any moment in life, each of us uses a part of our field necessary for a certain situation. Hence, we understand also the dependence of children on parents and the necessity of such dependence for the formation of human structure.

The next level of structuring is the level of ethnos, i.e. a group of people, joined by a unity of territory, religion, language, and concepts. Individual space-field structure is typical of each human and each ethnos. This is that very spirit of nationhood, this concept having been argued about by philosophers and historians for thousands of years. Within the scope of this model it becomes clear that the spirit of nationhood represents a structure, really existing in space and having its characteristics and properties. According to holographic principles, these properties show up in every element making up the structure, i.e. in every human included in it. Here we come to an understanding of the nature of national processes, always a burning problem for humanity, which again became more acute at the end of the twentieth century.

And, finally, the next level is the level of the whole of humanity, forming its own structure in the Universe and smoothly passing on to the level of Cosmic Consciousness.

All these structures have principally no limits, they are spread all over the Universe, they interact and interfere with each other. Evidently, the manifestations of these structures are multiple regular nets of various levels, registered in biolocation, like Kerr nets [Dubrov, 2001].

These structures also form a "program" for embryo development from an impregnated ovule. Molecular properties laid on the DNA level determine the belonging of the substance being formed to one or another species, i.e. fix a quasi initial code, and give certain nuances in the process of development (skin and hair color, nose form, etc.). The program of development is, however, set by space-field structures, formed by all the other members of the given species. Hence, a conclusion might be drawn that it is practically impossible for an individual to be developed in the absence of the other members of the given species. So, stories about hatching dinosaurs and "snowmen" will remain a fantasy. These notions are substantiated by the experimental fact that, on the level of an embryo, properties of other species are formed, under the influence of a "collective biofield" [Kaznacheev, 1991].

Levels of organization of space-field structures

Let us draw some conclusions, by introducing ideas on a few hierarchical levels of organization for space-field structures:

a) Cell level (although it is obvious that other lower levels exist);

b) Level of an individual organ;

c) Level of biological organism as a single system;

d) Level of a group of organisms unified and synchronized with each other;

e) Level of a large group of people, i.e. ethnos or nation;

f) Level of Humanity;

g) Level of Cosmic Consciousness.

As we have argued, structures of every level exist as a result of a resonance synchronization of elements that is based on information exchange. Such an information exchange takes place both inside each level and between all separate levels. Each individual element of the given level might generate information signals of different volume and direction. Interacting with each other, these signals are inter-increased and inter-eliminated, and all in all form a unified information signal, influencing the structure of both higher and lower levels. Analogously, this structure also forms information signals influencing its components, and the formation of all these signals takes place on the basis of self-organization principles.

Hence, it becomes obvious that the destruction of a certain portion of elements of the given system will not affect its functioning until the information signals of the rest of the elements will be enough for the resonance synchronization of all the system elements, i.e. for the maintenance of the existing structure. When this condition breaks, a more or less strong distortion of space-field structure takes place, which leads to the distortion of information signals of a higher level with respect to a lower level and, correspondingly, to the dysfunction of the weakest elements of this lower level.

We introduce the concept of **"critical creative mass"** as an important consequence. It means that the generation of creative activity can take place only at the presence of a certain amount of population forming its structure and, correspondingly, its information matrix, at a given place. Creative activity here is represented as a generation of certain ideas, interaction of these ideas with the information matrix, amplification and over-reflection to the source of these ideas (but, at the same time, to the other people and groups of people). This fact explains a simultaneous birth of the same ideas with different investigators, often in several parts of the world, which has repeatedly been evidenced in the history of science. The deepest necessity of creating cities and their role as cultural and scientific centers now becomes clear. The same process limits the level of development of nations based on tribal or family groups: in the process of development they do not form significantly large stable groups, needed for the formation of complex fields of consciousness.

A natural objection arises: what about the hermits, and why the greatest thinkers have always left big cities to generate great ideas? The answer to this question follows organically from the proposed hypothesis. The field of collective consciousness, structuring and amplifying new ideas, at the same time, imposes its restraints. New ideas become a part and development of the already existing ones, i.e. a part of the existing paradigm, formed on the given level of structuring. If some person feels that a new idea is coming, that is feels a possibility of contacting the consciousness field of another level of structuring, he should be maximally freed from the influence of this level for a verbal formulation of the new ideas. However, a further development of these ideas and structuring of the consciousness level by the new ideas is possible only in a big group. Moses, Buddha, Christ, Mohammed left for the desert for solitude and meditation, but then returned to people and preached their ideas amidst many tribesmen, and the revolutionary ideas of each of them were presented in a usual form, were connected with

the previous paradigm, and prima facia seemed to be its development. This is why they were developed and widely spread. Otherwise the ideas collapsed, even being introduced on the highest level, as it occurred in the notion of a single god by Pharaoh Amenhothep IV or in the idea of the flying apparatus designed and sketched by Leonardo da Vinci.

It is reasonable to assume that synchronizing signals of different levels are characterized by various frequencies, for example, higher and higher ones. At the same time, it is quite possible that this information is transferred due to non-electromagnetic radiation. Concepts of new types of interactions in Nature are being actively developed now, for instance, a concept of material flows of time (by N.Kozirev) or multidimensional space-time domain (by William Tiller). From this thesis it follows that the distribution of synchronizing radiation between various layers of hierarchy might be asymmetrical: the influence can be easier distributed top-down, than bottom-up.

Hierarchy of synchronization levels

We can introduce the notion of a hierarchy of synchronization levels, that is levels owing to which information synchronizing signals are formed. In our opinion, the first level of this kind is the level of functional organization, i.e. the level responsible for solving one or another problem in the organism. Systems of respiration, digestion, blood circulation, etc. pertain to this functional level. All these systems are inter-correlated and synchronized, i.e. according to our notions, they exchange information signals with each other and send these signals to the systems of the next or higher level, of which the following are worth mentioning:

- Level of reflex behavior, providing for functioning of the organism as a single whole, as a single biological system. On this level both information and energy exchange with the environment is important. Signals of the reflex behavior level account for the generation of new structures, connecting a few individuals into a single system.
- Level of conscious behavior of a human or animal, leading to performing of some conclusions, decisions and actions – a decision to take a certain type of food, stay awake or sleep, stand or lie, run or walk. All decisions, relating to normal vital activity are made on this level, although they are organized and directed by the signals from previous and next levels. For example, an animal will not be hunting for food if it does not feel hunger, i.e. if the corresponding signals from physiological receptors are not sent. At the same time, such signals can be represented by aims at certain reflex behavior, for example, necessity for copulation or building a nest for posterity. They can also be shown in the form of developed conditioned reflexes: Pavlov's dogs barking with the ring of a bell, or a person drinking a cup of coffee in the morning.
- Level of simplest mental work, not directly connected with physiological needs, although dependent on them. This level is typical of a human being and is also found in the higher orders of animals. On this level decisions are made for storing food, building a house for future cold weather, etc.
- Level of complex mental work connected with self-realization, rational construction of images, calculating logic and predictable situations, etc. Such activity is typical only of humans,

it determines current functioning in many respects - as well as activity of the previous level, and it rarely brings about the creation of new field structures. Such activity is purely operational, auxiliary for successful surviving of both an individual and a species as a whole. Information signals coming from these levels, however, determine simple collective structures, formed on lower levels in many respects.

• Level of movement of the unconscious or soul, that is the level determining the formation of both afunctional structures and collective space-field networks. By afunctional structures we mean quasi-stable formations, related to abstract notions like duty, honor, platonic love, creative work, etc., conflicting with rational functional behavior. Collective networks are structures like political parties, unions, religious, and military communities. These structures are characteristic of their own level of formation of synchronizing impulses, which can be compared with the notion of the collective or unconscious.

And, finally, we can speak about the highest level of synchronization, connected with receiving synchronizing impulses not from the next hierarchical level, but directly from the Highest Level. This phenomenon can be referred to in such processes as "intuitive" creativity in art and science, creative or religious illumination, "contacts with the highest mind," healing, and paranormal effects.

All these levels influence and depend on each other. Influence on one of them brings about an indirect reaction in all the others. Again, based on general principles, this effect is stronger top-down than bottom-up. We can thus distinguish two types of structuring: these are the levels of functioning and the levels of synchronization.

GDV bioelectrography as a method of registration of field structures

The notions given in this chapter are designed to give a better understanding of the principles of GDV-gram analysis. We register activity of the organism biological field. This field is not a constant hard structure but a living, fluctuating, "breathing" cloud, localized in a certain space area, but having no strict boundaries. For some time it is almost constant and stable, thus two exposures taken in short intervals give an apparently identical or very similar image. But suddenly, in reply to another field or signal imperceptible for us, it shakes, and a smooth wave comes through all the structure, responding in all its parts. This is like clouds: they are stable on an overcast day, but even in this stability we see changes.

All this is demonstrated by BEO-grams. Look at a dynamic picture of the GDV fluorescence. It lives, it fluctuates, but it is definitely seen how it keeps the properties of its structure. However, even these properties are not fixed. They are transitional. In all natural phenomena transitional areas play an important role - the transitional areas but not distinct boundaries between two space areas. We fly in a plane, a white shroud of clouds in the window, but it starts thinning out, a gleam of the earth beneath, and in a few moments a bright sun shines into

the cabin. The yellow waters of the great Amazon river flow into the ocean, and from above a clear transition area of their merging with the light blue salty waters of the ocean is observed. The color of this area is changing, it is almost constant in size, but an attentive look will easily find its fluctuations.

Similar dynamics pertain to BEO-grams. They are stable, reproducible, but they are living, fractal, and fluctuating. Therefore, the boundaries of the sectors are not well-defined, and, as a matter of fact, these are not boundaries, not discriminating lines, but transitional areas. It is this ambiguity in which the GDV method's complexity lies, but here also is its force. Ambiguity can be interpreted as a possibility of some or other decision, some or other conclusion. And here we see a general tendency of transition from strictly deterministic situations to the probabilistic ones. This tendency, a transition from hard rigid systems to living and dynamic ones, is a characterizing transition from Newtonian mechanics to the physics of the twenty-first century.

We see the dynamics of change, and these dynamics show "breathing" of the biological field. The field, which strives to compensate for defects and dysfunctions of the organism, permanently redistributes resources and changes the organism inner medium for the maintenance of homeostasis - an optimal state of work of all functional systems under given conditions. The field works as a single entity, a single system, with system interaction and interference of all organs and structures.

To reveal the changing bio-field today we actively pass from static GDV-graphy to the dynamic. This transition has become possible only recently, allowed by the emergence of a new generation of personal computers. Actuating pulses are applied within given time periods, 10 seconds for example, and a "film" is recorded - a consecutive series of exposures, followed by mathematical analysis which enables revelation of the dynamics of fluorescence changing. In the simplest variant this is a geometrical averaging followed by singling out stable repeatable elements. A more complex analysis assumes creation of time dependence of changing GDV parameters, so the next step is the visualization of dynamic pictures of biological fields in real time.

Chapter 15. Essay on Consciousness

The modern world is developing under the badge of materialism. Here lies its force, and here lies its weakness. When Descartes declared the independence of the soul and the body, he provided an opportunity for scientific knowledge of the world. From then on the soul has been a prerogative of the church, the body - of medicine and biology. Western science started its rapid development, without looking back to the dark shadow of the inquisition. Having brought great achievements in treatment of acute and infection diseases, this approach reached a deadlock solving the problems of chronic, as well as psychosomatic, diseases. Medicine continues considering a human as a physico-chemical machine, although in common discourse medicine does not deny the importance of the psychic factor. Methods of treatment are mainly based on statistical data, a physician does not have time to deal with an individual person. However, we now approach an understanding that the influence of feelings, senses, and emotional experience becomes not only important, but determining in our life. These notions support holistic ideas on the essence of human nature. To clarify the following arguments, it is expedient to introduce definitions of the notions used.

Consciousness *– endless, self-regulating substance, having nothing to be mixed with, source of movement, necessary part of all the living, having similar characteristics for animals and humans.*

Consciousness *– absolute, transphenomenal dimension of a subject in the light of existence. It does not have contents and consists in the affirmation of a transcendent object, i.e. an object which is seized by consciousness owing to the fact that it transcends itself.*

Consciousness *– multiparametrical perpetual continuum of states, undergoing continuous dynamics with an unlimited quantity of transitional states.*

The conscious *– that which is recognized by an individual, who can verbalize everything connected with it and be aware of his actions.*

The subconscious *– level, reflecting the transition from the sphere of the realized to the sphere of the unconscious, and vice-versa.*

The unconscious *– the basic mass of neuro-reflex acts, which although it is in functional interaction with the conscious, is never recognized in common conditions.*

[Shostak, Litaev, 1999].

Relation between the psychic and the physical*. For many centuries philosophers have been theorizing regarding the nature of consciousness and its interaction with the body. At present two main concepts dominate. According to one of them, processes going on in the brain in response to the presentation of sensor stimulus are identical to subjective senses. These two aspects are just different ways of studying one and the same phenomenon - brain functioning. This is a* ***monistic*** *viewpoint. From the other viewpoint,* ***dualistic****, the brain is a complex instrument of consciousness (or soul), independent of it. The problem of the relation between the psychic and the physical can not be solved using methods of natural sciences. It is impossible to set an experiment, which would disprove either the monistic or dualistic viewpoint.*

[Popper, Eccles, 1975]

Holism *(from Greek hólon - the whole) – a study of wholeness. Holism proceeds from wholeness of the world, unifying the spheres of psychological, biological, and finally, the most outward, although the most rational - physical reality. All these spheres represent a simplification and isolation of this ambient wholeness.*

[Philosophy encyclopaedia, 1998]

We adhere to the concept, within the scope of which a human is considered not just as the physical body, capable of producing thoughts, like liver produces bile, but rather as a triple, unified essence: physical body – consciousness (information structure) – the highest essence; in other words: the body, the soul, and the spirit.

A considerable part of our research is dedicated to the study of psycho-physiological states of the human, particularly, altered states of consciousness (ASC) by the GDV technique. Several chapters of this book are dedicated to this issue.

On the modern stage **altered states of consciousness (ASC)** are interpreted as the states of consciousness, qualitatively differing in the nature of human behavior and in energo-information mechanisms from common consciousness states. ASC are divided into the **artificially evoked**, **spontaneously arising**, and **psycho-technically conditioned states** [L. and D. Spivak, 1996; Newberg and D'Aquili, 2001].

Artificially evoked states are ASC appearing under the influence of psychoactive substances or psychoactive procedures (examples may be taking of psychotomimetics or sensory deprivation/overload).

Spontaneously arising ASC might emerge under common circumstances for a certain person (for example, falling asleep or having considerable stress), as well as under unusual or extreme conditions of life and work of a healthy individual.

Psycho-technically conditioned ASC accompany processes of psychic regulation or self-regulation in modern psychotherapy, regulation by way of extrasensory influence, as well as religious-magic ceremonies in traditional cultures and subcultures. As a rule, exciting (e.g. autogenic training according to Schulz) and calming (e.g. holotrophic therapy according to Grof) psycho-techniques are distinguished.

At the present stage, main research on ASC is being developed within the scope of the transpersonal paradigm. It was founded by the beginning of the 1970's by A.Maslow, A.Satich, S.Grof, et al. within the scope of psychology, and then rapidly spread to the other branches of science on the human. Transpersonal psychology is considered as the "fourth force," successive in relation to behaviorism (the "first force"), psychoanalysis, and humanistic psychology ("second and third forces," respectively). The essence of this construction consists in the fact that the object of the "first force" application is mainly consciousness, "second" – subconsciousness and unconscious, "third" – superconsciousness, and "fourth" – hyperconsciousness.

Hyperconsciousness includes a group of states, providing for the activation of hidden reserves of the brain and organism, the state of creative insight, and a group of transcendent states. All the mentioned transpersonal states are usually called altered states.

A lot of research seems to show that people who experience positive mental training enjoy much higher levels of psychological and even physical health than the public at large [Unestahl, 1986, 1996, 1997]. Statistical studies have shown that in general, even mild mystical and spiritual experiences are associated with higher-than-average levels of overall psychological health, expressed in terms of better interpersonal relationships, higher self-esteem, lower level of anxiety, clearer self-identity, an increased concern for others, and a more positive overall outlook on life. [Newberg and D'Aquili, 2001; Koenig, 1999; Greyson, 1993].

Today we encounter a paradox which arose in the sphere of investigating psycho-physiological correlates of ASC. On the one hand, a lot of material has been gathered, quite fully representing all main types of ASC. On the other hand, practically no specific patterns of brain activity have been found for ASC. Even more so, no electrical waves of a specific type have been found. Moreover, some infreguently mentioned patterns disclose a tendency to attenuation of brain activity as the ASC becomes deeper. Under this impression a number of leading research groups have strengthened their viewpoint that the brain support of ASC is either unessential or develops in some specific way.

Spivak proposed a table, where most representative observations of ASC under meditation are gathered (table 15.1) [Spivak, 1996]. In addition, if each mentioned type of brain activity is not specific for ASC, the consistent combinations of them are quite specific. It is advisable, therefore, to take not separate types of brain activity, but rather their chains, as the unit of correlation accompanying dynamics of ASC. Hence, of course, questions arise on the length of a minimal chain, direction and character of its development, method of joining to the other chains, ratio of inborn or acquired conditions of their formation, etc.

Moreover, it is worth taking into account that the characteristics of brain activity under ASC are heterogeneous and contradictory. Apparently, it is more expedient to consider ASC as a

special modus of brain activity on the whole. In this connection, conclusions by N.Bechtereva et al. about "high generalized reactivity" of the brain in onto- and filogenesis are quite fruitful.

At the same time there are a lot of data that prove strong connection of the ASC with activity of the autonomic nervous system. Many early studies demonstrated that practices such as tantric yoga and transcendent meditation, for example, are associated with significant changes in heart rate, blood pressure, and breathing – all of which are controlled by the autonomic nervous system [Murphy, 1993; Kandel et. al., 2000; Newberg and D'Aquili, 2001].

As it is written by Newberg and D'Aquili "The ability of human ritual to produce transcendent unitary states is the result, we believe, of the effect of rhythmic ritualized behavior upon the hypothalamus and the autonomic nervous system and, eventually, the rest of the brain. Studies have shown that participating in spiritual behaviors such as prayer, religious services, meditation, and physical exertion can lower blood pressure, decrease heart rate, lower rates of respiration, reduce levels of hormone cortisol, and create positive changes in immune system function. Since all these functions are regulat-

Table 15.1. Psycho-physiological correlates of ASC in the process of meditation [Spivak, 1996].

Meditation phases	Character of brain activity	ASC type
Initial (transition to meditation)	A. Some increase of left hemisphere activity B. General increase of alpha-rhythm (8-13 cycles/second)	Transition to meditative-specific kinds of activity Progressive muscular relaxation
Advanced	A. Pronounced shift to right hemisphere activity	Calm concentration on meditative-specific kinds of activity
Deep (discrete episodes)	A. "Bursts" of frontal-dynamic theta-rhythm (5-7 cycles/second) B. "Bursts" of high amplitude beta-rhythm (20-40 cycles/second) C. Short, focal, epileptolike "bursts" of delta activity, limited by frontal part	"Fall-through" to an "ocean feeling", preserving self-consciousness Deep insights with limited self-consciousness "Fall-through" to ecstatic feeling with a temporary loss of self-consciousness
Deep	A. Dying of both left and right hemisphere activity B. "Hyperfrontality" (heightened consumption of glucose in the frontal parts of cortex)	Processing of deep personal complexes and transpersonal problems
Concluding	A. Heightened synchronization of alpha-rhythm in various parts of the brain (frontal, parietal, cervical, temporal).	Successful conclusion of meditative-characteristic kinds of activity
Track	A. General heightened tonus of cortex under decreased tonus of limbic system	Heightened level of perception on the background of decreased emotional level ("skilled response")

ed by the hypothalamus and autonomic nervous system, the effect of ritual upon autonomic states seems clear."

Newberg and other scientists are finding that humanity's diverse array of devotional traditions have a powerful biological reality. During intense meditation and prayer, the brain and body both experience signature changes, as yet poorly understood, which could yield new insights into the religious experience and, one day, even provide clues to living healthier, more fulfilling lives. Already, scientists say, the young field has provided evidence that these meditative states — which rely on shutting down the senses and repeating words, phrases or movements — are a natural part of the brain and that humans are, in some sense, inherently spiritual beings.

"Some will interpret the research as evidence that God is a product of the brain, while others will say it is evidence that the brain is a product of some higher power's hand — that, as Benson put it, "perhaps God gave us the mechanism to understand and experience God in a certain way" [Newberg and D'Aquili, 2001].

"Prayer is the modern brain's means by which we can connect to more powerful ancestral states of consciousness," said Gregg Jacobs, an assistant professor of psychiatry at Harvard Medical School who has published several studies of the way brain waves change during meditation. With meditative states, people seem to turn off what Gregg called "the internal chatter" of the higher, conscious brain. During meditation, researchers have observed increases in the activity of the "theta" brain wave, a type that moves slowly and is known to inhibit other activity in the brain. Based on a preliminary analysis of recent data, Gregg said he has observed inhibitory theta activity coming from the same area of the brain, called the parietal lobe, that contains the becalmed oasis during prayer. Eventually, researchers hope that they can identify a common biological core in the world's many varieties of worship.

Conclusion

A physical body belongs to the material world and obeys its laws. A human informational structure which can be associated with the soul is a field structure, and the laws which we use to describe various fields are applicable to it. We can hypothetically speak to the idea that in its diversity the informational field is adapted to more and more sophisticated forms of biological life. Each of the steps can be characterized by the main properties and notions, schematically given in table 15.2.

And in this hierarchy we see a transition from material forms of life to the informational field forms of life. Therefore, when we speak about metaphysical levels, we consider the next level of reality, being not material, but based on several forms of material existence. This is the level of the super-physical, the level of ideal, the level of the Soul and the Spirit. This is the highest step in our hierarchy, at the same time, it is the basis of everything. Thus, it can be seen that this

level is based on all the previous and, at the same time, is their basis itself. In the process of development of the Spirit, it has come to a certain phase of self-expression and represented one of its endless essences in the form of Matter. In the process of self-development, Matter came to the creation of mind and to the moment of creation of the Spirit. The spiral closed. Therefore, we can speak about closing of the levels, about their coiling up in a spiral, having no end and no beginning, like the ring of Mobius. Would we step in any point of this ring, we can receive information on all the underlying levels, and in principle, about the upper ones, as well. It is only necessary to set a question. To find a complex method of approach.

And this approach turned out to be the GDV bioelectrography technique.

This is the first experimental technique, which considers not separate levels or steps of the ladder of Life, but casts a glance at all the levels simultaneously. Why is it so? Because in its very principle the method of bioelectrography is a method of stimulated response. An impulse is applied – an organism reacts to it according to its state. And the main secret of the method lies in the nature of this impulse. What is an organism? It is a spatial-field material structure, functioning on the principles of resonance. Therefore, when we apply a short impulse, containing a wide range of frequencies in compliance with a Fourier expansion, we receive a response in all the frequency band, i.e. on all the levels of the studied hierarchy. The more complex the system is, the higher are the levels of organization that participate in this response. For non-organic systems these are physical levels, for plants – biophysical, animals enable psycho-physiological reactions. Considering a human we take into account all the mentioned levels, and who knows what are other Universal levels, with which the highest forms of behavior are connected!

Thus, an experimental technique found itself in the researchers' hands, enabling information reception on the most diverse manifestations of Life. Of course, we do not yet understand this information in all its fullness. We can only intuitively feel its depth and richness. Results reached in recent years, however, leave no doubts as to the importance of these perspectives being opened.

It is worth mentioning that the importance of techniques for registering human body fluorescence was indicated by many gurus. In the works by Blavatskaya, Elena Rerich, Saint Germaine and many clairvoyants, the importance of techniques for investigating human fields for the science of the twentieth and twenty-first century is emphasized.

"Every thought of an individual, his every mood and sense instantly reflect on the radiation. This radiation is expressed in light and colors, clearly seen by keen vision... Human auras are glowing and flashing with shades of all kinds of colors. Pure, wonderful thoughts and feelings produce respective colors; dark, low concupiscence, emotional experiences, and passions – dark, smoky, muddy, and ugly forms of low lights... In his aura a person carries his health, happiness, and light, or diseases, grief, sufferings, and darkness" [Grani Agni Yogi, 1969].

In our concepts and practical work we adhere to the dualistic philosophy, consisting of the belief that a human body is a perishable cover, which is the carrier of the immortal soul. As a radio set is just a material transformer of field information, in the human body, the brain processes and produces information, being tuned into collective fields and resonating with the Music of Heavenly Realms. This dualistic viewpoint is principally unprov-

Table 15.2. Main principles of GDV phenomena interpretation.

LEVELS OF COMPLEXITY	PHENOMENA
Physical	Interaction of electromagnetic field with an object Gas discharge Processes on the surface Gaseous medium
Biophysical	Body impedance Skin properties Perspiration Gas emission
Psycho-physiological	Nervous system Influence of emotions and consciousness Somatotopic organization of brain Functional asymmetry of brain
Energo-informational	Entropy balance Fractality Connection with age
Field	Individual biological field Collective informational field
Consciousness	Triune essence of Human Body – Informational structure – Spirit

able, at any case from the perspectives of modern science. It should be either rejected or accepted. Next, using it as initial postulate, a system of philosophical notions and practical descriptions can be developed. Having accepted the idea of a Divine essence of the human, we receive an answer to many fundamental questions in life: what is the purpose of human existence? How does the development of Mankind go? Life on the Earth – a layer of active mold generated by chance or a Divine predestination? These questions will be discussed in one of the next books. In general, the centuries-old history of Mankind demonstrates that by trusting in the Highest Mind, trusting in God, many life questions and situations become clear and simple.

At the same time, this viewpoint determines many aspects of practical activity. One of the purposes of our work lies in connecting a scientific approach to the investigation of phenomena of life with a religious-philosophical approach. The twenty-first century is a century of biology and, first of all, a science of the Human. Developing a technology without taking into consideration its main user – the common individual – leads civilization to the brink of a precipice. World wars with mass destruction of population, nuclear deterrent, pollution of the environment – all these are results of a soulless way of development. The civilization should serve a single common person, and not some abstract idea in the service of State or Monopoly. Civilization should be directed, first of all, to the development of the spiritual essence of a person. We keep to a concept that the History of Mankind is not the history of wars and instruments of production, but the history of development of the Human Spirit. From a tribal Cannibalism to the world Society, united by global economics and the information web Internet.

Moreover, one of the main problems in Russia is an absence of spirituality in society, handed down by the communist regime. Renascence and the rise of humanistic ideas, development of respect for an individual person, inner self-esteem – herein lies one of the urgent aims for the coming decades. Without spiritual regeneration of society, it is impossible to reach another higher level of life and material well-being.

Therefore, to our mind, the promotion of ideas of spirituality is very important, and, especially, a demonstration by scientific techniques of the role of human consciousness in the material world. We can reproducibly and quantitatively measure the influence of one person on another, and the influence of a person on a physical process. Therefore, a thought represents not merely electrical impulses in the nerve net, but also a part of the transpersonal process, connecting each of us with the Universal Mind and uniting all of us in a single informational space.