CONTROL OF UHF ENERGY ABSORPTION PROCESS BY RESONANCE METHOD IN A SHIELDED OBJECT

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A research program has been developed to account for effect of transverse electric and magnetic fields on a biological object, reaction control of its dielectric constant change, quality factor and heat loss in UHF range in a rectangular resonator in the resonance absorption mode.

PACS: 42.60.Da; 87.58.-b

INTRODUCTION

Metastasis remains a major problem in cancer. That is, in fact, migration of the cancer cells through the circulatory and lymphatic systems which gives rise to new tumor formation in various tissues [1]. Violation of the genetic control is due to lack of the tissue regulation, and cells come out of the immune system control. When tissue homeostasis happens a proliferation occurs due to that T-lymphocytes cannot reach an infected cell from the bloodstream through the endothelial cell membrane to kill cancers.

In essence the oncogene concept reduces to an assertion that the source of malignant growth is enclosed in a normal cell, in its genome, while the initiated impulse comes from outside. Activation of eigen-genes (protooncogenes) under influence of chemical, physical, radiological and biological factors is considered to be a reason for the transformation. Tissue regulation with the restoration of disturbed genetic control has no genetic character and could be a plausible alternative.

In this paper a solution for strengthening the response of the immune system problem based on the following physical processes using UHF radiation:

1. Charge removal from the region of dielectrics with different values of dielectric constant and a dielectric waveguide.
2. Penetration depth of the UHF radiation into a biological tissue compared to other radiation frequencies.
3. Water as a polar molecule occupies ~ 70% of the blood composition.
4. Relaxation time of the interstitial fluid.
5. Water in free and bound states in a biological tissue, interference of UHF vibrations when committing changes in the molecular states.
6. Levels of UHF absorption power to allocate a limited region in a biological sample as it moves in the standing wave of the microwave-resonator.
7. Closed and open UHF-resonators and parabolic reflector UHF-antennas.
8. Of a particular interest are the processes taking place between water molecules in various states of molecular groups making up the biological structures.

1. MATERIALS AND METHODS

The most promising method for solving the stated problem is usage of UHF-radiation in the frequency range corresponding to the area of water dispersion. Water condition specifics should be reflected in dynamics of its dielectric properties, which are a valuable source of information on the relationship of body fluids in vessels. An UHF-resonator allows to record even small structural changes in biological components between free and bound water [2 - 4]. The purpose of this work is to develop an UHF-resonator for a living biological object for a mechanism of cleaning of the vessel with a dilute electrolyte.

Distribution of fields in a half-period cavity resonator with H_{011} type of oscillations and based on a rectangular waveguide with a continuous energy exchange between E- and H-fields is shown in Fig. 1.

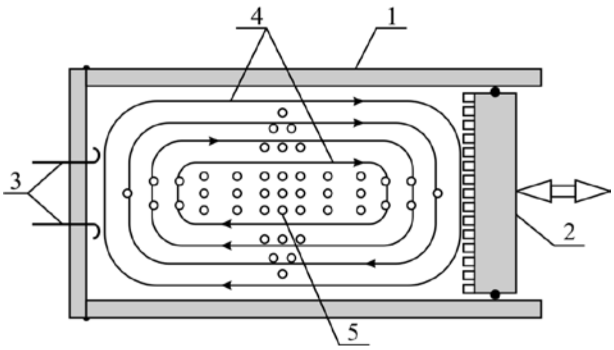


Fig. 1. Topography of E- and H-fields. 1 – waveguide of size 278×256×45 mm; 2 – shorting plunger; 3 – hinge connection; 4 – magnetic lines of force; 5 – electric lines of force. The parameters of the cavity resonator are as follows: f=0.5…1.1 GHz; λ_0=37.5 cm; λ_{cr}=36.8 cm; f_{cr}=815 MHz

2. CONTROL OF THE PROCESS OF ENERGY ABSORPTION IN THE UHF CAVITY

Introduction of a metallic screen [5] with a gap and a microwave absorber – energy (Fig. 2) into the cavity leads to a decrease in its resonant frequency and its Q-factor. These physical processes influence choice of the gap width when injecting the UHF-energy into a biological object to determine the state of water (an analogy of blood with its components) in free or in bound state.

The screen of the object (pos. 6, 10) serving as a radiation reflector is made of a copper foil with holes having 4 mm diameter and a thickness significantly greater that the skin effect. A clearance (see Fig. 3) is required to inject UHF radiation and electrodes into the living biological entity.

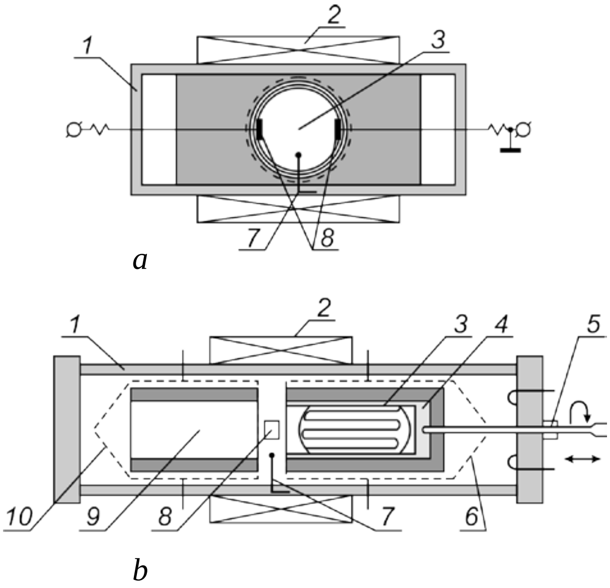


Fig. 2. (projections a and b). Scheme of joint effects of constant magnetic fields, combined with radio-frequency resonance diagnostics on a biological object. 1 – UHF cavity resonator; 2 – magnets; 3 – location of a biological object; 4 – transport cell of the object; 5 – mechanism of displacement and rotation of the object; 6, 10 – a screen with clearance; 7 – grounding for charge removal; 8 – electrodes; 9 – guide cylinder to move the object

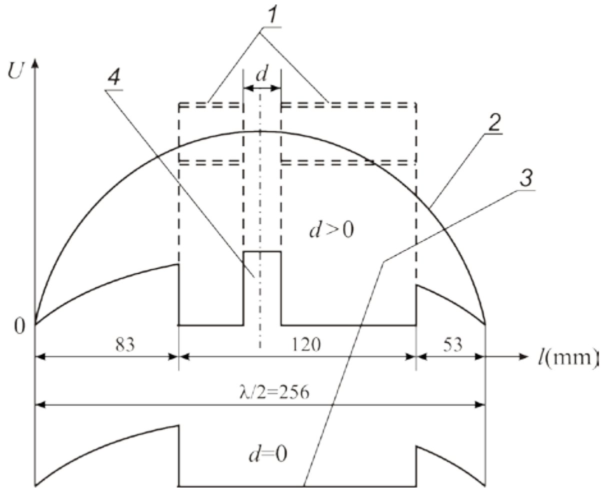


Fig. 3. Scheme of signal level distribution, excited in the cavity with a screen. 1 – screen; 2 – E-field of a standing wave in the cavity; 3 – E-field in the cavity with a continuous screen; 4 – E-field in the screen gap, d is the gap width in the screen. Distribution of E-field in the cavity with clearance of d = 20 mm in the screen is measured by moving a disturbance body of a thin metal disk (see Fig. 4)

According to Figs. 3 and 4 area with the highest level of absorption of the electric field is located in the center of the cavity. Higher vibration modes are not present, α is a transmission coefficient of UHF into absorber (water) through the gap d>0, and it is equal to $\alpha = \frac{Q_1 - Q_2}{Q_1}$, wherein Q_1 is a Q-factor of the cavity with screen, absorber and gap in the screen; Q_2 is a Q-factor of the cavity of the same geometry with zero clearance. Value of α is 30% for the gap of d = 20 mm (see Fig. 4). α can be reduced by lowering the size of the test object.

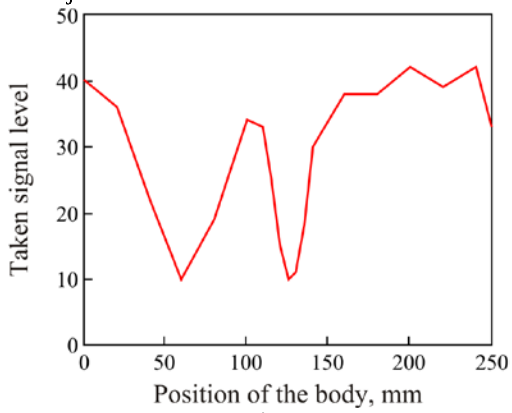


Fig. 4. Dependence of the taken signal level on the position of the perturbing body in the cavity

The Q value remains large and changes weakly when a large perturbing body (screen) is installed horizontally in the UHF cavity. This will allow to inject an electrode horizontally into the screen for electrophoresis in the E ⊥ H – fields configuration. The screen with openings reflects the UHF wave, but a part of it flows into the absorber with a large value of the dielectric constant. These processes have opposite directions, that determines the value of the Q-factor of the cavity. Difference in the Q-factor for a cylinder with and without water is due to the power loss in its end walls. A screen with openings of 4 mm diameter does not transmit UHF energy into the cylinder, as losses in the side walls of the hole in a solid and screens are almost identical. Difference in the Q-factor for a screened cylinder with and without water is due to the power loss in its end walls.

3. SHIELDED OBJECT IN THE UHF CAVITY

Principal features of the screen function in the cavity can be considered using a model of oscillation circuit with lumped parameters (Fig. 5).

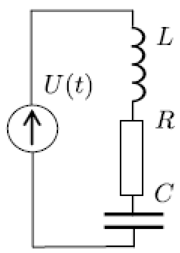


Fig. 5. The oscillation circuit lumped screen. L – inductance of the screen; C – capacitance of the capacitor with a water absorber; R – resistance, characterizing energy losses

The oscillation circuit collects energy of the electric and magnetic fields in the inductance and capacitance and is described by the oscillations [6]

$$L\ddot{q} + R\dot{q} + \frac{1}{C}q = U(t), \quad (1)$$

where q is electric charge; L – inductance; R – resistance, determined by energy losses; $U(t)$ – voltage in standing wave of the UHF cavity. Equation (1) can be presented in a standard format describing forced oscillations of the second linear oscillator

$$\ddot{q} + 2\delta\dot{q} + \omega^2 q = \frac{\omega}{\rho}U(t). \quad (2)$$

The resonance properties of the system can be written in the following form

$$I = \frac{U}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}, \quad (3)$$

where U – voltage on the capacitor plates; I – current through the daisy chain.

Maximum absorption of the UHF power occurs at the resonance condition of $\omega L - 1/\omega C = 0$. By reducing capacitance the daisy chain becomes inductive. Change of frequency and Q-factor of the cavity with the screen clearance size occurs in accordance with the formulas $\omega = (LC)^{-1/2} = \frac{1}{\sqrt{LC}}$ and $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ for the equivalent screen scheme. The total Q factor $Q = \frac{\omega}{2\delta}$ is determined by the total damping ratio (own losses in the cavity walls – damping ratio δ_0, losses in the screen – damping ratio $\delta_H$is determined by the following relation

$$\frac{1}{Q} = 2\frac{\delta_0 + \delta_H}{\omega_0} = \frac{1}{Q_0} + \frac{1}{Q_H}. \quad (4)$$

For a composite screen a change in the values of L, C should be taken into account according to the number of breaks in the screen. Value 2δ defines the width of the resonance curve of a cavity with a screen. $Q = \frac{F_{\text{Res}}}{\Delta F}$ defines its Q-factor, where ΔF is the difference between the side frequencies at the level of 0.5 $F_{\text{Res.}}$

Changing of the cavity resonance frequency depends on the magnitude of the energy stored in the introduced sample material [7], based on which it is possible to determine its dielectric constant according to the following formula

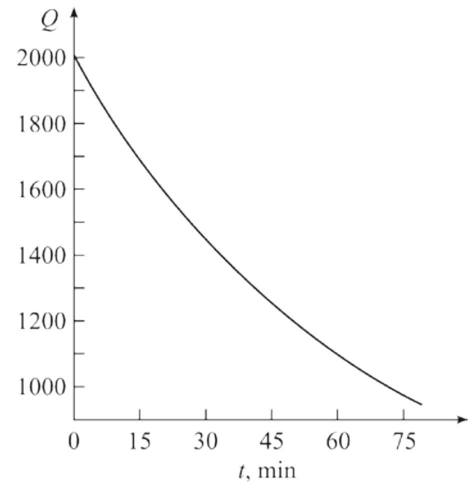
$$\varepsilon' = 1 + 0.5\frac{V}{V_\varepsilon}\frac{\delta f_0}{f_0}, \quad (5)$$

where ε' – dielectric constant of the medium introduced into the cavity. V_ε is the amount of the introduced dielectric; f_0 – natural frequency of the unperturbed cavity; $\delta f_0 = f_0 - f_1$ – frequency change when introducing the dielectric into the cavity; V – volume of the cavity at selected UHF vibrations frequency. A condition $V>>V_e$ follows from the theory of small perturbations In the dielectric placed in an alternating electric field a portion of the field energy is converted into heat energy, and heat losses are proportional to

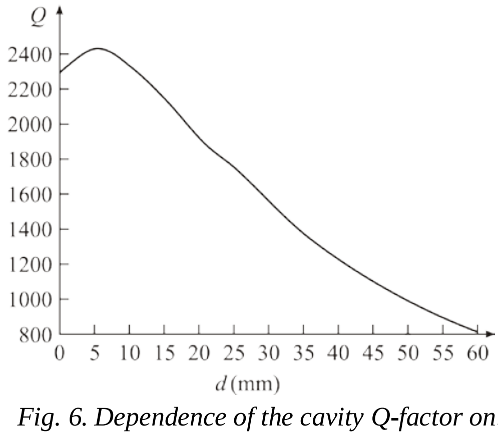
$$tg\delta = \frac{1}{2\varepsilon'}\frac{V}{V_\varepsilon}\left(\frac{1}{Q_1} - \frac{1}{Q_0}\right). \quad (6)$$

4. SENSITIVITY OF THE CAVITY

If a local leak occurs in the wall of the cylinder, through which water seeps out and is converted into steam accumulated in the volume of the resonator, additional losses with decreasing Q-factor are created. Figure 6a shows dependence of Q-factor of the cavity with a water-filled cylinder in the presence of a leak. The graph shows that the reduction in the Q-factor of the cavity over time is not linear. First, the Q-factor decreases sharply with further relaxation of its reduction speed. Sensitivity of the cavity depends on its Q-factor. The cavity is more sensitive to the conditions of humidity in its entirety. After elimination of the local leakage and the cavity volume ventilation the Q-factor recovers from 980 to 2000. For a gap in the screen with d = 5 mm (Fig. 6,b) an internal reflection of the UHF wave from water absorber with a large value of the dielectric constant is recorded.



a



b

Fig. 6. Dependence of the cavity Q-factor on:
a) time of leakage of water vapor;
b) gap width in the screen with water absorber

Interference occurs between the reflected waves and the screen of the open portion of the water absorber through a gap in the screen, which causes a local increase in the cavity Q-factor.

Based on Q-factor value change of the cavity the resonance method will identify gaps in the molecular bonds toxins membranes of capillary walls and substrates embolus intoxication of blood.

5. PROCESS OF CLEANING VESSELS AS A WAY TO DETOXIFY THE CAPILLARIES

The process of cleaning the walls of blood vessels occurs due to knocking of additional ions out from their surface by accelerated ions of the electrolyte in the applied electric field in the creation of the Lorentz force $\mathbf{F}_L = q[\mathbf{V}x\mathbf{B}]$ in E⊥B – geometry fields (Fig. 7). The centripetal force $F_c = MV^2/R$ equals to the Lorentz force for the motion of the ion in a circle.

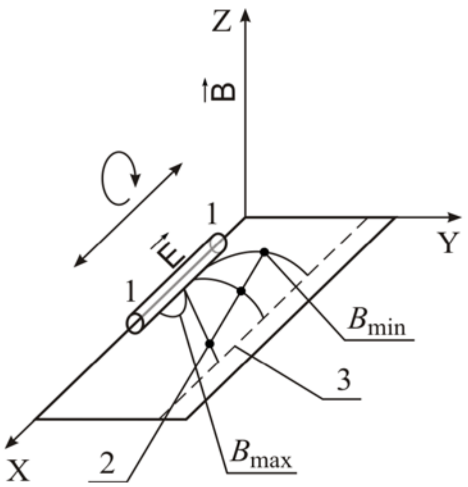


Fig. 7. Change of radius of the ions movement in the electrolyte volume at various values of the magnetic induction. 1 – electrodes in the electrolyte; 2 – radii of the ions in E⊥B – fields in the XOY plane at magnetic induction in the range of B_{min}-B_{max}; 3 – inner surface of the vessel

Radius of the cyclotron rotation with $\omega = qB/M$, and orbital period $T = 2\pi M/\theta B$ is given by

$$R_{cycl} = \frac{E}{qB^2}M = \frac{v}{qB}M = \frac{\sqrt{2M\varepsilon_{kin}}}{qB},$$

wherein *B*, θ, *V*, ε, *M* are magnetic induction, charge, speed, energy, and the ion mass, respectively. The value of ε_{kin} should be sufficient to break the covalent interatomic bonds, and $R_{cycl} > R_{vessel.}$ According to the reaction of electrolysis of water-activated sodium chloride strong solution $NaCl+n \cdot H_2O \rightarrow NaOH \cdot (n-1)H_2O + ½Cl_2 + ½H_2$ chlorine, caustic and hydrogen get released. Design of the vessel provides gas output from its scope. Chlorine is 2.5 times heavier than the air, and 2.3 volume of chlorine gets dissolved in a unit volume of water. Sodium hydroxide remains in solution. Water has the largest capacity of dissociating with the value of the dielectric constant $(\varepsilon = 81)$.

Current ionic conductivity is determined by the ion mobility $b = v/E$, where ν is the ion velocity acquired in an electric field $E = -U/d$, with *U* – the voltage on the electrodes, and *d* – the distance between them. At movement of the ions in a viscous medium they are affected by the internal friction force, which is subject to the Stokes' law as $E_{fr} = 6\pi\eta\rho v$. In order to overcome the friction force it is required that $E_{fr} = -qE$. Ion mobility is written as $b = q/6\pi\eta r$, where η – solution viscosity, *r* – radius of a positively charged ion. The absolute value of $|\beta| = |v|$ at $E = 1$. Velocity of positively charged ion is $v = \frac{q}{6\pi\eta r}E = bE$. The magnitude of the ion velocity in the electric field of the electrolyte determines the radius of its movement towards the vessel wall according to $R = \frac{v}{qB}M$. The conductivity of the electrolyte depends on the ions concentration and their mobility.

With increasing of magnetic induction (B_{max}) the radius of the ions movement is reduced, and the ions do not reach the walls of the vessel, which leads to a negative result for its purification (see Fig. 7).

For cleaning of the entire inner surface of the wall it is necessary to optimize magnitude of the magnetic induction and to rotate the vessel in the transverse direction w.r.t. the electric field E, i.e. around the OX axis.

6. EXPERIMENT

For the experiment as shown in Fig. 8 an aqueous sodium chloride solution with a sufficiently large dilution is applied.

After dissolution of the salt in water contains only anions and cations, and the solution remains electrically neutral. The electric field of the ion mobility of the electrolyte increases, reduced charge factor blocking ions of hydrogen-bonded water molecules.

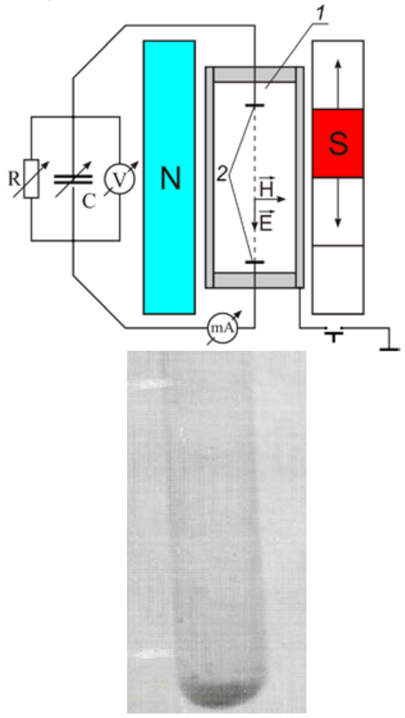


Fig. 8. Scheme of cleaning the surface of blood vessels accelerated ions in the mode of the Larmor precession. 1 – a vessel with an electrolyte; 2 – electrodes; S, N – pole permanent magnet variable-length S pole. Elements of the electrical circuit and the precipitate are shown directly in the picture

When the magnetic field *B* = 78 Oe is cleared vessel and contamination with solid walls it is allocated in the precipitate in the aqueous solution.

CONCLUSIONS

It opens up the prospect of developing a new technology based on the combined action of a biological object of constant electromagnetic fields and radio frequency resonance diagnostics in the decimeter wavelength range. Microwave radiation is supposed to be introduced into the object under study (a living organism) through a limited clearance in the protective screen to determine the level of intoxication and the state of the walls of blood vessels. A wide range of measurement capabilities of the resonator *Q*-factor enable explore the biological object in different states and monitor relative changes in its structure.

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Article received 09.11.2015

УПРАВЛЕНИЕ ПРОЦЕССОМ ПОГЛОЩЕНИЯ СВЧ-ЭНЕРГИИ РЕЗОНАНСНЫМ МЕТОДОМ В ЭКРАНИРОВАННОМ ОБЪЕКТЕ

А.Н. Довбня, В.П. Ефимов, Г.Д. Крамской, А.С. Абызов

Разработана программа исследования влияния поперечных электрического и магнитного полей на биологический объект и контроля реакции изменения его диэлектрической проницаемости, добротности и тепловых потерь в дециметровом диапазоне длин волн прямоугольным резонатором в режиме резонансного поглощения.

УПРАВЛІННЯ ПРОЦЕСОМ ПОГЛИНАННЯ НВЧ-ЕНЕРГІЇ РЕЗОНАНСНИМ МЕТОДОМ В ЕКРАНОВАНОМУ ОБ'ЄКТІ

А.М. Довбня, В.П. Ефімов, Г.Д. Крамськой, О.С. Абизов

Розроблено програму дослідження впливу поперечних електричного та магнітного полів на біологічний об'єкт і контролю реакції зміни його діелектричної проникності, добротності й теплових втрат у дециметровому діапазоні довжин хвиль прямокутним резонатором у режимі резонансного поглинання.