Study of the apparatus for UHF-therapy

UHF fields are used to heat tissues with dielectric properties (bone, fat, etc.). This effect is used to treat a number of inflammatory diseases in bones, joints and soft tissues with dielectric properties, with sinusitis, arthritis; bronchial asthma, neuralgia and other diseases.

UHF electric field:

- enhances blood and lymph circulation, stimulating the dehydration of inflamed tissues and reducing the vital activity of bacteria;
- has an antispastic effect on the smooth muscles of the stomach, intestines, gall bladder, bronchi;
- accelerates the recovery of nerve elements in case of inflammation or injury.

The advantage of the method is that it affects deeply located parts of the body without contact of the electrodes with the skin. This reduces the requirements for asepsis. In addition, the presence of a therapy circuit eliminates the possibility of electric shock to the patient.

The devices used for treatment with an ultra-high frequency (UHF) electric field are generators of electrical oscillations with a frequency of 40.68 MHz. Let's overview the principle of operation of such a generator.

One of the main elements of the device is an oscillatory circuit. It is ideally a circuit of capacitance C and inductance L connected in parallel and does not contain an active resistance R.

Oscillations in such an oscillatory circuit will be continuous. However, the real circuit also has active resistance, so the oscillations in it will fade out over time.

Generators are used to obtain continuous electrical oscillations. The technical basis of the generator can be vacuum tubes, transistors and integrated circuits. Electronic lamps are used where high power is required (tens and hundreds of watts), for example, in physiotherapy equipment.

Let us investigate the principle of operation of such a device using the example of a single-cycle tube generator based on a triode, in which an oscillatory circuit is connected to a three-electrode lamp and a power source (Fig. 1). In order to provide undamped oscillations in the oscillatory circuit, it is necessary to constantly replenish the oscillation energy lost in the active resistance of the circuit. These conditions are provided in the generator as follows. The coil L of the oscillating circuit is inductively coupled to the so-called coupling coil K, which is connected to the grid and the cathode of the lamp.

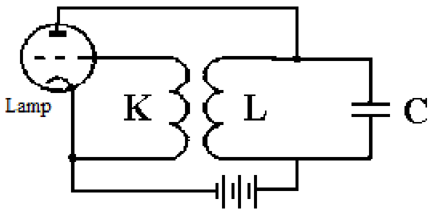

Figure: 1. Scheme of a single-cycle lamp generator (ideal oscillatory circuit).

The passage of the anode current through the lamp and the formation of voltage on the oscillatory circuit occurs at the moment when a positive potential is supplied to the lamp grid through the coupling coil. As a result, the received energy supports only half of the oscillation period in the circuit. Therefore, the generator is called single-cycle. The anode current generated in the circuit has the same frequency as the oscillations in the circuit.

When it is required to increase the oscillation power, a push-pull tube generator is used (Fig. 2). Again, for simplicity, consider a generator with an ideal oscillating circuit.

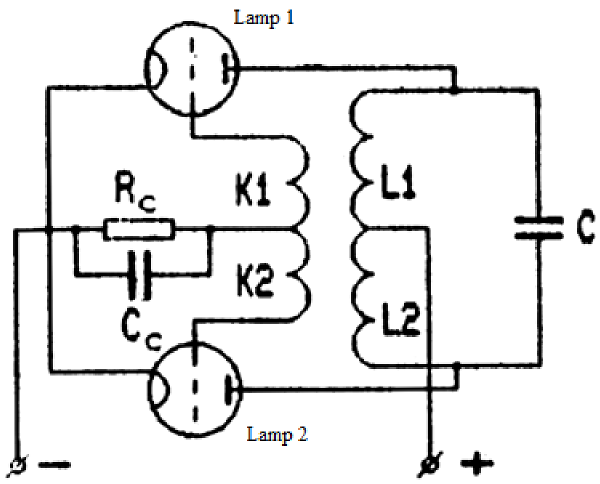

Figure: 2. Scheme of a push-pull lamp generator.

The circuit, to a certain extent, symmetrically repeats Fig. 1. In fact, now two lamps (L1 and L2) are connected to the oscillatory circuit, and the anode current of each of them passes through the corresponding half (L1 and L2) of the coil of the circuit. In this case, the positive pole of the power source is connected to the middle tap of the coil, and the negative pole is connected to the common point of the cathodes of the lamps. Inductors K1 and K2 are symmetrically connected through a resistor R_c to the common point of the cathodes of the lamps. Each of the arms of a push-pull generator works similarly to a one-cycle generator, replenishing the oscillating circuit with energy in the corresponding half of the oscillation period. As a result, the oscillating circuit is replenished with energy twice during the period.

The generator of electrical oscillations forms the basis of devices for high-frequency therapy, including UHF therapy. A feature of these devices is the presence of a special therapeutic circuit - a separate oscillatory circuit, to which electrodes located near the patient's body are connected (Fig. 3).

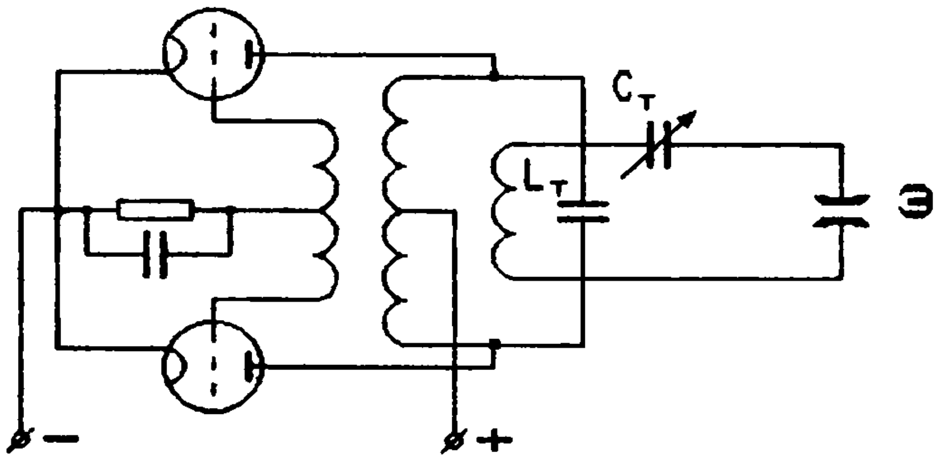

Figure: 3. Diagram of connection of the therapeutic circuit to a push-pull lamp generator (Lt - inductance coil of the therapeutic circuit, St - variable capacitor, E - electrodes).

The therapy circuit is inductively connected to the generator. This connection allows transferring high-frequency vibrations to the electrodes and eliminating the possibility of hitting the patient with high voltage present in the generator.

Due to the fact that different parts of the patient's body with different electrical parameters can be placed between the electrodes, the therapeutic circuit must be tuned into resonance with the generator during each procedure. This is done using a variable capacitor Ct.

The UHF apparatus used for this lab is a push-pull vacuum tube generator connected to a therapy circuit.

APPLICATION OF HIGH-FREQUENCY ELECTROMAGNETIC OSCILLATIONS IN MEDICINE

Electrical and magnetic vibrations used for therapeutic purposes are subdivided by frequency into several ranges;

1) low-frequency:

- low frequency (LF) - up to 20 Hz,
- sound frequency (3CH) - 20-20000 Hz,

2) high-frequency:

- ultrasonic frequency (UZCH) - 20-200 kHz,
- high frequency (HF) - 0.2 - 30 MHz,
- ultra high frequency (UHF) - 30-300 MHz,
- ultra-high frequency (microwave) - 300-3000 MHz,
- extremely high frequency (EHF) - over 3000 MHz.

Basic methods using high frequency (HF) oscillations:

1) darsonvalization (the effect of weak electrical discharges at frequencies up to 500 kHz on the nerve receptors of the skin and mucous membrane for therapeutic purposes),

2) diathermy (heating of tissues with the passage of current up to 1.5 A with a frequency of 1-2 MHz);

- in therapy (heating of deeply located tissues of the body) - is not currently used due to the shortcomings of the method and the emergence of new techniques;
- in surgery:
- diathermocoagulation (welding of blood vessels to reduce blood loss during operations, etc.).
- electrotomy (dissection of soft tissues);

3) inductothermy (heating of conductive tissues using a magnetic field at a frequency of 10-15 MHz, causing eddy electric currents in the tissues) provides the release of Joule heat per unit volume with a power (P):

$$P = k \cdot \gamma\omega^2 B^2,$$

where k is the coefficient of proportionality, γ - specific electrical conductivity, ω - circular frequency, V - effective value of magnetic induction.

4) UHF therapy (exposure of tissues to an electric field with a frequency of 30-300 MHz);

5) microwave therapy (microwave therapy at a frequency of 2000-3000 MHz, mainly water-containing tissues are warmed up);

6) EHF-therapy (application of electromagnetic fields with a frequency of more than 3000 MHz, low-energy impact on receptor zones, biologically active points for the purpose of control, correction of the function of internal organs).

PRIMARY ACTION OF THE UHF FIELD ON THE TISSUE OF THE BODY

Consider how an UHF electric field acts on an electrolyte and a dielectric.

In an electrolyte solution in an UHF field, an oscillatory motion of ions occurs according to changes in the direction of the external field strength. The onset of the conduction current is accompanied by the release of heat Q, and per unit time per unit volume will be released:

$$Q_э = kE^2/\rho \quad , (2)$$

where k is the coefficient of proportionality; E is the strength of the electric field; ρ - specific resistance of the electrolyte.

Under the action of the UHF field in the dielectric, a change in the position (rotational vibration) of polar dipole molecules or charged sections of macromolecules occurs in accordance with the reorientation of the external electric field (Fig. 4).

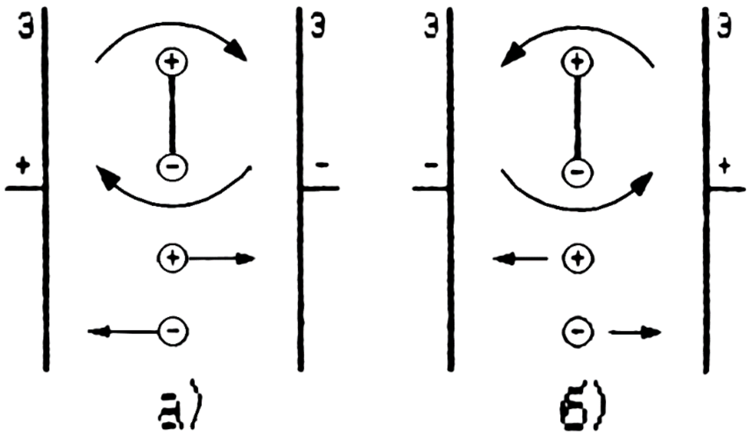

Figure: 4. Movement of the molecule-dipole and ions between the electrodes E when the UHF electric field changes.

In this case, the movement of the dipoles lags in phase from the fluctuations in the strength of the electric field E, which is accompanied by the formation of friction forces. As a result, in a unit volume of a dielectric, an amount of heat will be released per unit time $Q_д$:

$$Q_д = k \cdot \omega \cdot E^2 \varepsilon \cdot tg\delta, \qquad (3)$$

where k is the coefficient of proportionality; ω- circular frequency; E is the strength of the electric field;ε - relative dielectric constant; δ - the angle of dielectric losses, depending on the nature of the dielectric and the frequency of exposure.

Body tissues contain both electrolytes and dielectrics. Therefore, when determining the effect of the UHF field on the tissue, it is necessary to take into account the total effect:

$$Q = Q_э + Q_д \quad (4)$$

It should be noted that, depending on the selected frequency of oscillations of the electric field, it is possible to exert a preferential (selective) effect on either electrolytes or dielectrics. The frequency of the device for UHF therapy (40.68 MHz) provides the most efficient heating of dielectric tissues.

Well-nourished tissues contain high amounts of electrolytes. In this regard, tissues of muscles, liver, heart, spleen, etc. can be classified as electrolyte tissues. A similar approach makes it possible to indicate adipose, bone, tendons, etc. as dielectric tissues.

Often, during UHF therapy, not a thermal effect is used, which has a massive, high-energy effect, but the so-called oscillatory effect. In this case, the tissues are affected by a low-intensity high-frequency electric field, the main effect is on the position of ions and molecules in the tissues. As a result, the physiological state of cells is changed using a more subtle mechanism, introducing lesser disturbances into cells with disturbed balance of metabolic processes.