BIOEFFECTS MODULATION ELECTROMAGNETIC FIELDS IN THE ACUTE EXPERIMENTS (SUMMARY RUSSIAN RESEARCH)

Grigoriev Yu.

State Research Center – Institute of Biophysics of RF, Russian National Committee for Non-Ionizing Radiations Protection, e-mail: pgofgrir@rambler.r

The obtained data have specified the possibility of the effect of EMF modulation on the development of biological effect at a level of composite systemic interactions in an organism. It allows to discharge modulated EMF in the special group of radiations, which biological effect depends not only from magnitude of an absorbed energy, but also on the form of modulation "addressed" to this or that functioning system. It determines the conclusion, that at an assessment of modulated EMF danger, it is important not only to assess magnitude of an absorbed energy, but also the fact of contact of the human with this aspect of radiation. This circumstance brings in major indeterminacy by development of the EMF standards.

For last two decades series of outcomes of the scientific examinations indicating a singularity developments of bioeffects at exposure of modulated EMF (MEMF) in comparison with a continuous regimen (CW) were published in Russia and abroad.

The potential value of this phenomenon, in our judgement, yet is not realized by scientific community by way of an assessment of electromagnetic danger for the population. The approaches of the count of singularities of the MEMF effect till now are not defined by development of the conforming hygienic standards. It is important, that at some situations the biological effect will be determined not by an absorbed energy, but by the kind and character of EMF modulation.

Unfortunately, the results of the examinations conducted in Russia on a biological effect of modulated EMF till now are not known in the West and in the USA. The exclusion is only review by Pakhomov and Merphy, which has yielded the first information on outcomes of these examinations in English.

The analysis of results of 28 experiments is submitted, in which they have utillized modulated EMF of radio-frequencies of low intensity. The examinations were conducted as on models in vitro and in situ, and also on experimental animal in conditions of acute low intensive exposure to RF MEMF.

The experiments were conducted in Institute of biophysics of Cell of RAS, Institute of Biophysics of the ministry of Health of Russian Federation, Institute of physiology of RAMS Institute of a medical radiology of RAMS, St.-Petersburg state University, Tomsk state University.

The results of operational analysis can be conditionally divided into two groups. First group included results of experiments on establishing a role of EMF modulation in development of bioeffects, and also on establishing singularities of the modulated EMF exposure. In such case the comparative experiments with usage of the continuous and modulated magnetic fields were conducted. The results of the experiments only describing a biological effect of modulated EMF concern to the second group. In these experiences the comparison of the bioeffects called modulated and not modulated EMF was not conducted.

EXAMINATIONS IN VITRO AND IN SITU

Series of examinations of enzymatic systems under an exposure to modulated EMF with establishing of the most effective frequencies of modulation were carried out. The dependence of activity of mono amine oxidize, asparthate amine transferase, ATPase, actomisin and alkaline phosphatase from frequency of EMF RF modulation was probed at short-term EMF exposure of low intensity. The exposure in each experiment was equal for all probed frequencies of modulation owing to establishing equality of power performances. The biochemical examinations of activity of enzymes were conducted with usage of reference complex panel reagents, substratums and other bonds of firms "Sigma" (USA) and "Diakom" (Russia).

It was shown, that low intensive MEMF effect on enzymatic activity of monoamine oxidize (MAO-A) participating in the first stage catalyzing desamininig of monoamines, depends on a frequency modulation (Dolgacheva L. et al., 2000). Rats were subjected to EMF at 915 MHz, with frequencies of modulation of 2, 4, 6, 8,12,16 and 20 Hz, S=10 μW/cm^2, radiation time — 10 minutes.

It was fixed, that modifications of MAO-A activity in hippocampus and hypothalamus of a rat brain depends on frequency of modulation (Table 1).

Table 1

Modification of MAO-A activity in a hypothalamus and hippocampus of rat brain after the exposure to pulsewise-modulated electromagnetic radiations
(in relative unities)

Pulse rate, Hz	Number of rats	Number of tests	Cerebral structures	
			hypothalamus	hippocampus
Not exposed	5	20	0.65±0.33	0.59±0.02
2	3	12	0.53±0.02*	0.65±0.01*
4	4	16	0.93±0.13**	1.03±0.14**
6	3	12	1.04±0.13**	0.61±0.04
8	2	8	0.51±0.04*	0.74±0.06*
12	3	12	0.97±0.07**	0.85±0.08*
16	4	16	0.56±0.02*	0.90±0.11**
20	4	16	0.49±0.01**	0.56±0.02

* differences given from control on a t-Student criterion are reliable, $p<0.05$.
** same, $p<0.01$.

The greatest labilizing effect on MAO-A activity hypothalamus rendered MEMF with frequencies of modulation of 4, 6 and 12 Hz. In control the activity of an enzyme compounded 0.65±0.03 relative unities (r.u)., at experimental animal 1.04±0.13 ($p < 0.01$) r.u., accordingly. The exposure with frequency of 16 and 20 Hz was escorted by dropping of activity MAO-A up to 0.56±0.02 ($p < 0.05$) and 0.49±0.01 ($p < 0.01$) r.u., accordingly (Table). Droppings of MAO-A activity in hippocampus was not observed at EMF exposure in one of probed frequencies. Thus, the rising of MAO-A activity in hypothalamus of a rat brain was observed at frequencies of modulation of 4, 6 and 12 Hz, accordingly up to 143 ($p < 0.01$), 160 ($p < 0.01$), and 149 ($p < 0.01$)% from control values conditionally accepted for 100%. At frequencies of EMF modulation of 2, 8, 16 and 20 Hz dropping MAO-A activity of down to 82 ($p < 0.05$), 78 ($p < 0.05$), 86 ($p < 0.05$) and 74 ($p < 0.01$)% from a master level is marked. The effect of superweak pulsewise - modulated EMF on MAO-A activity in the hippocampus of the rat brain was mainly labilizing. The maximal rising of activity of an enzyme (up to 174% in comparison with control) is registered at frequency of modulation of 4 Hz.

Thus, modulated EMF of small intensity renders effect on an enzymatic system of a deamination of monoamines. Thus the expressiveness of bioeffect depend on a kind of modulation.

The MEMF effect on activity of asparthate amine transferase (ASAT) of serum of a donor blood of the human (Pashovkina M., Akoev I, 2001) was probed. The assays of serum of a blood were irradiated to EMF at 2375 MHz, range of modulation of 50–390 Hz, S=2 and 8 μW/cm^2, radiation time 5 mines. The modification of ASAT activity depends on a kind of modulation and from intensity (Table 2).

Table 2

Values of a relative modification of ASAT activity at miscellaneous frequencies of EMF modulation and miscellaneous intensity of exposure,% to control.

Modulation frequency, Hz	PFD, μW/cm^2	
	2	8
	(M±m)	(M±m)
50	146.6±6.7	175.3±5.3
70	286.6±6.4	154.0±14.0
90	162.6±3.8	184.0±4.0
110	155.6±5.7	198.0±3.6
130	235.6±3.5	76.0±6.2
150	125.3±3.7	325.0±5.7
170	247.3±8.3	371.1±5.5
190	345.6±3.4	156.4±5.4
210	133.7±3.5	503.7±4.9
230	292.8±7.0	254.6±6.2
250	243.3±6.2	127.3±3.4
270	187.7±5.0	100.6±7.5
290	158.3±2.2	162.7±4.9
310	129.7±4.7	254.3±5.6
330	217.3±8.5	211.0±7.2
350	114.7±3.5	77.7±3.5
370	479.4±8.5	139.6±1.6
390	400.4±8.4	592.3±4.6

Despite of small difference in an power flux density the effect for PFD of 2 μW/cm2 was more effective, than with PFD of 8 μW/cm2. At more low intensity, the exposure was for more frequencies of modulation elevating the activity of an enzyme for more than 200% and not of any case of the decrease of efficiency was lower than a master level.

ASAT has shown very high sensitivity to EMF and enlarged activity at some frequencies of modulation for almost in 4–6 times.

It is necessary specially to mark, that the directedness and expressiveness of effect was saved in repeated doubling experiments in simulated condition of exposure, but in various spans.

Probed effect of EMF modulation from 30 up to 310 Hz on a directedness and expressiveness of a response of an alkaline phosphatase (AP) of serum of a blood of the Guinea pigs at once after short-term exposure and follow-up through 20 and 30 minutes at various intensities, S=0.8; 8.0 and 40 μW/cm^2 was examined (Pashovkina M., Akoev I., 2001[a]). The dependence of

character and expressiveness of a response from frequency of modulation was obtained. The possibility of considerable effect of modulation on activity of enzymes as in a leg of its rising, and smaller degree in a leg of dropping (Fig. 1 and 2, Table 3 and 4) is marked. It is important to mark, that dependence of development of bioeffects on an aspect of modulation is influenced by PFD (Table 3, 4). The efficiency of MEMF exposure with PFD of 0.8 μW/cm^2 was higher, than at 8 μW/cm^2. So, rising of activity of an enzyme for more than on 20% marked already at 7 frequencies of modulation (at 1-minute exposure), as against EMF exposure with PFD of 8 μW/cm^2, which invoked rising activity above 20% only on two frequencies, and it was much lower, than at 0.8 μW/cm^2. Major efficiency for 5–30 times for the exposure to ore weak radiation was marked at identical frequencies of modulation in these two animal groups. The similar results were at three minute MEMF exposure.

Table 3

Relative modification of AP activity (% from control) in dependence from EMF intensities and time of exposure at miscellaneous frequencies of modulation (first sample with AP activity decrease).

Modulation rate, Hz	PFD, μW/cm²	M±m (1 min)	M±m (3 min)
70	0.8	87.2±1.22	112.0±0.83
	8.0	13.3±0.76	15.3±0.31
	40.0	–33.1±0.67	–37.5±0.32
90	0.8	44.5±0.02	57.8±0.93
	8.0	3.4±0.61	33.8±1.82
	40.0	–26.8±0.29	–57.8±0.17
110	0.8	25.1±0.34	27.7±1.31
	8.0	2.45±0.22	2.6±0.03
	40.0	–25.4±0.35	–76.3±0.26
170	0.8	33.7±0.32	42.4±0.28
	8.0	0.83±0.12	4.6±0.02
	40.0	–29.4±0.08	–9.5±0.26
190	0.8	23.8±0.74	25.7±1.25
	8.0	–5.6±0.31	–8.3±0.08
	40.0	–8.3±0.03	–35.8±4.9
230	0.8	11.8±0.05	13.4±0.94
	8.0	2.4±0.09	4.3±0.03
	40.0	1.1±0.06	2.5±0.08
310	0.8	21.7±0.35	23.9±0.61
	8.0	2.2±0.04	3.1±0.13
	40.0	1.7±0.04	4.8±0.06

Table 4

Relative modification of AP activity (% from control) in dependence from EMF intensities and time of exposure at miscellaneous frequencies of modulation (second sample, with rising of AP activity).

Modulation rate, Hz	PFD, μW/cm²	M±m (1 min)	M±m (3 min)
30	0.8	–12.2±0.08	–5.9±0.05
	8.0	7.4±0.07	9.1±0.08
	40.0	14.4±0.62	26.2±0.07
150	0.8	–5.6±0.05	–6.4±0.04
	8.0	1.7±0.81	3.2±0.14
	40.0	14.4±0.58	27.2±0.45
250	0.8	–24.7±0.34	–17.5±0.12
	8.0	7.2±0.03	9.7±0.16
	40.0	63.1±0.64	79.1±0.15
270	0.8	6.3±0.03	12.1±0.22
	8.0	15.8±0.03	18.4±0.03
	40.0	28.6±0.64	39.5±0.01
290	0.8	15.4±0.02	–14.6±0.35
	8.0	20.3±0.06	27.1±0.99
	40.0	40.0±0.09	59.0±0.54

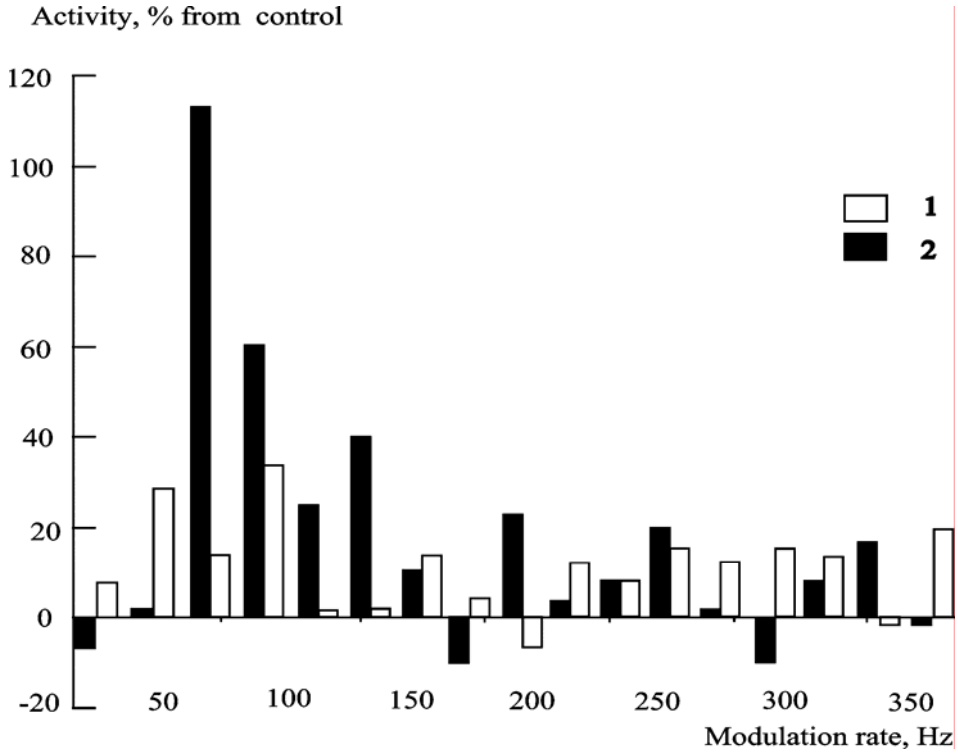

Figure 1. Dependence of activity of an alkaline phosphatase of serum of a blood of the Guinea pigs on frequency of modulation at 3 minute EMF exposure with PFD of 8 μW/cm^2 (1) and 0.8 μW/cm^2 (2).

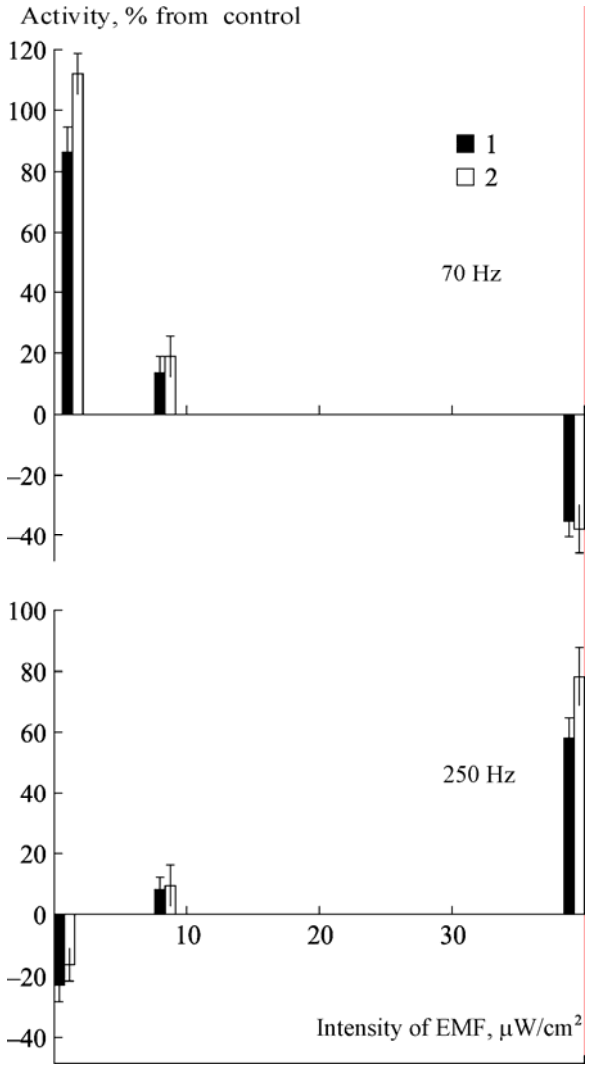

Figure 2. Two types of dependence of activity of an alkaline phosphatase of serum of a blood of the Guinea pigs from modifications of intensity of EMF exposure at frequencies 70 and 250 Hz with an exposition 1 min (1) and 3 min (2).

For study of cases of inverse directness of effect of the modulated microwaves at a modification of intensity of exposure, the available data have supplemented by experiments on alkaline phosphatase effect of microwaves with PFD 40 μW/cm^2 at conservation of other conditions. The common materials (Table 3 and 4) have shown, that among frequencies of modulation in examined band of 10–310 Hz, there are two frequency groups appealing as dropping of activity of an enzyme (concerning control modifications) at augmentation of intensity of EMF exposure (from 0.8 μW/cm^2), and rising it in the same conditions. In the first frequency group the modification of effect is inverse to body height of power dose, and in the second group is corresponded to the obtained dose.

From the obtained experimental data it follows, that the highest biological efficiency of the exposure is possible in series of cases at the most low intensity of exposure. The analysis of results of experiments has allowed the authors to establish, that from all utilized parameters of exposure in this experiment (frequency of modulation, duration of an irradiation, intensity of exposure) greatest effect on activity of an alkaline phosphatase rendered frequency of modulation and intensity of exposure. So, for each frequency the intensity of EMF exposure at a modification of the magnitude in micro-watt levels was capable abruptly to vary a directness of effect to activity of an enzyme from the expressed promoting effect to considerable inhibiting effect and on the contrary (Fig. 2). All has depended on an interval of intensities for the given frequency of modu-

lation. The augmentation of duration of an irradiation with 1 up to 3 min influenced to a lesser degree, and raised the effect of EMF exposure a little.

The efficiency of frequencies of modulation can not show the labilizing or inhibiting properties in transition zones of intensities, where the sign of effect varieties. For an alkaline phosphatase in the conducted examinations this region, approximately, is at a level 5–15 μW/cm^2. There are basis to guess, that it depends on frequency of modulation and from magnitude of effect in a little to other regions of intensities, where the effect shows.

The authors show a possibility of conservation of a directness and efficiency of an effect of frequency of modulation at a backup of experiments after a considerable span.

In vitro studied MEMF effect on ATPase activity of actomisine complex (Pashjvkina m., Akoev I.). Actomisine agent (AM) was discharged of a skeletal muscle of rat and irradiated to EMF at 2375 MHz, modulation 50–300 Hz. Despite of high EMF intensity (S=40 and 200 mW/cm^2), the results of the given experiment were included in the report, since in this work the legible dependence of bioeffect on modulation was obtained.

In a frequency range of 50–300 Hz at S=40 mW/cm^2 the ATPase activity was reliably enlarged (Fig. 3) for about a maximum at frequency of 270 Hz (285±25%, $p < 0.05$). The expressed suppression of ATPase activity however was marked at frequencies of 130 and 300 Hz. In series at S=200 mW/cm2 the augmentation of ATP activity was more expressed in a frequency range of 80–150 Hz (Fig. 4)

The clear MEMF effect on GAOA-, glutamate and cholinergic system of a rat brain (800 MHz, S=1mW/cm^2 was detected in conditions of acute exposure (Yurinskaya M., 1994; Kuznetsov V. et al., 1991). Animal were irradiated within 5 minutes to both continuous EMF, and impulses of the rectangular form with frequency of 2.5; 3; 5; 7; 16 and 30 Hz. The examinations conducted at once after EMF exposure and “sham exposure”.

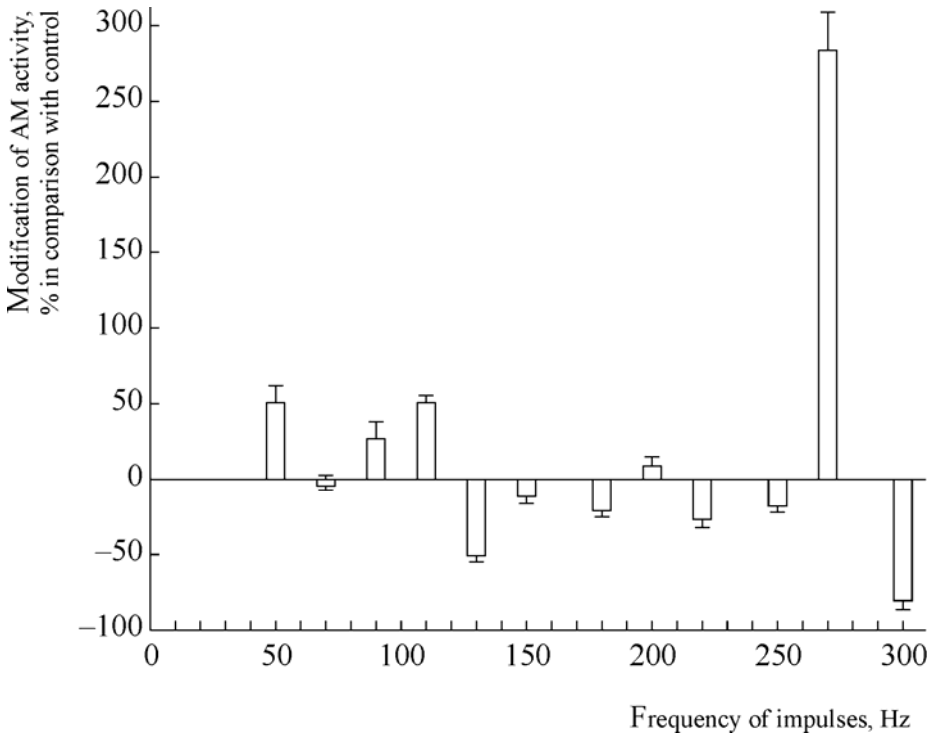

Figure 3. Dependence ATPase activity of AM from frequency of EMF modulation (S=40 mW/cm^2, t=1 min). On an abscissa axis — frequency of impulses, Hz; on an axis of ordinates — modification of AM activity, % in comparison with control.

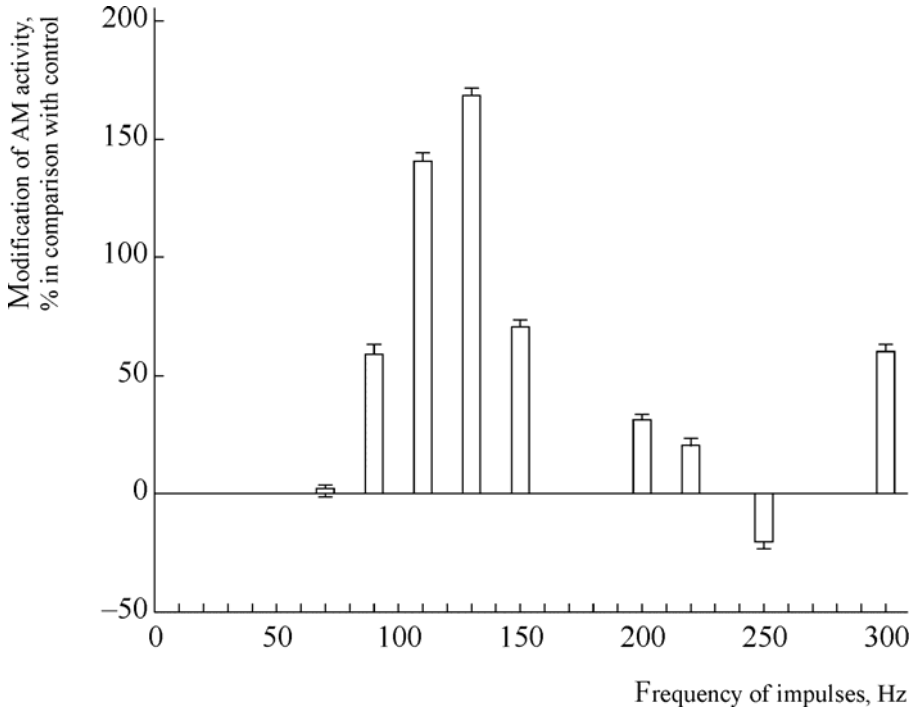

Figure 4. Dependence ATPase activity of AM from frequency of EMF modulation (S=200 mW/cm^2, t=1min). On an abscissa axis — frequency of impulses, Hz; on an axis of ordinates — a modification of AM activity, % in comparison with control

Statistically reliable and most significant modifications of bundling were obtained by a GAOA receptor of ^{3}H-muscimole at frequency of modulation of 16 Hz (800 MHz, S=1 mW/cm^2, radiation time of 5 minutes). The muscimole amount was decreased on 30–35% in comparison with control (Table 5). The root-mean square deviation at frequency of 16 Hz was minimum in comparison with a scatter on other frequencies of modulation.

Table 5

Dependence of bundling 3H-muscimole by a GAOA receptor from frequency of EMF modulation (carrier frequency of 800 MHz, modulation from 3 up to 30 Hz, PFD of 1 mW/cm^2, radiation time of 5 minutes).

Modulation frequency, Hz	B*
3	1.07±0.31
5	0.96±0.17
7	0.83±0.25
16	0.70±0.05
30	1.35±0.30
No modulation (CW)	1.12±0.13

*footnote: B — the ratio of muscimole bundling with GAOA-receptor at irradiated rats to muscimole bundling with a receptor at control (sham exposed rats).

At examination of bundling of a glutamate in rats irradiated to 915 MHz, S=1mW/cm^2, radiation time of 5 minutes, modulation of 2.2 and 16 Hz the greatest effect was observed at 16 Hz as well as in case of muscimole bundling, but the effect was of an inverse directness. (Fig. 5). The amount of a bound glutamate has increased on 200–220%.

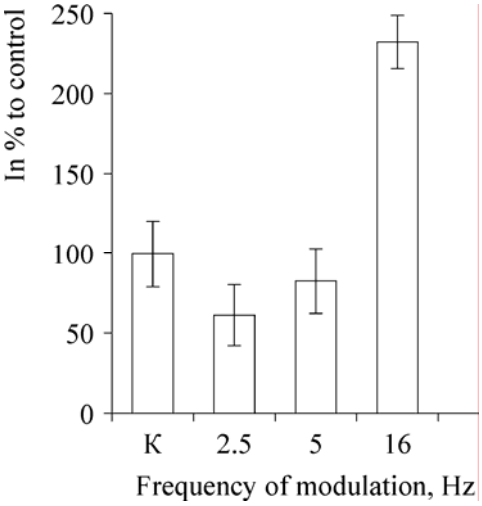

Figure 5. Dependence of bundling of a 3H-glutamate by synaptic membranes from frequency of EMF modulation (915 MHz, frequency of modulation from 2.5 up to 16 Hz, S=1 mW/cm^2, radiation time of 5 minutes). On an axis of ordinates — bundling of a ^{3}H-glutamate in% to control; on an abscissa axis — frequency of modulation.

The padding examination of effect of electromagnetic fields modulated by low frequency, on synapses receptors of a brain was conducted at exposure with various magnitude of intensity and time of exposure. (Yurinskaya M. et al, 1996).

Wistar rats were irradiated to EMF of 800 or 950 MHz, modulation with square-wave pulses of 2.5, 3, 5, 7, 16 and 30 Hz at porosity of 32%, S=10, 50 and 100 μW/cm^2. The time of exposure in miscellaneous series was 1, 5, 15 and 60 min. Animals were put in a cell from organic glass, the exposure was realized from the open waveguide docked with a wave-guide duct. An MEMF exposure was subjected simultaneously to three animals. In check experiments, rats were put in non-echo chamber on the conforming time without an irradiation.

Animals were decapitated at once after MEMF exposure and "sham" exposure. As a GAOA receptor they have utilized ^{3}H muscimole, the experiments were conducted on synaptic neurosomas and synaptic membranes. Bundling ^{3}H of a glutamate was realized on synaptic somal membranes. Synaptic neurosomas were received from a cortex of rat brain.

Dependence of bundling ^{3}H muscimole and ^{3}H glutamate from EMF power flux.

The examination of MEMF effect at general organism exposure has shown, as GAOA and glutamatic system of the rat brain are very sensitive to low intensive MEMF (Fig. 6). At MEMF exposure, the modification in bundling receptors with GAOA and glutamate receptors has descended by a various mode: for GAOA receptors the decrease of bundling, for glutamate receptors — augmentation was observed. GAOA and glutamatic system of the rat brain have responded to MEMF by an inverse mode, as it takes place at a stress and some pathologies in the CNS. Modifications in functioning the indicated systems have depended upon MEMF rate: the more radiation power, the effect is more especially expressed. The maximal effect was observed at an energy flux density of 1mW/cm^2. It is necessary to mark, that modulated EMF rendered effect on bundling ^{3}H-muscimole and ^{3}H-glutamate was at smaller values of EMF rate. At value of an EMF power flux density of 10 μW/cm^2 the decrease of bundling ^{3}H-muscinole has made 88±12% in comparison with control, and augmentation of bundling ^{3}H glutamate was equaled to 120±12%.

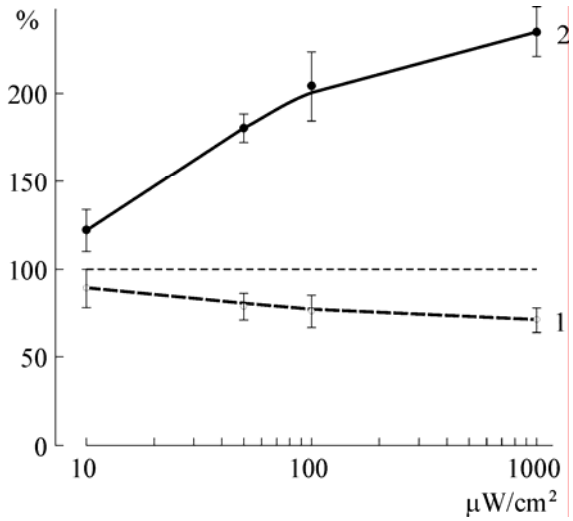

Figure 6. Dependence of bundling ^{3}H muscimole (1) and ^{3}H glutamate (2) from MEMF power flux density (carrier frequency of 915 MHz, radiation time of 5 min, frequency of modulation of 16 Hz). The bundling at control animal was closed to 100%. On an abscissa axis — an power flux density, on an axis of ordinates — bundling in% to control.

The dependence of bundling 3H-muscimole and 3H-glutamate from time of EMF exposure. Carrying out of examination have shown, that for GAOA system the maximal effect was observed in exposed animal during 1 min: the decrease of bundling labeled muscimole has made 50–55% in comparison with control, and at 15th and 60th minute of exposure the effect was less expressed (Figure 7).

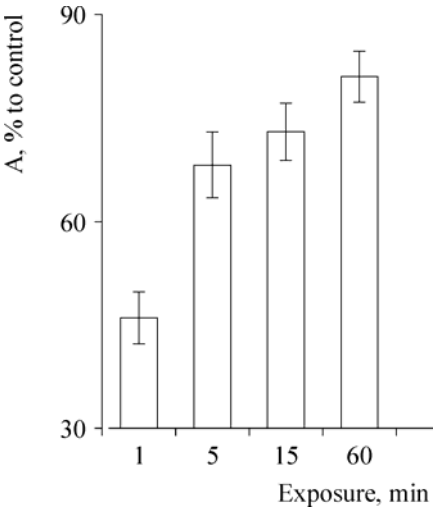

Figure 7. Dependence of bundling ^{3}H glutamate by synaptic membranes from time of EMF exposure. A — the attitude of bundling of a ligand with a receptor for irradiated rats to bundling for control animal (in% to control). A carrier frequency is 800 or 915 MHz, power flux density is 1 mW/cm^2, frequency of modulation is 16 Hz.

At examination of bundling glutamate in a time dependence of the MEMF exposure, animal was irradiated during 1 and 5 min, frequency of modulation was 16 Hz. The maximal effect was observed at 5th min of exposure, the augmentation of bundling has made 200–220% versus control (at 1st minute irradiation augmentation of bundling ^{3}H glutamate is 130±6%).

Thus, even it is enough of 1 minute exposure of modulated emission, that at rather low intensity of microwaves is essential to change a reactivity of CNS. At a more long MEMF radiation time the effect became less expressed. It can specify that compensatory mechanism "is included" in an organism in reply to a radiation effect.

MEMF effect on concentration dependencies of bundling ^{3}H- muscimole and ^{3}H-glutamate. In separate experiments the problem was investigated, whether at the expense of that there is a

modification of an amount of the bound marked ligand — the affinity of bundling of a ligand varies or the amount of linking fields in conditions of EMF modulated exposure varies. For this purpose the concentration dependencies of bundling ^{3}H- muscimole and ^{3}H-glutamate for control and irradiated animal were obtained and the Sketchard graphs are built.

The muscimole dissociation constant has varied insignificantly (Fig. 8) and made 480±60 nM, that is quite compounded with given one obtained by other authors. After the exposure, the muscimole dissociation constant has varied insignificantly, but thus the amount of linking fields has varied. The Figure of binding sites for muscimole was sank from 17.4±0.8 pmol/mg of protein at control up to 10±2 pmol/mg of protein at irradiated animal. As it is visible in a Fig. 9 the dissociation constant of a glutamate at control animal (227±15 nM) is more than value of a dissociation constant in experiment (103±10 nM), i.e. after the exposure, the affinity of bundling has increased. As to an amount of places of bundling for a glutamate after the exposure, it practically did not vary. Thus, as it is visible from the provided data, at MEMF exposure constant of bundling, and number of linking fields have varied.

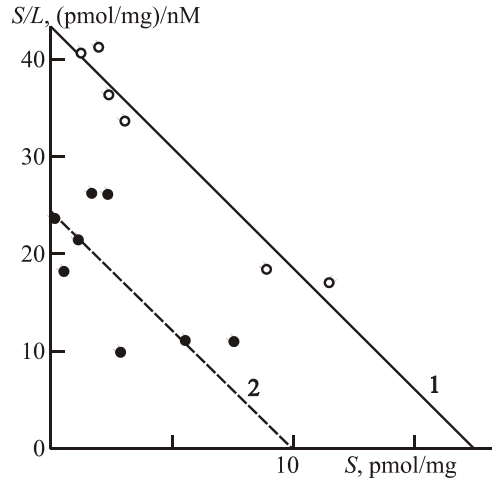

Figure 8. The Sketchard graph for the assessment of parameters of bundling ^{3}H muscimole by synoptic membranes. 1 — bundling ^{3}H muscimole in control, 2 — bundling ^{3}H muscimole after exposure. A carrier frequency is 915 MHz, power flux density is 1 mW/cm^2, frequency of modulation is 16 Hz, radiation time is 5 min. S is an amount of a bound ligand, L is the concentration of a free ligand.

To the present time large data about microwave effects in different physiological and biochemical parameters of cerebral structures, specific organs and whole organism are accumulated. The adequate theoretical explanation of results is the complex problem. Nevertheless, these results are well compounded with the literary data on stressful effect (electroshock, pain stress, immobilization) on receptor properties of GAOA receptors. The experiments on MEMF exposed animals have shown, that the greatest modifications of GAOA receptor concentration descend within the first five minutes. Furthermore, at 15th and 60th minute of the exposure the effect became less expressed. It is interesting, that the similar dependence in a modification of receptor properties of GAOA receptors in a cortex of a brain is observed at 24th hour of immobilization stress: the essential decrease of concentration of GAOA receptors at first minutes, then step-by-step homing to norm, and to 24th hour even the augmentation in comparison with control. As a matter of fact various phases of a modification of receptor properties of GAOA receptors at MEMF exposure are similar to phases of the common adaptation syndrome.

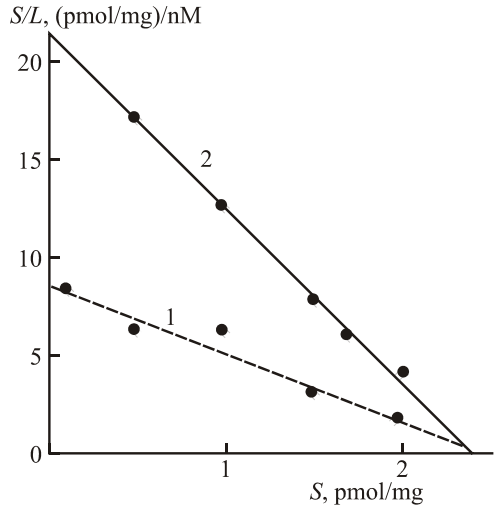

Figure 9. The Sketchard graph for assessment of parameters of bundling glutamate by synaptic membranes. 1-bundling of a ^{3}H-glutamate after exposure. Conditions of an exposure as in a Fig. 4 S is the amount of a bound ligand, L is the concentration of a free ligand.

Thus, it is shown, that the MEMF effect on receptor systems of a brain depends both on intensity, and from duration of EMF exposure. It is possible to assume, that the modulated electromagnetic radiation "includes" a complex of stressful responses in an organism, which further, probably, educe under the scenario of a common adaptation syndrome.

They have examined the effect of pulsewise - modulated EMF of weak intensity on secondary DNA frames (Siomin Yu. et al, 2002).

DNA samples (3 mL) in polypropylene vials a dia of 12 mm were put in a foam support (control and experiment) so that they placed in series with center distance of vials of 25 mm. Samples were subjected to the exposure of impulsive or continuous EMF of intensity of 600 $\mu V/cm^2$ and frequency of 1.05; 2.05 or 2.39 GHz during 30 mines at 18ºC within non-echo chamber. At a quantization of a field the frequency of a cycling compounded 4 Hz, duration of impulses was 25 ms, S=600 $\mu V/cm^2$. A support with exposed vials irradiated in the region of the formed wave (3 m from polishing material of the radiating antenna) in isodose field (±10%) at vertical orientation of a E-vector. The control assays also were in the chamber within the radiation time, shadowed by the ferrite screen. The examinations conducted at once after exposure.

In experiments they have utilized DNA, secured of a thymus gland of mice by a phenolic method. As a result of the conducted examinations ascending value of a maximum of curves of a denaturation was obtained and fast reaching of a maximum at a quantization was observed (Fig. 10). The inverse effect was obtained at continuous exposure (CW). It was fixed, that the impulsive radiation at all three utilized carrier frequencies invokes statistically significant differences between kineticses of a DNA denaturation in the irradiated and control solutions.

The authors has specially marked, that the obtained bioeffect is steadily replicated and highly reliable at usage of the chosen mode of exposure.

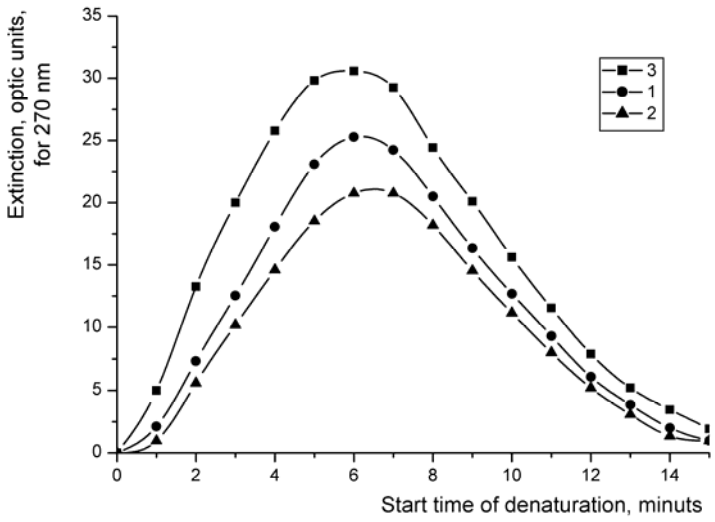

Figure 10. Kinetics of a denaturation in control (1) and DNA samples subjected to exposure to continuous (2) and modulated by frequency 4 Hz (3); (EMF of 1.05 GHz, S=600 μW/cm^2).

The attention, from our point of view, should be attracted to results of experiment, in which studied effect of EMF "oscillating" frequency on DNA discharged from of salmon fish semens (Kim Yu et al., 2001). A wet DNA film, stabilized with bound water, was irradiated to "oscillating frequency" in a band of 8.15–10 Hz at PFD of 5, 10, 20 or 40 mW/cm^2 with duration of 1, 5, 15, 30 and 60 minutes.

This kind of exposure already at S=5 mW/cm^2 has decelerated the rate of a desorption of water in DNA membranulas, influenced in conformation metamorphosises of polymeric molecules*. The irradiation quenched conformation passage of DNA molecules from a hydrated B-conformation in an A-conformation at a desiccation of membranulas. In irradiated membranulas during a desiccation (decrease of relative humidity of a film) the DNA molecules have prolonged to remain bound with molecules of water and, hence, saved high order state as against control. As it was not revealed of any reliable modifications in the most molecular DNA frames, it has entitled the authors to consider, that the detected effects of EMF effect on a possibility of conformation passages are stipulated by a modification of the frame of water, bound with DNA. Probably, it also serves the cause of the rate decrease of a desorption of water from DNA membranulas and stabilization of DNA molecules in hydrated high ordered double-helical B- conformation. It is supposed, that the ability of EMF of particular parameters will steady DNA frame to influence DNA functional properties as carrier of the genetical information.

Except for biochemical examinations in vitro the experiments on performance of responses of quarantined frames of a nervous system were conducted at MEMF exposure. A role of EMF modulation as the possible factor influencing background impulsive activity (BIA) of neurons of a section of a brain (Zakharova N. et al., 1993, Zakharova N. 1995, 1998) first of all was probed.

EMF exposure was realized at 0.9 GHz in a continuous regimen and with a quantization of 7, 16, 30 and 60 Hz. The porosity was always peer 5, the pulse duration was various: at 7 Hz — 28 ms; at 16 — 12 ms; at 30 Hz — 6.7 ms. The specific absorbtion rate (SAR) was peer 1.4 W/kg. Up to, in time and at once after exposure probed background impulsive activity (BIA) of

*Experiments where complex EMF exposure modes were applied though with high intensity can extend knowledge regarding bioeffect modulation induction

80 neurons in experiments with the modulated exposure, 28 neurons with the not modulated exposure was examined. BIA was recorded by non-artifact electrodes. Electrical activity of neurons was recorded on the tape recorder for an aftertreatment on the computer. They have conducted a constant integration of streaming frequency of each neuron.

At EMF exposure with modulation of 7 Hz, neurons in most cases (13 of 17 cells) already on the first minute of the exposure have responded by decrease of frequency of the discharges to 27%. Such frequency drift was saved during all radiation time. After the arrest of exposure, the tendency to regeneration of frequency was not observed (Fig. 11, A). The remaining 4 cells have not reacted on the irradiation.

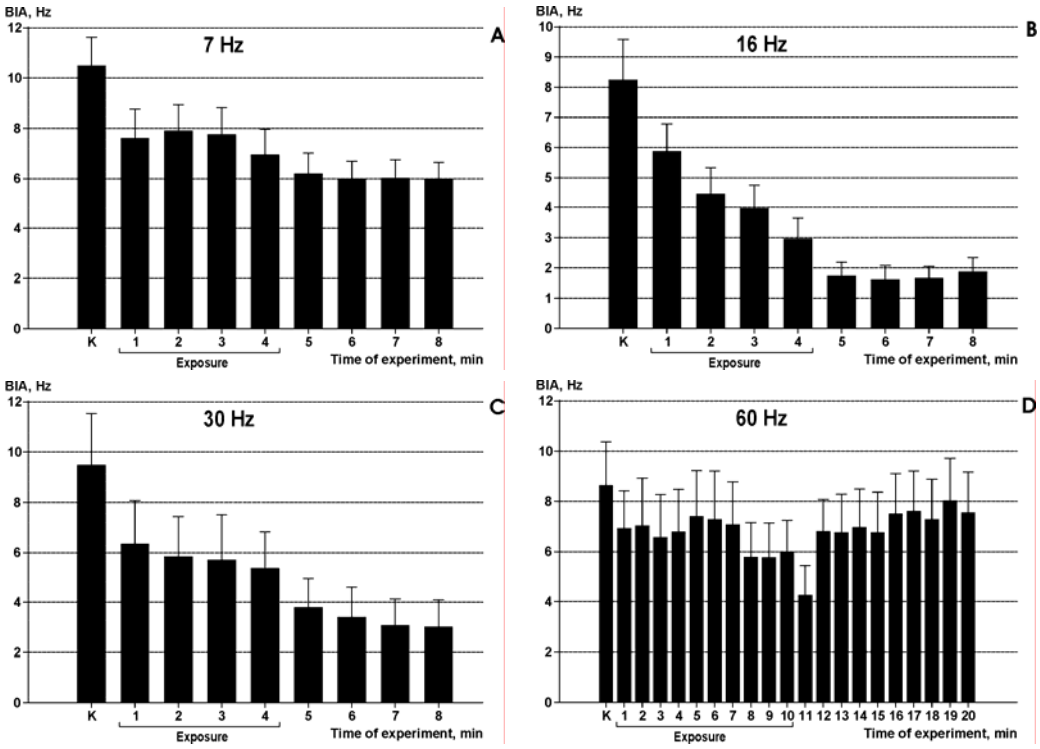

Figure 11. Effect by pulsed modulated EMF on background impulsive activity (BIA) of sections of a neocortex. Each column of the chart — average value of BIA frequency of all cells, probed in the given paste, in one minute and standard deviation average: K — in control, in a radiation time (line under the graphs), the subsequent columns reflect time after an irradiation by pulsed modulated EMF. The frequencies of modulation are indicated above each chart. Average SAR was 1.4 mW/g for all frequencies of modulation. A — 7 Hz modulation; B — 16 Hz modulation; C — 30 Hz modulation; D — 60 Hz modulation.

At frequency of 16 Hz, 15 of 17 cells have the induced decrease of frequency of background activity by 24% on the first minute of an irradiation and on 65% to the end of the fourth minute of exposure. The tendencies to BIA regeneration was not traced (Fig. 11, B). The exposure with frequency of 30 Hz modulation has invoked a response of BIA inhibition only at 7 of 16 probed cells approximately on 28%. In this case tendencies to regeneration was not traced after deenergizing the generator (Fig. 11, C). The remaining 9 cells in this series in reply to exposure have not reacted reliably.

The exposure with frequency of 60 Hz has induced statistically significant short-term decrease of BIA frequency against control in less than third (5 of 19) probed cells approximately on 20% at first minute after the arrest of an irradiation. There was a tendency to regeneration of frequency at 2nd minute after an irradiation (Fig. 11, D).

In experiments with a continuous irradiation average SAR was selected to be equal to average SAR used in experiments with the modulated irradiation (1.4 mW/g). In examinations with a

continuous irradiation, the BIA inhibition at 16 of 28 cells (Fig. 12) also is revealed, but change of a frequency drift observed at a constant integration was more monotonic, than at the modulated irradiation. At the not modulated irradiation the tendency to regeneration of BIA frequency after an irradiation to a level of control was traced. The significant inhibition occurred only to the fourth minute of an irradiation and the intensifying of effect was not observed after the arrest of an irradiation.

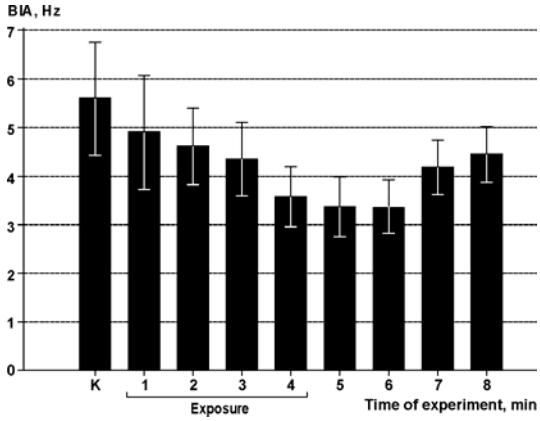

Figure 12. Average value of BIA frequency of neurons of sections of a neocortex in time and after exposure to not modulated EMF in each minute. K — up to an irradiation; in time (1–4 mines) and after (5–8 mines) irradiation with average SAR of 1.4 mW/g; on an abscissa axis — time of examination.

The attempt was made to reveal modifications of brain neurons pulsation at MEMF exposure with usage cross correlation analysis. (Zakharova N., 1996).

As model of examination the experiencing frontal sections of a sensomotor cortex of a brain of the Guinea pig were utilized.

The EMF irradiation was conducted at 900 MHz, SAR in an alveole of volume 1 cm^3 with sections there was 1.4 mW/g, a quantization was 7, 16, 30 and 60 Hz.

The examinations conducted up to, in time and at once after MEMF exposure.

The spontaneous activity a steam of neurons was recorded exocellularly by one microglass electrode. Cross correlation functions (CCF) of cells were calculated. The CCF statistical analysis for cells obtained from 51 neighbor steams was conducted, which impulsive streams were clearly divided with the help of amplitude discrimination.

In CCF of the level of significance of 5% reliable deflections from a mean level h_{12} were found, showing mutuality in cellular pulsations of examined cell couples. On all frequencies of modulation the decrease of the correlation coefficient was in most cases observed during exposure with lack of the legible tendency to regeneration of degree of constraint of the steam of neurons after the arrest of exposure.

The decrease of correlation at an irradiation can testify, that MEMF desynchronizes work of crustal neurons in neuronic ensembles. The modification of correlation in activity of probed nervous cells at a microwave irradiation, apparently, is connected to effect of radiation on synaptic transmission between neurons. One of the causes of deterioration of carrying out synaptic signal in a nervous tissue can be depressing of a power metabolism or attrition of neurons mediator pool.

Thus, utilizing filing of spontaneous impulsive activity of neurons of experiencing sections of a neocortex and cross correlation analysis, it was shown, that the electromagnetic radiation renders noticeable downstroke of transneuronal correlation and accordingly there is a deterioration of synaptic transmission between cells of a cortex.

With the purposes of examination of possible effect of modulated EMF of small intensity on a more composite functioning system the model of an isolated frog heart (Aphrikanova L., Grigoriev Yu., 1996) was utilized. In experiments, the composite regimen of modulation was utilized at low level of intensity. The principle of modulation frequency changed in time was applied at a constant countrexposure of frequency setting. An irradiation was conducted on experimental installation generating microwave with frequency of 9.3 GHz. As the dimensions of frog heart are comparable to a wavelength of radiation, an irradiation was conducted in conditions which are coming nearer to maximal absorption of the radiation energy.

Modulated EMF on its amplitude was characterized by varying frequency of modulation from 1 up to 100 Hz at a depth of modulation of 30 and 100%; a pulse shape was rectangular, meander, S=0.016 mW/cm^2. Distance up to the object got out by such, that the irradiation was uniform. The general plan of conditions of experiments is provided by Table 6.

Table 6

General characteristics of conditions of experiments

Test No.	Animal number		PFD, mW/cm²	EMF mode and exposure time, min			Total exposure time, min
	Test	control		CW	Pulsed, Hz	Time at each mode, min	
1	28	28	0.016	-	6–10	1	5
2	32	32	0.016	-	1–10	1	10
3	20	20	0.016	-	1–10, 20, 30, 40, 50, 60, 70, 80, 90, 100	1	19
4	10	10	0.016	CW	-	5	5

The examinations were conducted in a radiation time, and after exposure within 24 hours. 180 frog hearts were utilized in total.

They have estimated a beat frequency of heart during each 30 minutes within 6 hours from the moment of manufacture of the isolated heart preparation, during exposure, and also within day after an irradiation. Simultaneously, observations were conducted in control (sham exposure) in the same terms. It is important for an assessment of a response on an irradiation, that heart in Ringer solution can be pruned within two days.

Besides, the morphological criterion of a state of erethitic tissues of heart was the assessment of process of a vital staining of frames of an interatrial septum by a stain of azine group with neutral red (NR). The method of an intravital staining has enabled to judge vitality of frames by granule forming criterion, and also about a state of their permeability (on a degree and dynamics of staining). Other vital stain, methylene blue, was utilized for an assessment of a state of choline energetic synapses on independent neurons of a Ludwig node.

Intact uncolored hearts for 24 hours of observations have decelerated the rate on the average on 7%; the cardiac standstill was not present (Fig. 13). Half-hour stays of a quarantined drug heart in solution of a stain in itself have resulted in the modification of its function. The Figure of constrictions was decreased by 30%, and 14% of hearts ceased to be pruned (Fig. 13). At a stimulation of the stopped hearts by strong light or mechanical stimulus of pacemaker range (venous sinus) the beat was recovered. After the arrest of process of a staining of heart the rate of

constrictions was gradually accumulated reaching the initial level. And only to the end of experiment in hour 24, the heart beat number was sunk on the average on 20%.

The response of hearts irradiated in a continuous regimen, was inappreciable, and differed from the colored unirradiated hearts a little.

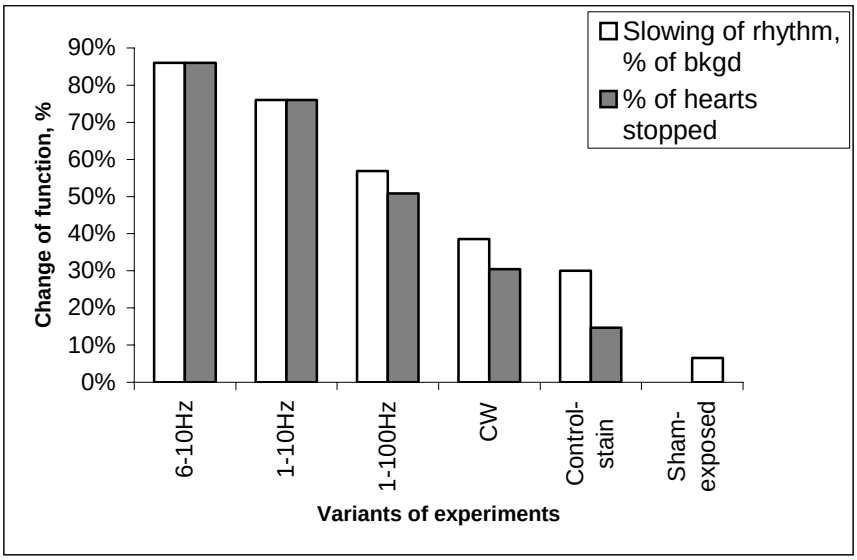

Figure 13. Change in the number of beating and stopped isolated frog hearts, EM irradiated using the continuous regime and for various pulse modulations from 1 to 100 Hz.

At an irradiation in the modulated regimen, the sharp decrease of heart beat number was marked, the number of the hearts which have ceased to beat (Fig. 13) was enlarged also. The greatest effect was obtained at a frequency drift of modulation in a band of 6–10 Hz and time of exposure of 5 minutes. Under these conditions of exposure, there was a retardation of a rhythm to the subsequent cardiac standstill at 85% of hearts (at a continuous regimen — 38%). The effects were particularly reversible.

The irradiated hearts washed from a paint have recommenced constrictions, and the accumulated rate, however, within 2–3 subsequent hours in major percent of cases has been noted to have sharp heart beat decrease and secondary cardiac standstill. In these cases, challenging procedures have ordered only to short renewing of cardiac constrictions. In 2–3 hours after MEMF exposure in neurons and muscle elements of heart, the violation of granule forming process was observed. The great number of neurons has gained the angle forms and diffuse coloring of a core and cytoplasm. In muscle fibers, the number of stain beads was diminished, cytoplasm was slightly tinted, and a number of muscle cores were also colored in intensively red color. Simultaneously, the appearances of a gelatinization of synapses on cells of a Ludwig node and intensive tincturing of Schwann cells in region of a taper of an axon were marked. Such results can speak about violation of vitality of the irradiated frames of heart and about the development of process of paranecrosis.

Thus, in all series of the MEMF irradiation of hearts with changeable frequency of modulations in range from 1 up to 100 Hz, it has rendered much major effect on function of heart, rather than irradiation in a continuous regimen of generating.

The value in shaping bioeffect of correlation between an initial state of a system of an organism and conforming EMF modulation (Aphrikanova L., Grigoriev Yu., 1966) was examined. In these purposes, the model of an isolated frog heart was also utilized. An isolated frog heart irradiated to EMF of 9.3 GHz, S=0.016 mW/cm^2 with modulation in three regimens: (a) 20, 22, 24 and 25 Hz; (b) 32, 34, 36 and 38 Hz; (c) 40, 42, 44, 46 and 48 Hz was investigated. In an initial

state on a heart beat frequency they were divided into 3 groups: (I) 20–30 beats in 1 min; (II) 31–40 and (III) 41–50. The regimens were chosen according to an initial beat frequency of an isolated heart. The duration of each irradiation was 1 minute. Also there was an exposure with a continuous EMF regimen (group IV) and "sham" irradiation (group V). Magnitude of modifications was estimated on a rank system.

At each of three regimens of modulation the greatest modifications in a rhythmicity of heart from the initial level were under condition of concurrence of their magnitudes (Table 7). The greatest modifications were at EMF exposure in a regimen of modulation at 20–28 Hz in group of hearts with frequency of beats of 20–30 strokes a 1 minute.

Table 7

Frequency drift of frog heart beats in dependence from modulations of microwave field and initial frequency of heart beats

Group	No. of hearts	Modulation frequency, Hz	Rank number (group averages)			Total rank number
			Initial heart beat rate			
			20–30	31–40	41–50	
I	23	20, 22, 24, 25, 28,	**50**	3	3	56
II	28	30, 32, 34, 36, 38	11	**12**	9	32
III	22	40, 42, 44, 46, 48	9	1	**16**	26
IV	26	Continuous wave	1	-	-	2
V	30	"sham exposure"	-	-	-	0

EXAMINATIONS IN VIVO

It was supposed, that the role of modulation in development of bioeffects should be more brightly expressed at examination of a response of an integrated organism. In this connection, series of examinations were conducted with usage of behavioral responses.

The rat behavior after EMF exposure at 915 MHz with a frequency modulation of 4, 6,16 and 20 Hz was probed; a radiation time was 10 minutes (Semenova T. et al., 2000). At all given frequencies of modulation, S=10 mW/cm^2. They have utilized magnetron generator for exposure. There was an animal group with a "sham" irradiation.

Immediately after an irradiation, the animal behavior was examined in conditions of an operation on them of series of stressors: a unfamiliar situation of open space, height, glare. With this purpose, they have conducted observations of behavioral singularities in the uplifted cruciform labyrinth, when animal should make jogs on narrow rays of a labyrinth at major height above ground level. This procedure is widely utilized for an assessment of an affective behavior of rats in particular expressiveness of the level of uneasiness. They have estimated time of "freezing behavior".

The labyrinth was consisted of two open (40×12 cm) and two closed (40×12 cm) sleeves restricted by opaque walls of 40x40 cm dimension. The orifices in the open sleeves were posed vice-versa apart 10 cm. The labyrinth was at height of 90 cm above a level of floor. All experi-

ments were conducted in the morning — from 9.00. In the beginning of experiment, the animal was put in a central part of a labyrinth and during 5 min was observed. They have recorded the number of calls in the open and closed rays of the labyrinth, the number of passages in rays of a labyrinth and time of the freezing behavior response. After the end of work with animal, they have wiped the floor of the labyrinth and through 10–15 mines have began work with the following animal.

As a result of EMF exposure modulated by frequencies of 4 and 6 Hz, the number of entries in the open rays of a labyrinth within 5 min observation has increased in 3.7 and in 4.5 times accordingly in comparison with control, that is a parameter of considerable dropping at an animal level of uneasiness from stay in a labyrinth (Table 8). At modulation frequency of 16 Hz, the modifications of this parameter were expressed more weakly — number of entries was enlarged in 2.3 times, and at 20 Hz its value in essence did not differ from control.

Table 8

Singularities of rat behavior in a cruciform labyrinth after MEMF exposure

Modulation frequency, Hz	No. of rats	Number of entries to "open rats"	Number of entries to "closed rats"	Freezing time, s
control	9	1.1±0.2	6.8±0.6	24.0±4.0
4	7	4.1±0.7**	8.7±1.2	5.7±1.8**
6	4	5.0±0.6**	9.7±1.7	5.0±1.5**
16	6	2.5±0.3*	7.0±1.9	1.8±0.9***
20	9	1.0±0.1	4.0±0.7**	50.4±8.9*

Footnote. Differences from control on a t-Student criterion are reliable:
* — $p < 0.05$; ** — $p < 0.01$; *** — $p < 0.001$

On a parameter of time of freezing behavior describing a degree of manifestation of passive defensive behavior, multi-directed EMF effect was also detected depending on the frequency of modulation. Under EMF exposure at frequency of modulation of 4, 6 and 16 Hz, the time of freezing behavior was sunk in 4.2, 4.8 and 13.3 times, accordingly. At rising frequency of modulation up to 20 Hz, the time of freezing behavior, on the contrary, has increased in 2.4 times.

The motor performance determined on number of entries in the closed rays of the labyrinth, did not undergo reliable modifications after EMF exposure modulated by frequencies of 4, 6 and 16 Hz. However, at frequency of modulation of 20 Hz, the level of this parameter was sunk in 1.7 times.

Thus, the comparative analysis of EMF modifications of parameters of an affective behavior (table 8) has revealed, that the number of entries in the open rays of the labyrinth is changed by the EMF exposure with frequencies of modulation of 4 and 6 Hz, with increase up to 373 and 450% accordingly in comparison with control conditionally accepted for 100% ($p < 0.01$). On frequency of modulation of 16 Hz this parameter was enlarged up to 225% ($p < 0.05$), and at frequency of 20 Hz the tendency to its decrease was observed.

The comparative analysis of the data, submitted in the table characterizes modifications of responses of freezing behavior under low intensive EMF exposure at miscellaneous frequencies of modulation. It is shown, that at modulation of 4, 6 and 16 Hz the reaction duration is decreased in 76% ($p < 0.01$), 79% and 93% ($p < 0.001$), respectively. At frequency of the modulation of 20 Hz, the freezing period has exceeded a control level on 110% ($p < 0.05$).

The rather serious responses were fixed in rat behavior at MEMF exposure (Sudakov K, Antimonii G., 1973, 1977 Antimonii G., 1974). Rats irradiated to EMF of 40 MHz with the modulation of 50 Hz had depth of modulation of 80–100%, field strength of 100–120 V/m, duration of

exposure was from 5 minutes till 2.5 hours. The phase modifications of behavioral responses down to development a cataleptic state at a part an animal were registered in these experiments.

They have tested possible effect of modulated and not modulated EMF on epileptiform activity of rats with potential presence of audiogenic cramps (Konovalov V., 2001). Animals were irradiated to EMF at 880 MHz, S=1mW/cm^2, 5 minutes/day, within 5 days. 40 rats were divided into 4 series: Ist series — a continuous irradiation; IInd series — modulation of 4 Hz; IIIrd series — modulation of 16 Hz; and IVth series — a "sham" irradiation. Animals were observed within 1.5 years thereafter.

As a result of MEMF exposure, there was the suppression of a convulsive predisposition in animals at modulation of 4 Hz and 16 Hz. At a continuous mode of exposure, this effect was expressed insignificantly and it was exhibited only in 3 months after an irradiation (Table 9).

Table 9

Exhibiting audiogenic cramps in rats (%) of four experimental groups after exposure to not modulated and modulated EMF

Time of repeated testing after a course of exposure (provocation of audiogenic cramps)	Animal group			
	1 (CW)	2 (4 Hz)	3 (16 Hz)	4 (Sham exposure)
1	2	3	4	5
Day 1	100	20*	20*	100
Week 1	100	20*	20*	100
Week 2	100	20*	20*	100
Week 3	100	20*	20*	100
Month 1	100	20*	20*	100
Month 2	100	20*	20*	100
Month 3	80	60	80	100
Month 4	80	60	80	100
Month 5	80	60	80	100
Month 6	80	80	80	100
Month 12	20*	80	20*	100
Month 18	37,5	66,6	25	100

* Statistically significant difference by Student criterion ($p< 0,05$)

The effect of modulated EMF on the mechanism of targeted animal behavior (Sudakov K., 1976, 1998) was investigated. The experiments were conducted on rats, which were irradiated to EMF of 30 MHz, frequency of modulation of 2, 7 and 50 Hz, depth of modulation of 80%, field strength of 30 V/m. They have utilized the generator, which condenser plates were hardened along walls of the scoop. Duration of exposure was 10 minutes.

The MEMF effect on the response of a self-stimulation during exposure was examined. 30 rats were utilized in the experiment. The irritation of frontal, lateral and back hypothalamus and middle and lateral kernels of the septum was effected by an electrical current of 10–12 A, duration of impulses of 0.1–0.5 ms. They have invoked a response of a self-stimulation in all animals.

At an EMF exposure with frequency of 2 Hz modulation during the first 2 min, the augmentation of frequency of a response of a self-stimulation for 93% was observed, then the frequency of a response of a self-stimulation was sharply sunk and through 4 min petered completely (Fig. 14.A). At an MEMF exposure with frequency of 7 Hz modulation in the first 2 min, the response of a self-stimulation practically did not differ from background and only then, during 12–15 min,

the decrease of its frequency (Fig. 14.B) was observed. Other picture was observed at an MEMF exposure with 50 Hz modulation— practically at once from the beginning of exposure all animal responses of a self-stimulation were quenched (Fig. 14.C). Characteristically, that the indicated MEMF effects did not depend on localization o of stimulating electrodes endpoints (stimulated area of the brain).

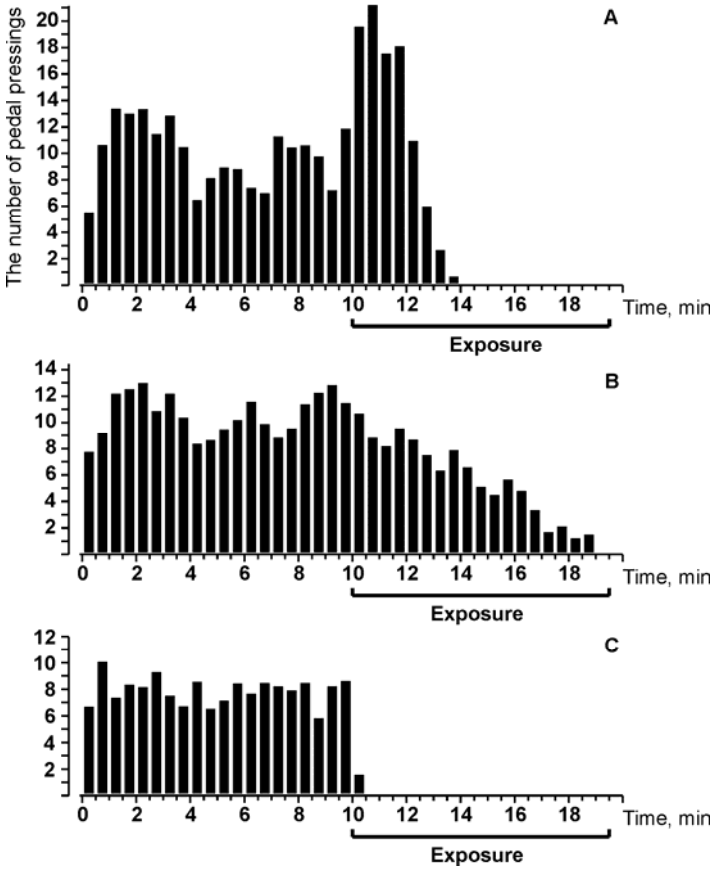

Figure 14. Dynamics of the self stimulation rate in case of EMF exposure at different modulation frequencies. A — 2 Hz; B — 7 Hz and C — 50 Hz. Each column is the number of pedal pressings per 30 s period averaged for 10 animals. The line is the MEMF exposure time.

The motor performance of the rabbits in conditions of a chronic impulsive irradiation to microwaves of low intensity (Grigoriev Yu. et al., 1995) was investigated.

The rabbits were irradiated with electromagnetic field at 1.5 GHz. The character of modulation was impulsive, impulse of the rectangular form, pulse duration of 16 ms, recurrence rate of impulse of 0.12 Hz, S=300 μW/cm^2. Animals were irradiated daily for 30 minutes within one month. Electromagnetic exposure and "sham irradiation" were applied in the random order.

The observations of the motor performance of the rabbits were conducted during daily exposure for 30 minutes within 1 month.

In the term of 30 minutes of true or "sham" irradiation, the rabbits were put in specially made organic glass cell. Out of door piezocrystal permitting to differentiate motor reactions was attached to a floor of a cell. The graphic entry of motor reactions and their handling were led with the help of a polygraph and " Televideo- 286 " (USA).

Only since day 14 of chronic exposure, the alarms were developed at animal reliable disadaptation motorial exhibitings as intensifying disturbing.

The response of separate neurons of a brain on a low intensive packed impulsive microwaves was investigated. (Moiseeva N., 1996).

The experiments were conducted on the rabbits. EMF exposure was applied at 1.5 GHz, 100% amplitude modulation, meander, pulse duration of 0.4 ms, recurrence rate of 1000 Hz, duration of packs of 16 ms, with frequency of their repetition of 0.12 Hz, S=300 μW/cm^2. The exposure was conducted in sound isolated non-echo chamber with a reflectance factor of 30 dB.

The generator of a microwaves (G3–21) was used. The radiation time was 1 minute. As control, the animal group with "sham irradiation" was utilized. The examinations were conducted up to, in time and at once after exposure.

The experiments were conducted on 22 rabbits of Chinchilla breed with body mass of 3 kg. The bioelectric activity of 139 neurons of sensomotorial and parietooccipital ranges of a cortex of a brain was studied. The impulsive activity was noted with the help of a small-type micromanipulator with a walk of the screw by 500 microns. The submersed microelectrode was served by the glass capillar with a bottom diameter of 1–3 microns, filled with three-molar normal saline solution of sodium chloride (resistance of 5–30 MOhm). They have utilized chlorine vinyl tube with the same solution on the basis of agar wires.

Analyzed frequency of the discharges of neurons and their character in the period of 3-minute entry (1 min — background, 1 min — irradiation and 1 min — after exposure). An irradiation and control were conducted in randomized order.

Under MEMF exposure, the activity of neurons has reliably varied, the number of the neurons which have changed the frequency has increased. The character of a response of neurons depends on their initial activity (Table 10–12). The neurons excitanted in the time of MEMF exposure have changed the response on inhibition in the time of after-exposure.

Table 10

Performance of responses of neurons of sensomotor range of the brain cortex of the rabbit on low intensive packed impulsive microwave radiation

Character of responses	An amount of neurons,% from total (63)	Central frequency		
		before	during	after
Excitation	24.14*	5.5±0.66	16.3±0.78	6.03±0.64
Inhibition	31.03*	11.82±0.7	4.3±0.49	4.3±0.49
Non reacted	44.83*	9.82±0.67	9.34±0.68	9.34±0.79

* $p < 0.01$ versus control (Table 12); ** $p < 0.01$ versus background.

Table 11.

Performance of responses of neurons of parietooccipital range of the brain cortex of the rabbit on low intensive packed impulsive microwave radiation

Character of responses	An amount of neurons,% from total (63)	Central frequency		
		before	during	after
Excitation	23.23*	5.52±0.4	11.25±0.76**	2.83±0.47**
Inhibition	30.47*	9.67±0.73	3.58±0.68**	4.45±0.61**
Non reacted	46.3*	6.13±0.52	5.9±0.47	5.33±0.42

Footnote. See note to Table 10; * $p < 0.01$ versus total of the registered neurons; ** $p < 0.05$ versus an initial background

Thus, at EMF exposure within 1 minute at 1.5 GHz, 300 $\mu W/cm^2$ at a packed quantization the modification of activity of neurons of the brain cortex was registered.

In repeated experiments, the modulated EMF effect on impulsive bioelectric activity of neurons of the brain cortex of the rabbit with the same aspect of modulation also was investigated, except for packed impulsive exposure. (Lykjanova S., Moiseeva N., 1998).

Table 12.

Performance of responses of neurons of sensomotor and parietooccipital ranges of the brain cortex of the rabbit on sham irradiation (control series)

Ranges of a cortex	Reaction character	An amount of neurons,% from total (63)	Central frequency		
			before	during	after
Sensomotorial (72 neurons)	Excitation	3.04	5.2±1.32	6.94±1.5	7.8±1.09
	Inhibition	11.75	9.1±0.32	6.1±0.53	6.3±0.38
	Not reacted	85.21	8.7±0.4	8.0±0.44	8.6±0.41
Parietooccipital (73 neurons)	Excitation	5.65	2.26±2.2	4.1±1.6	8.4±2.15
	Inhibition	10.3	5.47±0.44	3.2±0.52	3.93±0.45
	Not reacted	84.05	6.2±0.42	5.8±0.38	6.5±0.39

The irradiation of animals was conducted in non-echo chamber, reflectance factor of 30 dB. EMF applied was at 1.5 GHz, quantization, pulse duration 0.4 ms with a recurrence rate of 1000 Hz, S=30 μW/cm^2. The generator G3–21 (Russia) was used. Time of exposure was 1 min. There was a series with "sham irradiation ".

The examinations were conducted up to, in time and after exposure within 1 minute. The experiments were conducted on 22 not anesthetized male rabbits of Chinchilla breed, 3 kg body weight, which were softly fixed on the wood machine tool. They have studied extracellular bioelectric activity of neurons of sensomotor and parietooccipital ranges of the brain cortex. They have recorded the impulsive bioelectric activity applying small-type micromanipulator made of organic glass with a walk of the screw of 500 microns, which was fastened on a head of the rabbit and allowed to record impulsive activity not only before and after, but also in the EMF valid time. The submerged microelectrode was served by the glass capillar with a bottom diameter of 1–3 microns, filled with molar solution of sodium chloride (resistance of 5–30 MOhm). The intact electrode was fastened on an ear of the rabbit. They have utilized chlorine vinyl tube with a normal saline solution on the basis of agar as the wires. They have analyzed frequency of the discharges of neurons and their character in 3 min of an entry (1 min — a background, 1 min — irradiation and 1 min — after-exposure).

Irradiation and "sham" irradiation were conducted in the randomized order. Statistically estimated exhibiting of the response on frequency pulsation of neuronic activity in the time of the irradiation was done in comparison with the background and conforming control of examinations, utilizing a t-Student and χ^2 criteria.

The quantitative performance of modifications in impulsive bioelectric activity of sensomotor and parietooccipital ranges of the brain cortex in conditions of the conducted experiments is submitted in Table 13. From the table it follows, that the irradiation in comparison with control, has reliably resulted to lot of neurons reliably changing the frequency of bioelectric activity if compared to the initial background. Among responding neurons (from 55 up to 60%), the identical amount of cells as with a response of augmentation of pulsation frequency and with its decrease was observed.

In Tables 14 and 15 the performances of pulsation frequency of neurons in control and with MEMF irradiation are submitted. As follows from Table 14, the reliable modifications in control pulsation frequency of neurons were practically missed. In the time of MEMF exposure, both decrease and increase of the pulsation frequency could reliable take place (Table 15).

Table 13

Comparative performance of percent of responses of neurons of sensomotor and parietooccipital ranges of the brain cortex of the rabbit in experiments with MEMF irradiation

Series (conditional name)	Brain cortex range	No. of recorded neurons	% of total neuron number		
			Confident pulsation change of:		Not reacted
			increase	decrease	
MEMF	Sensomotorial	105	27.62*	2.38*	40.0*
	Parietooccipital	84	25.0*	29.76*	45.24*
"sham" exposure	Sensomotorial	72	2.7	11.1	86.2
	Parietooccipital	73	5.48	10.96	83.56

* $p < 0.01$ versus control, by χ^2criterion

Table 14

Performance of frequency pulsation of neurons in sensomotorial and parietooccipital ranges of the brain cortex of the rabbit in experiments with a "sham" irradiation

Brain cortex range	Response character	Central frequency, Hz		
		before	during	after
Sensomotorial (72 neurons)	Excitation	5.2±1.32	6.94±1.5	7.8±1.09
	Inhibition	9.1±0.62	6.1±0.83	6.3±0.98*
	Not reacted	8.7±0.4	8.0±0.44	8.6±0.41
Parietooccipital (73 neurons)	Excitation	2.26±1.5	4.1±1.6	8.4±1.9
	Inhibition	5.47±0.94	3.2±0.92	3.93±0.85
	Not reacted	6.2±0.42	5.8±0.38	6.5±0.39

Footnote. The quantitative performance of responses is submitted in Table 13 $p < 0.05$ versus an initial background on a Student criterion.

Table 15

Performance of responses of neurons of sensomotor and parietooccipital ranges of the brain cortex of the rabbit on the MEMF irradiation

Brain cortex range	Response character	Central frequency, Hz		
		before	during	after
Sensomotorial (105 neurons)	Increase	6.1±0.89***	11.2±0.64*	9.2±0.58*,**
	Decrease	8.92±0.88	4.32±0.7*	8.85±0.69**
	Not responded	6.9±0.54	7.5±0.69	7.1±0.85
Parietooccipital (84 neurons)	Increase	4.92±0.45***	8.4±0.53*	6.9±0.48*,**
	Decrease	6.53±0.39	4.13±0.57*	6.89±0.75**
	Not responded	5.4±0.83	6.38±0.71	6.05±0.66

* $p < 0.05$ versus an initial background on a Student criterion.

** $p < 0.05$ versus the exposure time on a Student criterion.

*** $p < 0.05$ at comparison to background values of neuron pulsations with inhibition character of responses.

At first minute after MEMF exposure in case of an activation of bioelectric activity, the tendency of homing to background magnitudes was marked, and, in case of inhibition, the bioelectric activity did not reliably differ from an initial background. It is necessary to mark, that the

character of a modification of neuron pulsations due to the modulated EMF exposure was connected to an initial background. In the background, the tendency to the greater pulsation frequency in a case the decreased rate has taken place in comparison with an acceleration of the discharges of neurons under MEMF effect. In opinion of the authors, the correcting MEMF effect is present.

Above-stated findings are reflected in histograms of the allocation of the frequency of neuron pulsation in MEMF experiments (Figures 15 and 16). From Figure 15 it is visible, that the pulsation frequency of excitatory neurons is reliably enlarged and is saved during all period of the MEMF irradiation. In the time of an after-exposure, the bioelectric impulsive activity was sunk, though remained above background. Surveying a response of neurons pulsation sinking on MEMF exposure (Fig. 16), it was marked, that the pulsation frequency was reliably sunk in the time of MEMF irradiation and was recovered up to average background values in the time of "after-exposure". In the time of MEMF exposure, the packed group irritation of neurons was observed, which in the time of "after-exposure" has regularly varied. These histograms follows, that the character of a neuron excitation was various and depended on an initial background.

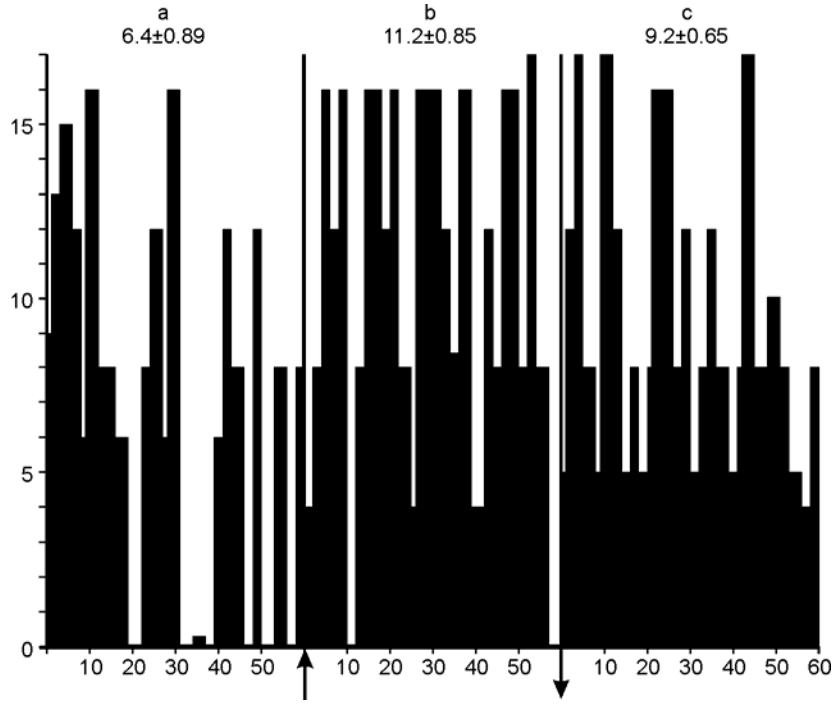

Figure 15. A histogram of allocation of frequency of neuron pulsation excitanted in reply to an one-minute MEMF irradiation; a — a background, b — the time of an irradiation, c — after an irradiation. On abscissa axis — time, s; on an axis of ordinates — pulsation frequency, s^{-1} (Hz).

Thus, the presence of a response of extracellular bioelectric activity of neurons on low intensive MEMF is found. The character of a response was determined by a background, testifying correcting MEMF effect.

Some examinations were dedicated to examination of modulated EMF effect on bioelectric activity of the animal brain. Certainly, the given pilot model does not allow quantitatively precisely to estimate character of modifications, however to reveal the particular tendency of modulated EMF effect on a spectrum of bioelectric activity of a brain.

The effect of 980 MHz EMF pulsewise modulated at 12 and 27 Hz, S=30–50 mW/cm^2 on bioelectric activity of the brain (Ivanova V. etal., 2000) was examined. The experiment was conducted on cats. The EEG was realized by carbon leads in range of vertexum. Time of single-pass

exposure was 20 min. During repeated MEMF exposures, the augmentation of spectral rate of a spectrum of biological currents in the 12–18 Hz band.

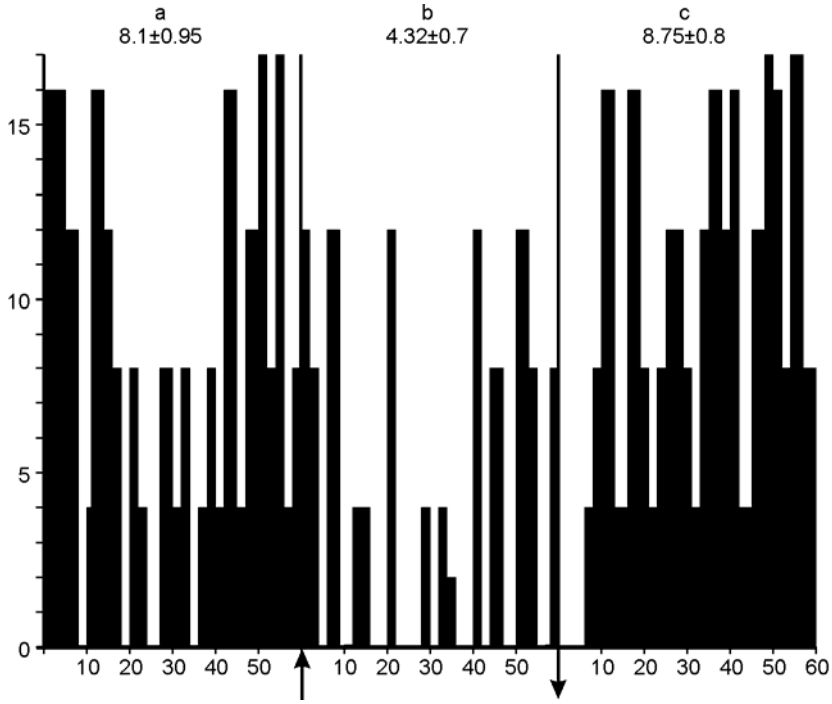

Figure 16. A histogram of allocation of frequency of neuron pulsation inhibited in reply to an one-minute MEMF irradiation; a — a background, b — the time of an irradiation, c — after an irradiation. On abscissa axis — time, s; on an axis of ordinates — pulsation frequency, s^{-1} (Hz).

In the other experiment the effect on cooperative bioelectric activity of various frames of a brain for modulated low intensive EMF (Grigoriev Yu. и др. 1995) was investigated. Four series of experiments were conducted:

1. Control — sham irradiation — K;
2. Series with an impulsive irradiation at frequency of 0.12 Hz (O_1);
3. Series with an impulsive irradiation at frequency of 1000 Hz (O_2);
4. Series with packed impulsive irradiation; a pulse-recurrence frequency — 1000 Hz, recurrence rate of packs — 0.12 Hz (O_3).

In all cases PFD was 300 $\mu W/cm^2$ in impulse. One rabbit have been exposed to only one regimen of an irradiation: single 30 min exposure. However, each animal in the casual order has participated in a control series with a sham irradiation. Detailed quantitative performance of experiments and the parameters of an irradiation are submitted in Tables 16 and 17.

Table 16

Quantitative performance of experiments

Series		No. of rabbits	No. of 30 min exposures
No.	Conditional name	In series	In series
1	K	30	-
2	O_1	10	10
3	O_2	10	10
4	O_3	10	10

Table 17

Parameters of MEMF irradiation

No	Conditional name	Irradiation parameters							Exposure time, min.
		Carrier frequency, Hz	Mode	Characteristics of;					
				pulses		packs			
				S, μW/cm^2	Duration, ms	Frequency, Hz	Duration, ms	Frequency, Hz	
2	O_1	1.5	Pulsed	300	16	0.12			30
3	O_2	1.5	Pulsed	300	0.4	1000			30
4	O_3	1.5	Packed pulsed	300	0.4	1000	16	0.12	30

The electrodes were implanted to each rabbit on the conventional method, according to coordinates submitted in the stereotactical atlas of E. Fifkova and J. Marshal. The ranges of a cortex and following subcortical formations were examined including: the basal amigdalum core (AB: AP-1, SD-5, V-16), hyppocampus (HiP: AP-5, SD-5, V-5), septum (NSL: AP-4, SD-1, V-3), front department of hypothalamus (AHA: Ap-2.5, SD-1.5, V-12), head of the tail kernel (PS: AP-4.2, SD-2.8, V-8.6). In a cortex and hyppocampus, most electrodes were implanted at the left and on the right, and on the right in remaining parts.

As electrodes and abducent wires have utilized chlorine vinyl pipette and tubes filled with normal saline solution on the basis of agar in a consistence of a gel. They had resistance of 1 MOhm and met the requirements showed to conductors of biological potentials. Abduction of biological currents was realized by a monopolar method with inert electrodes on nasal bones. In the time of experiment, the rabbit was softly fixed for paws on the wood machine tool. The experiments were conducted in conditions of electrophysiological experiments meeting the MEMF test requirements.

As a result of the conducted experiment, the reliable modifications of bioelectric activity of frames of a brain were obtained at all three modes of exposure, approximately equally. It has not allowed the authors to share conditions of exposure on their efficiency. In all three series, modifications were determined by an initial background, however they did not fall outside the limits of normal functioning and concerned, mainly, θ ranges of hyppocampus. The reliable difference between control and irradiation was marked only in biological currents of hippocampuses.

The experiment was posed with the purpose of clearing up of mechanisms of the suppression of somatic vegetative responses to modulated EMF (Kashtanov S., Sudakov S., 1981). The experiment was tried in rabbits. Animals were irradiated to EMF at 40 MHz with modulation of 7 Hz, field strength from 30 up to 300 V/m. The duration of exposure was from 10 mines up to 2.5 hours.

At the first stage, the effect of the suppression of somatic vegetative responses was found to be induced by the irritation of the ventral kernels of a hypothalamus. On the second investigation phase, they have conducted a serial coagulation of separate frames of the brain and found, that the reticular formation participates in realization of vegetative reciprocal responses at MEMF exposure.

The responses in various compartments of the nervous system were examined at modulated EMF exposure in conditions of an emotional stress (histochemical examinations), (Gorbunova A. et al., 1981).

The rabbits in a state of an emotional stress were utilized. Animals were irradiated to EMF at 39 MHz, modulation of 7 Hz, depth of modulation of 80%, field strength of 30 V/m. A field was framed between two plates of the capacitor coherent with the SHF generator. Immobilized ani-

mals were disposed between plates, so that saggetal line of the body was placed horizontally and perpendicularly to lines of MEMF force. A radiation time was 3 hours. The examinations were conducted at once after an irradiation.

The tests were conducted on 86 rabbits. The emotional stress was invoked by an electrical current irritation in hypothalamus, skin of extremities and ears. In a nodulose ganglion of a vagus nerve, upper cervical, star-shaped ganglions, sympathetic clusters and clusters of a sympathetic line-up at a level 4–6 of thoracic segments they have determined a content of water-soluble proteins. A spectrum of lactate dehydrogenase (LDH) was examined in clusters of an independent nervous system and conductive system of heart.

MEMF has selectively labilized limbic frames of the brain and depressed the bottom-up effect of a reticular formation on a cortex of major hemispheres, rising fastness to an emotional stress and enlarging ability to adaptation.

For an assessment of a role of modulation at MEMF exposure, the procedure detailed in general physiology of imprinting (Grigoriev Yu., 1996; Grigoriev Yu and Stepanov V., 1998) was utilized. The imprinting is an original aspect of memorizing: at birth the organism fixs in the memory, that it has seen for the first time.

129 embryos of chickens were irradiated at day 16 of an incubation to EMF at 9.3 GHz; 5 min exposure, S=40 $\mu W/cm^2$ with a quantization of 10 and 40 Hz, meander, pulse duration of 2.5 ms. Besides, there were series with a continuous irradiation (CW) and "sham" exposure.

The imprinting suppression (up to 50%) was found in newborn chicken only for series of EMF exposure at 10 and 40 Hz (Table 18). In case of CW exposure (S=40 $\mu W/cm^2$) and in control group, the imprinting disturbance was not found.

Table.18

Imprinting in chickens after an EMF irradiation of embryos for continuous and modulated regimens

Series No.	Series name	PFD, $\mu W/cm^2$	Exposure time	No. of embryos	No. of chickens with imprinting
1	Control – sham exposure	-	-	83	81 (97%)
2	Continuous exposure	40	5	27	23 (89%)
3	10 Hz or 40 Hz modulated exposure	40	5	19	9 (50%)

In one of experiments the problem was posed to examine the possibility of the brain bracing of a particular regimen of EMF modulation (Grigoriev Yu, 1996). In this experiment, the imprinting model was also utilized, and the signal of a EMF quantization was utilized as imprint stimulant. An irradiation of chickens was realized at incubation day 16 in non-echo chamber: EMF at 9.3 GHz with the quantization of 1, 2, 3, 7, 9 or 10 Hz, S=0.04 mW/cm^2, time of each irradiation was 5 minutes.

The possibility for the development of temporal communications at 15 diurnal chicken embryos was earlier shown through an electrocurrent and sound (Hunt, 1949). Taking into account these results, the authors have assumed, that the electromagnetic modulation waveform can be fixed by a brain and gain value of an imprint signal. The plan of experiment was as follows: incubation day 16 embryos were MEMF irradiated with modulation of 1, 2, 3, 7, 9 and 10 Hz. After birth of chickens, the sensing imprinting period (24 hours after birth) was passed and in this period any choronomic irritator was not shown to a chicken. In 48 hours after birth, strobe lights with the same frequency were shown to a chicken as imprint stimulant, from which the embryo was subjected to an electromagnetic irradiation for day 16 of an incubation. The difference between alleged light stimulant and differentiation stimulant was equal to 8 Hz.

The experiments were conducted on 127 embryos (chickens). A possibility of imprinting exhibiting on imprint stimulant with the light frequency similar to EMF modulation, which has exposed embryos at day 16 of an incubation, and at light blinking frequency of 1, 2, 3, 7, 9 or 10 Hz is submitted in Figure 17. The analysis of the obtained materials has allowed the author to make a deduction, that the obtained data testify that the embryo brain at day 16 of an incubation can fix electromagnetic stimulant with modulation of 9 or 10 Hz and store this information during particular time after birth. Thus, the obtained data assume, that the regimen of EMF modulation can be fixed by a brain.

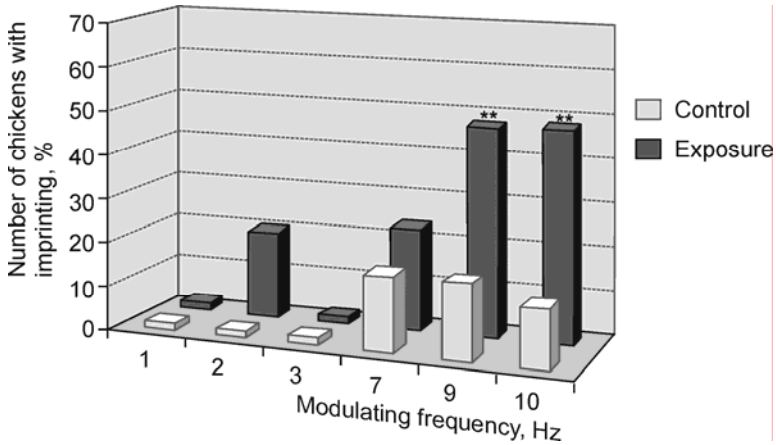

Figure 17. Number of chickens, which brain has fixed an electromagnetic modulation waveform (imprinting is established)

The fruit fly embryos were utilized for an assessment of the modulated EMF biological effect (Bolshakov M. et al., 2001; Bolshakov M., 2002). Embryos were irradiated to MEMF at 460 MHz, quantization 2.5, 6, 10, 16, 22 and 40 Hz (porosity of 25), average SAR of 0.12 W/kg, absorbed power per impulse of 3 W/kg. The SAR impulsive magnitude was identical at porosity from 12.5 up to 6 at frequency of modulation of 16 Hz. Embryos were irradiated at temperature +24.5°C. Control groups: a "sham" irradiation and physical control. Time of exposure is 5 minutes.

Time of embryo development (age) was counted from a beginning of egging on a medium within 10 minutes accuracy. In experiment they have utilized embryos in the age of 15 hours and 10 minutes. The tests were tried in 30 thousand embryos and the sample size was not less than 1000 on each experimental point.

The results of experiments were estimated on an percentage of the interrupted development (PID) calculated as percent of imagoes from conforming egg number, which amount was 100%. PID was taken into account in three experimental groups: (1) test group, in which embryos were subjected to MEMF irradiation; (2) "the sham irradiated group", in which embryos were subjected the same experimental procedures, as irradiated embryos, but without EMF exposure (delivery to a place of an irradiation, location on 5 min in temperature controlled conditions, the EMF generator was switched off, homing in a thermostat for an incubation); (3) control embryos group, which all time were in temperature-controlled conditions (24.5°C), on which they have estimated a streaming functional state of a laboratory population of flies.

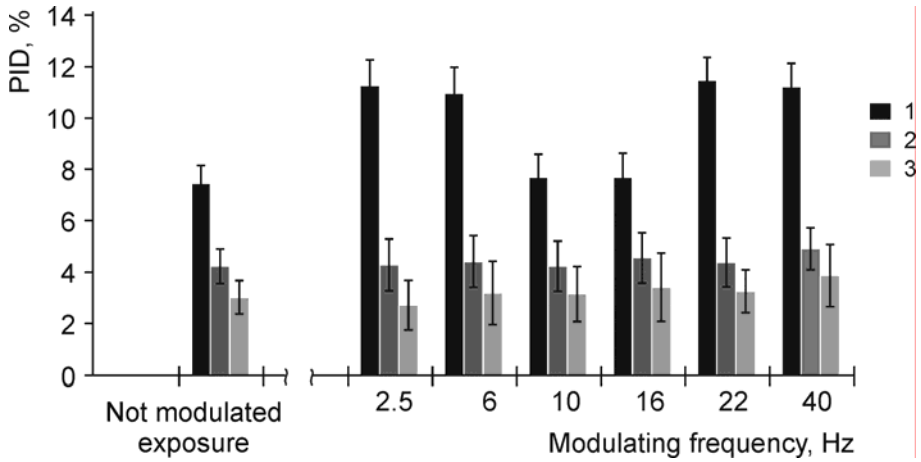

Figure 18. Effect of MEMF exposure at 460 MHz on SAR of the fruit flies (the average values and errors, average with level of significance < 0.05) is submitted. For comparison the results for 5 minute not modulated exposure with SAR of 6 W/kg are given. 1 — SAR after an MEMF irradiation; 2 — SAR for "sham irradiated" flies; 3 — SAR in laboratory control

The results of the experiment has shown, that the MEMF irradiation has rendered effect on embryos of the fruit fly in the age of 15 hours 10 mines. This effect depends on frequency of modulation (Fig. 18 and 19). It is important to mark, that difference in modulated (0.12 W/kg) and not modulated (6 W/kg) SAR has resulted to almost 50 times difference.

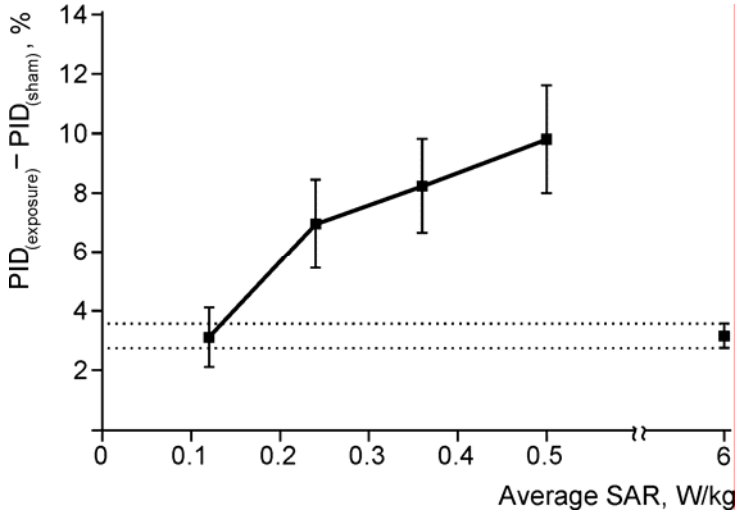

Figure 19. The dependence of MEMF irradiation effect in embryos of the fruit flies at frequency of 16 Hz (average SAR varied in dependence on porosity — from 25 up to 6). For comparison the average value of effect is submitted for not modulated EMF with SAR of 6 W/kg and error of mean (dashed lines).

The modulated EMF effect in the fruit flies embryos on the background of a temperature rise of environment (Bolshakov M., 2002) was examined. The tests were tried in 15 thousand embryos, which were subjected to not modulated EMF with SAR of 6 W/kg (in impulse) and 0.12 W/kg (in average) and modulated electromagnetic exposure at 6, 10, 16, 22 Hz, SAR of 3 W/kg. In all series, including control, the ambient temperature was 40°C. For all modes of exposure the sample was not less than 1000 embryos for each of groups.

The results of exposure were estimated on percentage of the interrupted development (PID). PID magnitude was calculated as percent of imago from conforming total egg pool, which total amount was 100%. PID was estimated in four various groups: (1) continuous irradiation of embryos, (2) MEMF irradiated embryos; (3) "sham" irradiated embryos, which were subjected to

elevated temperature only without EMF and (4) control embryos, which were constantly contained in temperature-controlled conditions at fixed temperature of 24.5°C. The effect of exposure was determined as a difference between PID of groups subjected to continuous EMF, modulated EMF and "sham" irradiated groups.

Combined exposure to not modulated EMF with SAR of 6 W/kg and heat up to 40°C has resulted to inappreciable PID augmentation; the effect has appeared statistically not significant in comparison with effect at standard temperature of 24.5°C: 3.8±1.1% in conditions of heat against 3.2±0,7% at standard temperature. The effect of elevated temperature exposure only (40°C) has made 1.3±0,7%.

The findings of investigation of MEMF effect on a background of heat is submitted in Figure 20. As it is visible from this drawing, the effect essentially depends on frequency of a quantization. MEMF with frequencies of modulation of 6 and 22 Hz on a background of heat was specific to some enlarged PID, in comparison with PID at standard temperature. Vice-versa, at frequencies of modulation of 10 and 16 Hz, the exposure on a background of elevated temperature has initiated smaller PID ($p < 0.05$), rather than at standard temperature (figure 20). The PID magnitude under condition of elevated temperature was at PID level for "sham" irradiated embryos.

Thus, the effects of heat and exposure of a EMF quantization of 6 and 22 Hz are additive. At frequencies of 10 and 16 Hz the bioeffect was decreased.

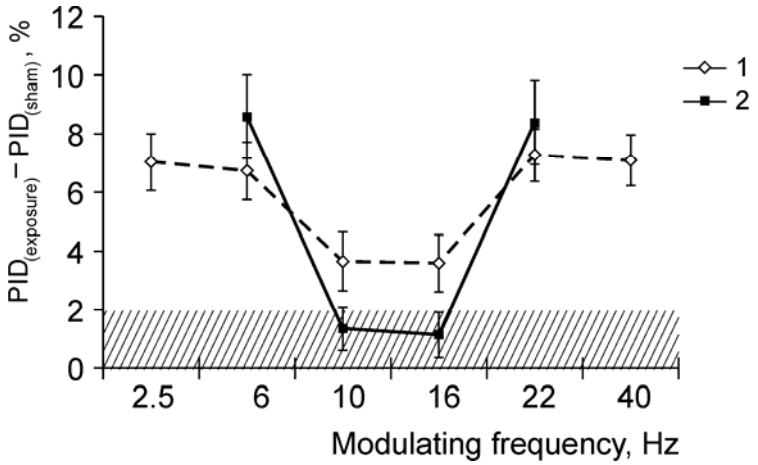

Figure 20. Modifications of percent of the interrupted development in the fruit flies after 5 minute MEMF exposure of embryos of age of 15 h 10 mines at standard temperature of 25°C (1) and on a background of elevated temperature of 40°C (2). The shaded space — 95% confidence interval for average PID values of "sham" irradiated embryos

The low intensive modulated EMF effect on development and vitality of Tickhyalomma Asiaticum (Burenkov M. et al. 1996) was investigated. The tests were put on ovums, hungry larvas, satiated larvas and hungry nymphs of the first laboratory Tickhyalomma Asiaticum generation.

The MEMF irradiations was conducted through days 5–10 after the egg pool forming or after a saturation of insects and passage them in the following phase of development. They have utilized the following modes of exposure: R1 (K) — "sham" irradiation; R2 — broadband radiation in a band of 1–4 GHz, quantization of 7 Hz, pulse duration of 20 ms, average S=20 μW/cm^2; R3 — carrying frequency of 3 GHz, packed quantization, frequency of impulses of 1 kHz, frequency of following of packs of 7 Hz, duration of a pack of impulses of 20 ms, average S=10 μW/cm^2; R4 — same, as R3, but at average S=20 μW/cm^2; R5 — broadband radiation in a band of 1–4 GHz, quantization of 2 Hz, pulse duration of 20 ms, average S=30 μW/cm^2; R6 — carry-

ing frequency of 1 GHz, quantization of 2 Hz, pulse duration of 20 ms, average S=30 μW/cm^2. The examinations were conducted at once after an irradiation and during all development cycles.

Insects were kept at ambient temperature (22–23°C) in the humidified scoops. Each test has consisted of 2–4 repeated variants, and the separate variant has included either one complete egg pool or 10 larvas and nymphs.

The following basic results were obtained.

1. *MEMF ootids irradiation effect in hungry larvas delivery*. Total number of delivered larvas was identical in all series. The differences were found in course and terms of their delivery, and also in dynamics of the subsequent activity. The delivery delay was observed in all experiment variants. In control, 50% of larvas were delivered at day 12 versus days 15–32 for irradiated ones (table 19). The least delay in development was marked in a regimen R2. The variance between experiment and control in this case has made 3.4 days ($p < 0.09$). The delivery of 50% of larvas in regimens R3 and R4 was at days 25.3 and 32.2, accordingly. The differences from control were statistically reliable ($p < 0.01$); the difference between control and experiment has achieved accordingly 13.4 and 20.3 days. The similar tendencies were noted in dynamics of activity of delivered larvas. Insects delivered from intact and irradiated parents in regimen R2 became fissile at the first day after delivery, while in regimens R3 and R4 the activation was delayed and the delay halftime, T_{50} was different ($p < 0.0001$) for intact and irradiated egg pools (regimens R3 and R4), so the essential differences were for variant R2 versus variants R3 and R4.
2. *MEMF effect on a survival rate of hungry larvas and nymphs*. The MEMF irradiation of hungry larvas and nymphs was conducted on days 7–10 after delivery. The duration of the surviving of larvas and nymphs in all variants of experiment was lower, than that in control. So, the parameter T_{50} for larvas and nymphs in control has made accordingly 13.8 ± 1.9 and 36.9±2.0 (tables 19), in experiment (regimens R4 and R5) it was less (9.5–11.9 and 27.1–28.2) at days 2–4 and 9–10.
3. *MEMF effect on development of satiated larvas.* The experiment was conducted on insects of spring and autumn generations. An irradiation of satiated larvas was conducted at day 10 after insect saturation. They have utilized regimens R3, R4, R5 and R6. First delivered nymphs have appeared in identical terms after an irradiation, both in spring, and in autumn generation: on days 16–18 after the saturation of larvas; the experimental and control variants did not differ. On other parameters the essential apostatizes were observed. The molting of both irradiated, and intact insects of spring generation flowed past in considerably more short terms, than for autumn one. The period of molting in the first series has occupied from 2 to about 5 days, whereas it was 8–12 days in second series. The greatest apostatizes are marked in an amount of delivered nymphs. The satiated larvas of spring generation have appeared less sensing to all EMF regimens. In all variants, 100% of metamorphosises of larvas in nymphs were observed. The subsequent survival rate of delivered hungry insects did not differ from control values and was close to 100% within 16^{th} –25^{th} subsequent day.

Thus, MEMF has practically invoked noticeable physiological modifications in Hyalomma asiaticum organism for all examined regimens. These modifications were expressed in the delivery delay of larvas from irradiated egg pools, in the decrease of the activity and survival rate of delivered insects. The similar findings were observed in the delivery course of hungry nymphs from the irradiated larvas. The augmentation of the average PFD from 10 up to 20 μW/cm^2 has enhanced the observable effect. So, the delivery duration and activation of 50% of larvas was enlarged for 30–35%, and the survival rate of hungry nymphs of autumn generation, vice-versa, was sunk twice.

Table 19

MEMF Effect on delivery, activation and duration of a surviving of hungry nymphs of various phases of Hyalomma asiaticum development

Exposure regimen	No. of insects	No. of groups	Regression factor	$T_{50,}$ days
Delivery duration of larvas				
R1(K)	3000	2	0.24±0.002	11.9±1.0
R2	3000	2	0.25±0.01	15.3±0.1
R3	3000	2	0.08±0.01	25.3±0.1
R4	3000	2	0.07±0.01	32.2±0.7
Activation duration of larvas				
R1(K)	3000	2	-	1.0
R2	3000	2	-	1.0
R3	3000	2	0.08±0.01	17.03±0.4
R4	3000	2	0.07±0.01	23.9±0.5
Survival duration of hungry larvas				
R1(K)	20	2	0.14±0.01	13.8±1.9
R4	20	2	0.14±0.01	11.9±1.0
R5	20	2	0.14±0.01	9.5±4.0
Survival duration of hungry nymphs				
R1(K)	150	15	0.05±0.01	36.9±2.0
R4	150	15	0.05±0.01	27.1±2.7
R5	250	20	0.05±0.01	28.2±20

The experimental application of the broadband radiations in a band of 1–4 GHz (R2 and R5) with frequencies of modulation of 7 and 2 Hz has invoked generally similar, but essentially less expressed effects, than on carrier frequencies of 3 and 1 GHz with the same modulation. The most expressed biological effect of radiation was expressed in depressing of development and augmentation of the insect mortality, on miscellaneous phases of its life cycle, which was detected for exposure at 3 GHz with frequency of modulation of 7 Hz. The especially acute violations in weep of physiological processes have taken place during embryonic development and metamorphosis.

CONCLUSOION

The analysis of 28 biological experiments conducted in vitro, in situ, and in vivo in the former Soviet Union (FSU) and later in Russia with usage of the modulated electromagnetic fields of radiofrequency allows to make the following basic conclusions:

- EMF exposure of biosystems with less or more composite regimens of modulation the development of bioeffects, both physiological, and unfavorable, which are distinct from bioeffects induced by not modulated EMF is possible;
- the acute modulated EMF exposure of low intensities (non-thermal levels) can result in development of pathological effects;
- there is a dependence of development of a reciprocal biological response on the intensity and directness of the concrete regimen of EMF modulation; this dependence was fixed at all levels of biological systems — in vitro, in situ and in vivo;
- as a rule, modulated EMF has invoked more expressed bioeffects, than continuous regimen of modulation;

- the effect of EMF RF modulation is more expressed at lower levels of intensity.

The obtained data have specified the possibility of the effect of EMF modulation on the development of biological effect at a level of composite systemic interactions in an organism. It allows to discharge modulated EMF in the special group of radiations, which biological effect depends not only from magnitude of an absorbed energy, but also on the form of modulation "addressed" to this or that functioning system. It determines the conclusion, that at an assessment of modulated EMF danger, it is important not only to assess magnitude of an absorbed energy, but also the fact of contact of the human with this aspect of radiation. This circumstance brings in major indeterminacy by development of the EMF standards.

The individual singularities of the man are essentially important, the individual sensitivity to a particular regimen of EMF modulation, that dilates a problem of hypersensitivity to EMF.

As a result of the conducted experiments with MEMF, the effect of an initial state of biosystem on expected effect is detected. The given fact is rather important, since does not allow to establish common regularity in the development of bioeffects at particular aspects of modulation. As a matter of fact, the initial background of a system of an organism can determine the character and directness of a reciprocal response, that complicates the prognosis of expected effects in conditions of MEMF exposure on the population.

The role of modulation gains the major significance at low intensity (at non-thermal levels of EMF). In this connection, this factor becomes now leading at an assessment of population exposure to EMF RF.

The experimental recognition of dependence of development of bioeffect from an aspect of modulation specifies recruitment phenomenon of new gears of interaction of an organism with MEMF, which are not clear and demand the future study.

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