

It is approved  
on meeting of department of  
medical informatics, medical and biological physics  
27 August 2020  
Minutes №1 of 27 August 2020

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### Methodical instructions

for students' self-preparation work at preparation for a practical lesson  
at home and at the classroom

Subject matter           **Medical and biological physics**  
The unit                    2. Bases of medical physics  
Theme of lecture:       **Fundamentals of the UHF-therapy and the UHF-  
  inductothermy.**  
Year                         1  
Faculty                    Medical, Stomatological  
Speciality                 Medicine, Stomatology

Poltava - 2020

**The topic significance:** the is very important for future doctors in their professional activity, positively influences the students in their attitude to the future profession, forms professional skills and experience as well as taking as a principle the knowledge of the subject learnt.

**Specific targets:**

- To mastering with principle of operation of UHF-therapy device and UHF-inductothermy device;
- To know principles of effect of UHF electric and magnetic fields on biologic tissues and organisms;
- To be able to carry out laboratory and experimental work with UHF-therapy and UHF-inductothermy devices;
- To research process of UHF electric field energy absorption in electrolites and in dielectrics;
- To form the professional experience by reviewing, training and authorizing it.

**Basic knowledge, experience, skills necessary for studying the topic in connection with other subjects**

| Disciplines  | Obtainable skills   |
|--|---|
| Previous (providing disciplines):<br>physics, chemistry, biology | To know bases of electrodynamics.<br>To know mechanism of electrolytic dissociation, appearance of ions, radicals, peroxides, hydroperoxides.<br>To describe mechanism of formation of diffusion potential (electrochemical potential).<br>To describe electrokinetic appearances.<br>To know structure of oscillatory circuit (oscillating loop), Thomson formula. |

|  |  |
|--|--|
|  | <p>To describe appearance of relaxation oscillations and continuous (persistent) oscillation.</p> <p>To explain the essence of the methods: UHF-therapy, SHF-therapy, inductothermy.</p> <p>To write down and analyse the formula for quantity of heat, allocated in a unit volume for a time unit at the influence of UHF electric field.</p> <p>To explain principle of operation of UHF-therapy device.</p> |
| The subsequent disciplines:<br>Normal physiology | To know effects of alternating electric fields on cells, tissues and whole organism functioning.   |

**Materials for the before-class self-preparation work:**

**List of main term, parameters, characteristics, which student have to learn at preparation to class:**

| Term                         | Definition   |
|------------------------------|--|
| UHF                          | Ultra-high frequencies 30–300 MHz                            |
| SHF-radiation                | Superhigh frequency electromagnetic radiation 300 MHz–30 GHz |
| SHF-therapy                  | Superhigh frequency therapy                                  |
| Microwave radiation          | Electromagnetic wave of frequencies more than 300 MHz        |
| Radio-frequency oscillations | Oscillations with frequencies 200 kHz–30 MHz                 |
| Inductothermy                | Influence on bioobject by alternating magnetic field         |

**Theoretical questions to class:**

1. What are electric field (EF), magnetic field (MF), electromagnetic field (EMF)?
2. Describe basic characteristics of these fields. Note formulas and measurement units of EF, MF, and EMF basic characteristics.
3. Describe mechanism of action of EF, MF, and EMF on biological tissues in dependence on fields characteristics.
4. What is polarization?
5. What is case of electric currents?
6. Why field energy is absorbed in mediums?
7. Describe mechanism of biologic tissues heating in UHF electric and magnetic fields.
8. Essence of the method of UHF-therapy.
9. The mechanism of influence of UHF electric field on human tissues.
10. Essence of the method of inductothermy.
11. Function of units of the apparatus for UHF-therapy.

**Practice work executed at class:**

To study:

- manual of UHF-therapy device and UHF-inductothermy device;
- block diagrams of these devices.

To do:

- research of heating of dielectric (nonconductor) and electrolyte in fields of UHF-therapy and UHF-inductothermy devices.
- draw up protocol.

Investigate dependence of temperature of an electrolyte and an nonconductor on the time of UHF electric field influence on it.

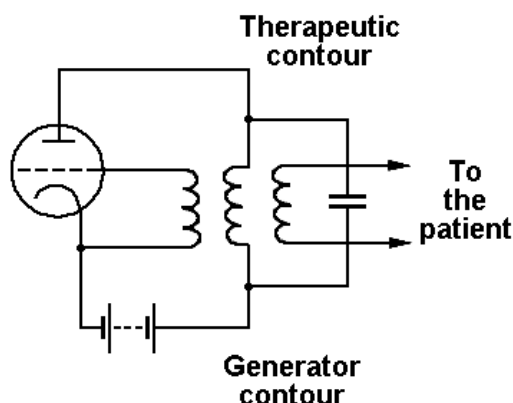


Fig.1. The block scheme of UHF-therapy device YB4-66.

1. Learn the block scheme of UHF-therapy device. Draw it.  
Read manual of device.
2. To prepare UHF-therapy device for work:
  - connect device to power grid;
  - switch on device, to let it to heat 3–5 min.;
  - set power 40 W;
  - neon lamp allocated between plates of therapeutic contour must shine of bright rose-colored light;
  - set cuvettes with electrolyte (NaCl solution) and with dielectric (turpentine oil) in therapeutic contour;
  - to tune UHF-therapy device in resonance.
3. To carry out study of electrolyte and dielectric heating in UHF electromagnetic field: to write down temperature data each 5 min. into the table.
4. To draw graph of temperature (C°) on time (min.).
5. To draw conclusion.

Table.

| Time, min | Temperature |              |
|-----------|-------------|--------------|
|           | Electrolyte | Nonconductor |
| 0         |             |              |
| 3         |             |              |
| 6         |             |              |
| 9         |             |              |
| 12        |             |              |
| 15        |             |              |

### Contens of the topic.

Abbreviations:

EF – electric field;

MF – magnetic field;

EMF – electromagnetic field;

BT – biological tissue, biological cell.

Electrical currents can be induced in tissues without electrodes, if tissues (some parts of huruan body) are placed into an alternating electromagnetic field, alternating currents are induced in them. Heating of tissues with the help of currents induced by an alternating field is the base of the following methods, such as inductotherapy, UHF-therapy (UHF – ultra-high frequencies), and microwave therapy (SHF-therapy).

An important point is that effect of high-frequency electromagnetic oscillations on the human body is not only thermal.

Electrical current effect on tissues depends on current type. The following current types are distinguished: direct, impulse (effect depends on impulse shape) and alternating ones.

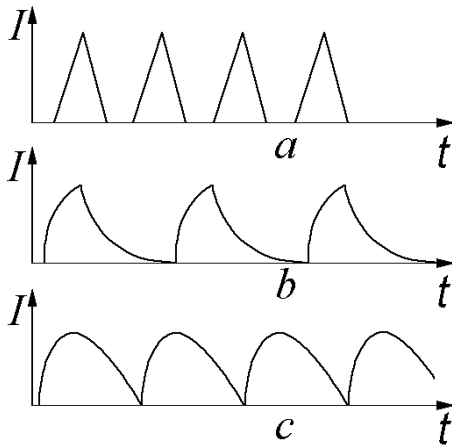


Fig.1. Impulse currents graphs at different impulse shapes.

The impact of radiation on human body is present even then when thermal effect is insignificant. The action of electromagnetic radiation on human body is not studied enough. It is apparent that biological action of radiation can be seen on different layers: subcellular (molecular), cellular, on tissue level, organs, body, population, and global one.

The result of *unfavorable effect of electromagnetic radiation* of radio frequency range can be both direct pathological phenomena (internal diseases or dysfunction) and weakening of human body protection and adoption. It is accepted as correct a negative effect of high intensity electromagnetic radiation on cardiovascular, central nervous, endocrine, hematogenic and other systems. Alternating electro magnetic fields effect can cause dizziness, high fatigability, high irritability, memory weakening, insomnia, general weakness and other negative results. If even small electromagnetic fields act upon human body for a long time, they cause strong dysfunction in cerebral cortex.

Strict hygienic standards of permissible levels of electromagnetic fields acted upon human bodies are developed in this connection. Within the frequency range from 30 kHz to 300 MHz electric field intensity ( $E$ ) (characteristic of electrical component of electromagnetic field) is standardized. Within the frequency range from 300 MHz to 30 GHz electromagnetic radiation energy flux (i.e. energy of electromagnetic radiation acted upon unit of surface area during unit of time) is standardized.

Biological tissues have resistance and capacitive properties.

*Medical methods based on use of alternating electromagnetic field.*

**Inductothermy.** During inductothermy an *alternating magnetic field* effects patient's tissues. A standard instrument for inductothermy produces magnetic field changing with a frequency of 13,56 MHz or 40,68 MHz. A magnetic field is produced with the help of coil (an inductor) through which an alternating electrical current of a corresponding frequency flows.

An alternating magnetic field induces eddy currents in tissues, when those currents flow tissues are heated and heat is evolved.

During inductothermy a specific heat power evolved in unit of the volume is defined by the formula:

$Q = \nu^2 \sigma H^2$ , where  $\nu$  is frequency of alternating magnetic field,  $\sigma$  – electric conductance of tissue,  $H$  – magnetic field strength.

Or  $Q = k \omega^2 B_0^2 / \rho$ , where  $k$  is proportionality factor, dependent on the sample geometry;  $\omega$  – cyclic frequency of alternating magnetic field;  $B_0$  – amplitude of magnetic induction,  $\rho$  – specific conductivity.

Hence, tissues having less specific resistance (good conductors) are heated better.

The tissues are heated effectively upon the depth of 6–8 cm. An increase of temperature in tissues intensifies the circulation of the blood in them, causes different ferments activation. In the course of inductothermy human body immune system is being stimulated.

**UHF-therapy.** In the course of UHF-therapy an *alternating electric field* of UHF-range (frequencies of 30–300 MHz) effects on a patient's tissues.

A standard instrument for UHF-therapy induces electromagnetic oscillations of 460 MHz frequency (the wavelength is about 65,2 cm – decimeter range) or 2375 MHz.

The UHF-field induces electric currents in a patient's tissues (more precisely, charged particles oscillations – bias currents) of the same frequency as the frequency of the UHF-field. Emerged currents heat patient's tissues, moreover when these frequencies of electromagnetic radiation are used, the hottest are those tissues, which have less conductivity, i.e. tissues-dielectrics.

At frequencies 40,68 MHz dielectrics are heated more than electrolites also.

A specific heat power, evolved during UHF-therapy, is defined by the formulas:

In electrolytes:

$q_1 = E^2/\rho$ , where  $E$  – electromotive intensity (electric-field intensity),  $\rho$  – specific resistance of electrolyte.

In dielectrics:

$q_2 = \omega E^2 \epsilon \epsilon_0 \operatorname{tg} \delta$ , where  $\omega$  – cyclic frequency of alternating magnetic field,  $\epsilon \epsilon_0$  – dielectric permittivity of medium,  $\delta$  – angle of dielectric loss,  $E$  is a root-mean-square value of electric-field intensity. Or  $q_2 = \omega E_0^2 \epsilon \epsilon_0 \operatorname{tg} \delta / 2$ .

$E = E_a / \sqrt{2}$ , where  $E_a$  is the amplitude of electric-field intensity (effective electric field strength).

**SHF-therapy** (*superhigh frequency therapy*). If SHF-therapy is used for healing patient's tissues, it means that patient's tissues are affected by electromagnetic waves with frequency within the range of 300 MHz–30 GHz. At SHF-therapy the muscle tissues and the blood are heated well, as they take up radiowaves well, as absorption is caused water content mainly. Fat and bones are heated less.

The commonly used devices are those ones that produce electromagnetic waves from the following standard wavelength values: for decimetric waves (DMW) therapy ( $\lambda = 65,2$  cm,  $\nu = 460$  MHz), for microwave (MW) therapy ( $\lambda = 12,6$  cm,  $\nu = 2375$  MHz).

Decimetric waves and microwave therapies differ from each other in the depth of radiation penetration in tissues. When decimetric therapy is used,

The depth of decimetric waves penetration in tissues is near 9 cm; the microwave penetration depth is near 3–5 cm.

#### **Direct electric and magnetic fields.**

Direct electric field influence on tissues causes dielectric polarization due to molecules reorientation: which behave as dipoles. It results in ions shift and change of their concentration in different areas of tissues. Ions shift lasts until electric field that they have developed will not compensate external electric field effect on ions.

*Electrostatic shower* (or *franclinization*) and *aeroionic therapy*. At that a patient is placed in a strong electrostatic field (voltage up to 50 kV is used), where partial air ionization occurs. As this takes place, aeroions are produced as well as air ionization products – ozone and ozone oxides that irritate skin receptors and mucous membrane receptors of respiratory tract.

It activates functional state of central nervous system, raises neurologic level, improves sleep etc.

*Magnetic therapy* – direct and low frequency alternating magnetic fields biological effects on human body are not studied enough. Weak heating effect, stimulation of regeneration, influence on chemical reactions behavior take place in magnetic fields.

## Other **ELECTROPHYSIOTHERAPY**

**Galvanizing** is application with the medical purpose of a continuous constant electric current of small force (up to 50 mA) and low voltage (30-80 V). *The mechanism of activity:* enriching of microcirculation; rising of vascular walls permeability; metabolism rising; englobement activation; distracting, anesthetizing activity due to irritation of skin receptors.

**Faradization** is application low frequency alternating-current with the medical purpose. *The mechanism of activity:* drop of nervous cells excitability - decrease of pains as a result; rising of nervous tissue metabolism;

**Darsonvalization** is application with the medical purpose alternating-current high frequency, high intensity and small force. *The mechanism of activity:* local depressing of dermal sensitivity reaching at sufficient duration and intensity of a current almost up to the complete anaesthesia; narrowing, and then the dilating of dermal vessels promoting enriching blood circulation and lymphokinesia, nutrition of tissues, to augmentation of metabolic product outflow.

**Franklinization** is application of static electricity for the medical purposes. *The mechanism of activity:* it is insufficiently investigated: there are discordant data on influence on arterial pressure, body temperature and metabolism.

**Diadynamic [currents] therapy** is treatment by two low-frequency impulse currents of small force (up to 50 mA). *The mechanism of activity:* analgesic activity; a stimulation of metabolic processes; a stimulation of an englobement.

**Fluctuorization (Флуктуоризация)** is application with the medical purpose variable, in part or completely a rectified current of low voltage (up to 100 V) with chaotically changed (up to 2000 Hz) frequency and amplitude (up to 3 mA/sm<sub>2</sub>). *The mechanism of activity:* least excitant activity is rendered with the symmetric oscillations of a current as changes of ion density at semipermeable membranes in some degrees are flattened by the same changes of ion density occurring in opposite direction at current veering (sense of current). Aperiodicity of change of peaks originating of exaltation rises stimulating activity and reduces tissues adaptation in comparison with activity of periodic oscillations of current with identical voltage. More strong activity rectified oscillations render in part have, even more strong - completely rectified.

**Electropuncture (Электропунктура)** method of action on biologically active points (sites) of an organism certain currents types of low and high frequency (use impulse currents of low frequency more often). *The mechanism of activity:* analgesic activity; hyposensitive activity; mobilization of nonspecific protection mechanisms of an organism due to its adaptable responses.

**Electrodream** action by impulse currents of small intensity with the purpose of normalization of a function state of central nervous system through the receptor apparatus of a head. *The name of a method appeared unsuccessful. During wide application of it was found out, that medical activity of it is not always connected to dream.*

**Inductothermy.** The method of the electrotreatment, working factor of which is a high-frequency variable magnetic field. Activity of energy of this field produces appearance of the induced (inductive) eddy (vortex) currents which mechanical energy transfers in heat. Vessels extend, the blood-groove is accelerated, arterial pressure drops, and the coronary circulation is enriched. Anti-inflammatory and resorptional activity of inductothermy is connected to thermogenesis and intensifying of a blood-groove. There is also a depressing of muscles tone that matters at spastic stricture of a smooth musculation. Depressing of excitability of nervous receptors causes anesthetizing and sedative activity.

At this method of treatment it observes rising calcium content in tissues, bacteriostatic activity. Indications to inductothermy administration are subacute and

chronic inflammatory diseases of internal organs of a small pelvis, ENT (ear, nose, throat) organs, diseases and traumas of a locomotorium, peripheral and central nervous system.

**Electrical stimulation** is application of an electric current with the purpose of activation or intensifying of activity of fixed organs and systems. The words "electrical stimulation" is frequently used completely improperly for notation of any action by an electric current. To stimulate by currents it is possible many organs and systems; for this purpose it is necessary application adequate procedures and parameters.

In practical work the widest application have received electrical stimulation of heart that is special partition of medicine, and electrical stimulation of motor nerves and muscles.

**Electrical defibrillation** is carried out with the help of a single current impulse of sufficient force and duration, generated in the special device - a defibrillator.

**Implantable heart pacemaker.** Device that supply normal heart rhythm at diseases harming own heart pacemaker – sinoatrial node.

**Electrical stimulation of muscles.** It is applied with the purpose of a stimulation of regeneration of the muscle apparatus after traumas and the long-lived immobilization.

### Self-control tests.

1) Indicate correct formula for calculation of evolved heat quantity at dielectric heating:

A)  $q = \omega E_0^2 \varepsilon \varepsilon_0 \operatorname{tg} \delta / 2$ ; B)  $q = k \omega^2 B_0^2 / \rho$ ; C)  $q = v^2 \sigma H^2$ ; D)  $q = E^2 / \rho$ .

2) Indicate correct formula for calculation of evolved heat quantity at electrolite heating:

A)  $q = \omega E_0^2 \varepsilon \varepsilon_0 \operatorname{tg} \delta / 2$ ; B)  $q = k \omega^2 B_0^2 / \rho$ ; C)  $q = v^2 \sigma H^2$ ; D)  $q = E^2 / \rho$ .

3) Indicate Tomson formula: 1.  $\omega = \frac{1}{2\pi\sqrt{LC}}$  2.  $\omega = \sqrt{\frac{1}{LC}}$  3.  $\omega = \sqrt{\frac{L}{C}}$  4.  $\omega = \sqrt{\frac{C}{L}}$

4) Indicate formula of natural frequency:

1.  $\omega = \frac{1}{2\pi\sqrt{LC}}$  2.  $\omega = \sqrt{\frac{1}{LC}}$  3.  $\omega = \sqrt{\frac{L}{C}}$  4.  $\omega = \sqrt{\frac{C}{L}}$

3.  $T = 2\pi\sqrt{LC}$  4.  $T = \frac{1}{2\pi\sqrt{LC}}$

5) Treatment with inductive currents was prescribed for the patient. Indicate tissues, which are heated more:

- A) blood, lymph, skin;
- B) blood, lymph, muscles;
- C) skin, muscles;
- D) bones, skin.

6) Conduction currents heat more effective follows tissues:

- A) blood, skin, muscles;
- B) bones, skin;
- C) bones, skin, muscles;
- D) skin, blood, lymph, muscles.

### Task 1.

To calculate capacitance of human body with 70 kg mass. To set: this capacitance is equal the capacitance of the sphere with mass equal to the human mass. Average density of the human body is equal to 1 g/cm<sup>3</sup>.

### Literature recommended

Main sources.

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- Korovina L.D. Biophysics with beginnings of mathematical analysis and statistics. Extended course of lectures. Vol.2. Bases of thermodynamics. Biomembranes. Electricity and magnetism. – Poltava, 2017.– 114 p.

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**Methodical elaboration have prepared by senior lecturer, PhD biol.Sc. Korovina L.D.**