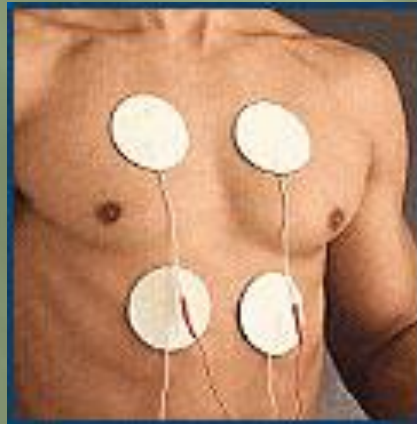


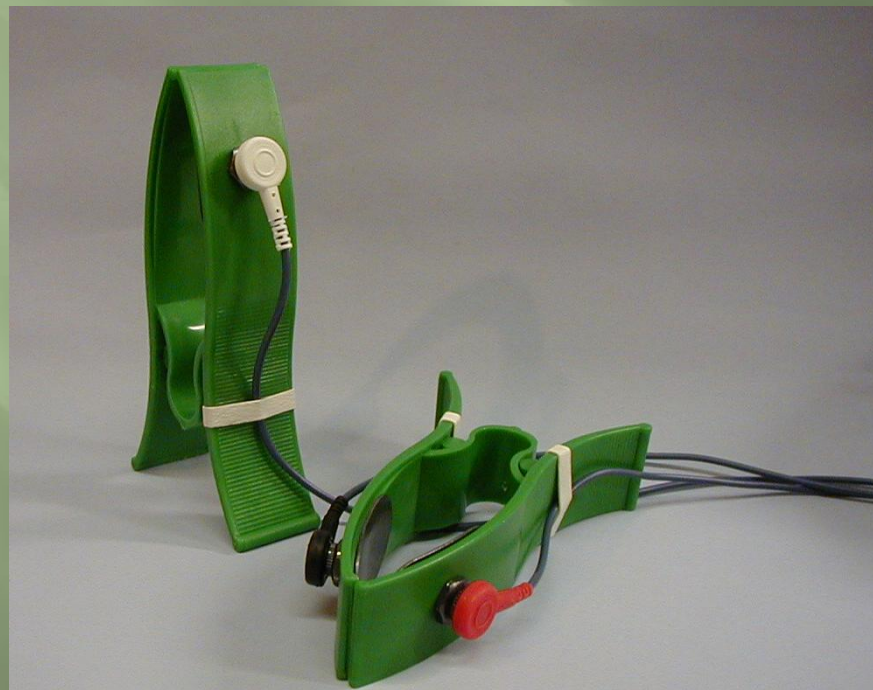
PHYSICAL BASES OF ELECTRONIC MEDICAL APPARATUS. SENSORA & AMPLIFIERS.



Lecture 9

MEDICAL ELECTRODES & THEIR FORMS

An electrode is an electrical conductor used to make contact with a nonmetallic part of a circuit (e.g. a semiconductor, an electrolyte or a vacuum). The word was coined by the scientist Michael Faraday from the Greek words *elektron* (meaning amber, from which the word electricity is derived) and *nodos*, a way.

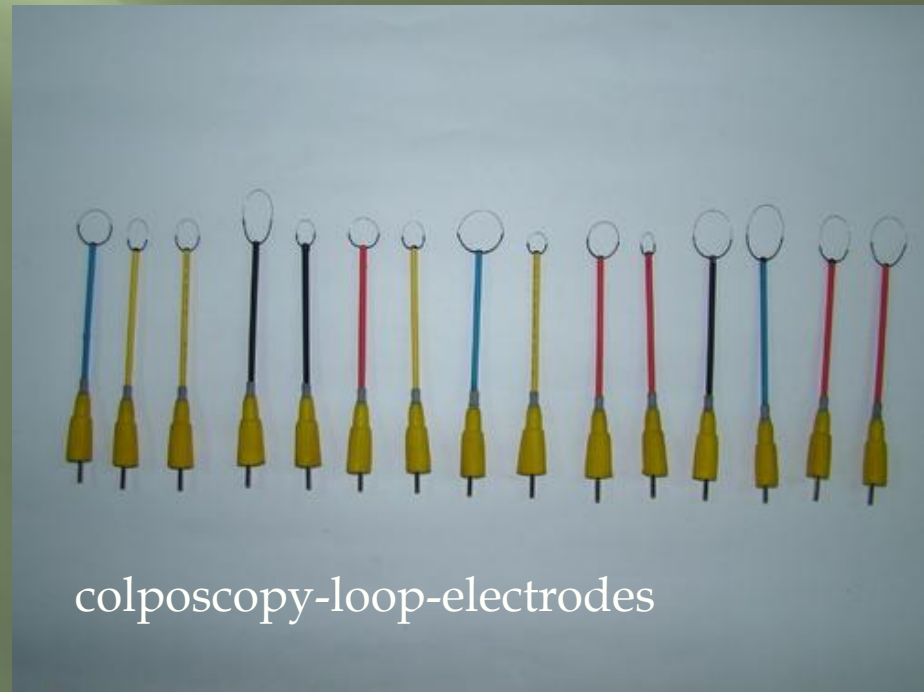
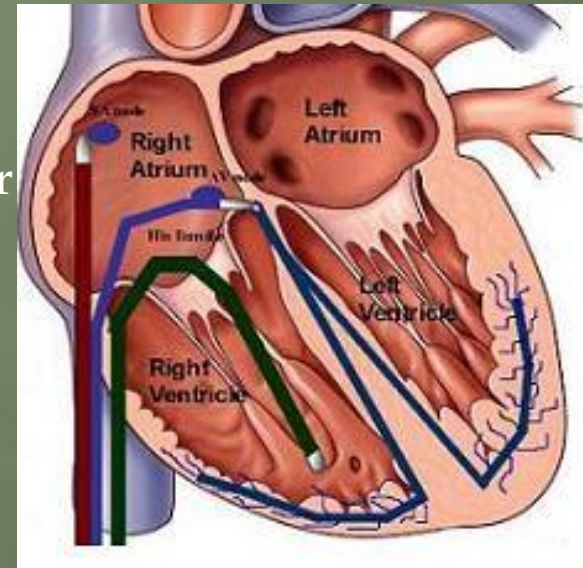


MEDICAL ELECTRODES & THEIR FORMS



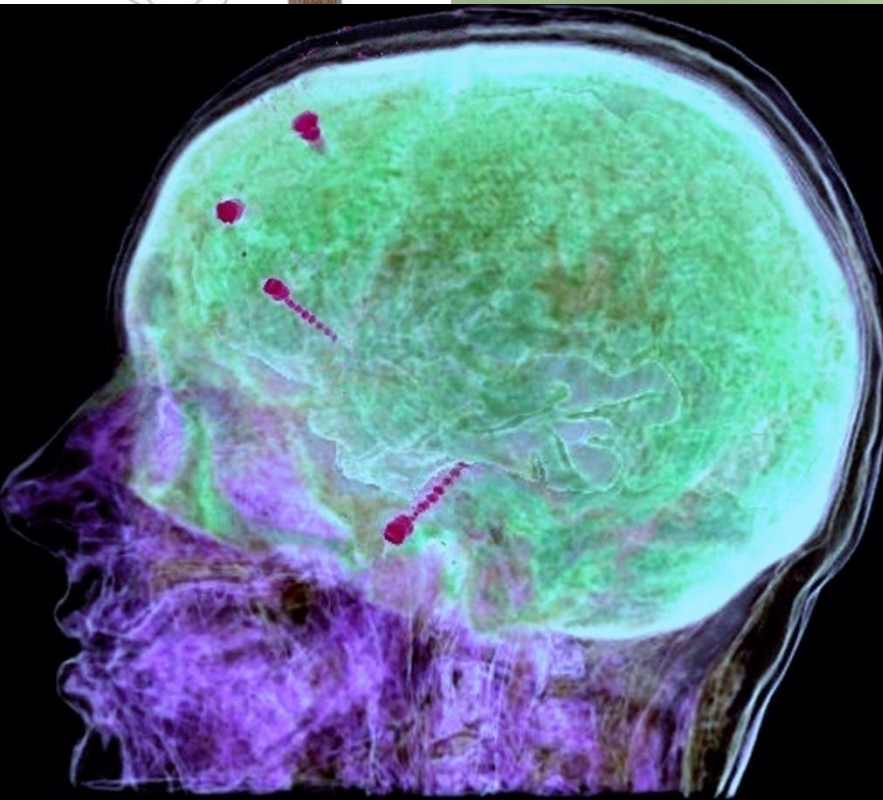
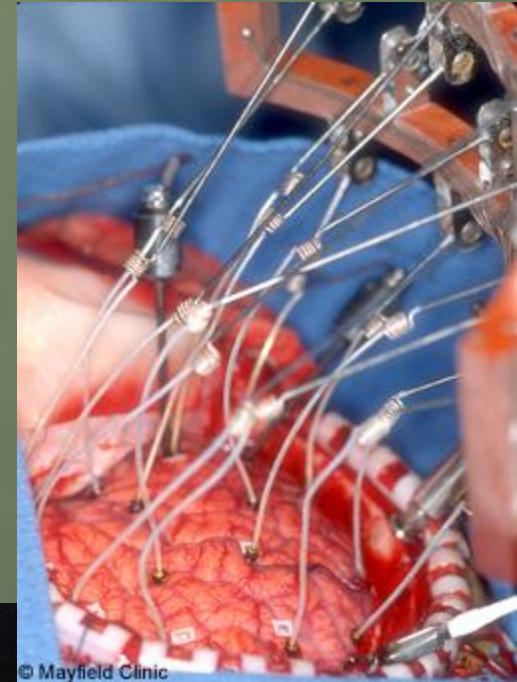
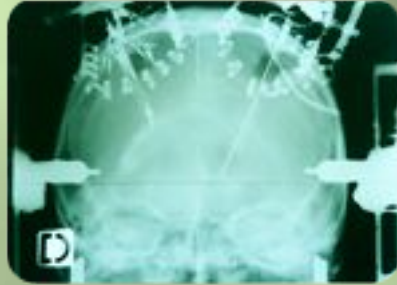
ECG electrodes

Heart stimulator electrodes



colposcopy-loop-electrodes

MEDICAL ELECTRODES & THEIR FORMS



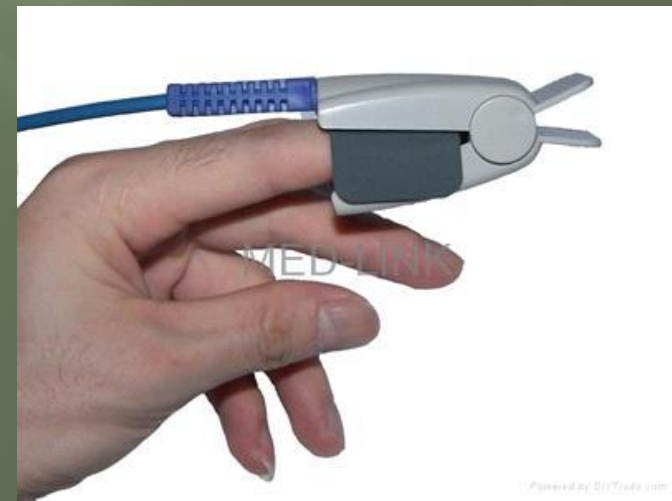
TRANSDUCERS



A **transducer** is a device that converts one type of energy to another. Energy types include (but are not limited to) electrical, mechanical, electromagnetic (including light), chemical, a coustic or thermal energy. While the term transducer commonly implies the use of a sensor/detector, any device which converts energy can be considered a transducer. Transducers are widely used in measuring instruments.

Active (generative) transducer - can generate electromotive force under the influence of different non-electric energies (heat, etc.).

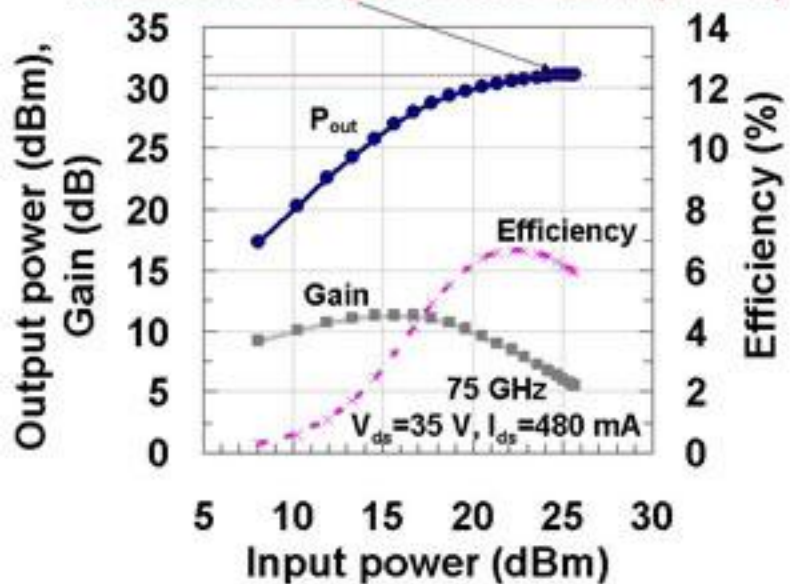
Passive (parametric) transducer - needs the power supply (direct or alternating current).



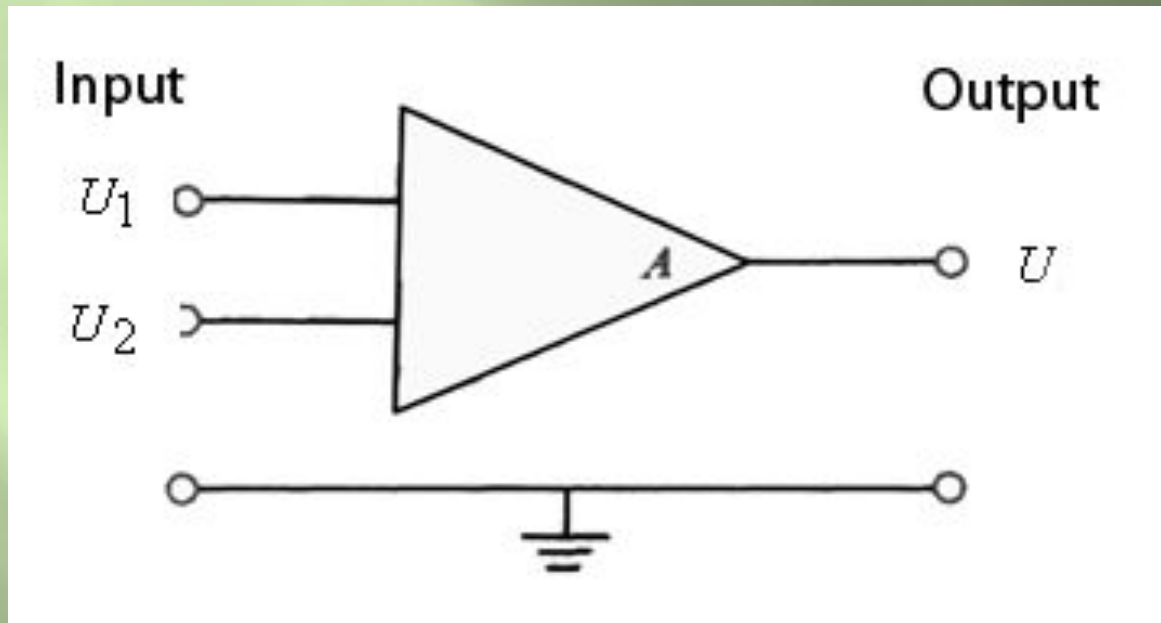
ELECTRONIC AMPLIFIERS



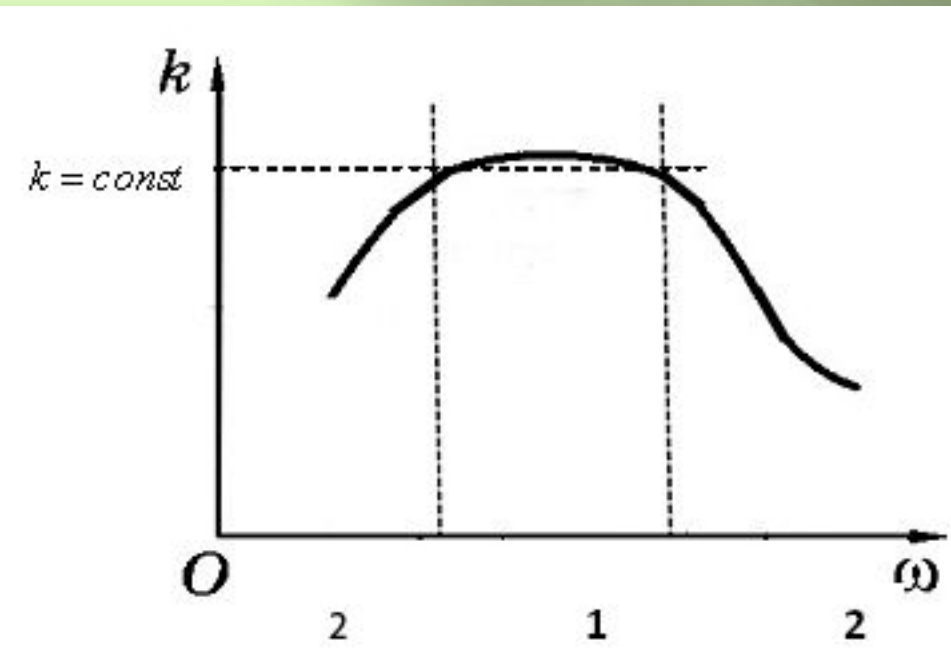
Maximum Output: 31.13 dBm (1.3 W)



AMPLIFIER SCHEME



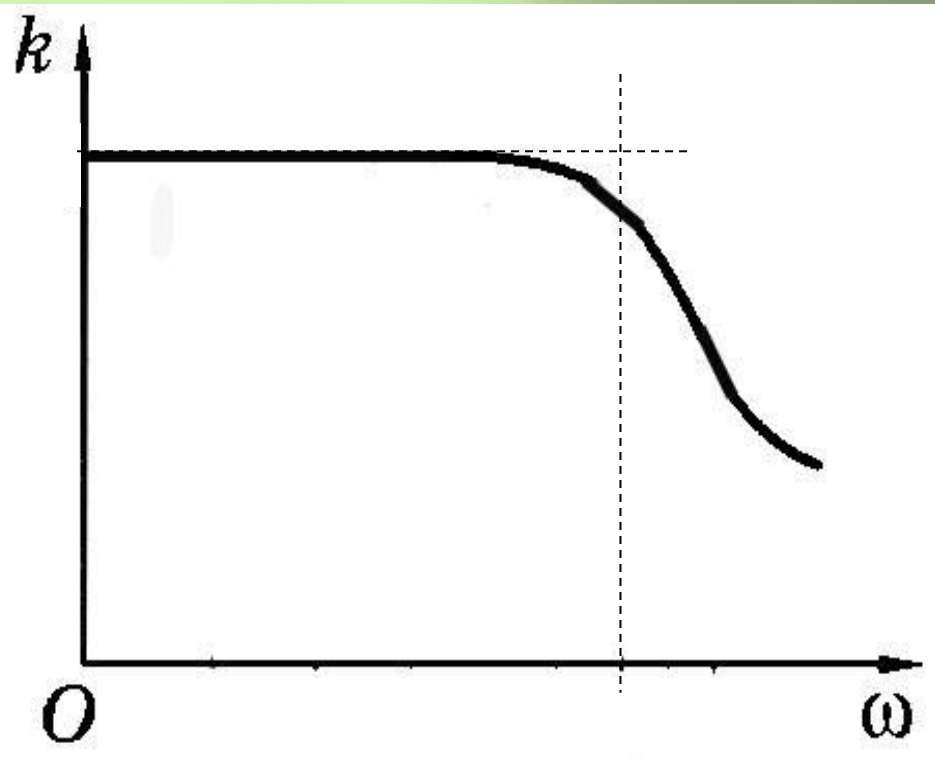
AMPLIFIER CHARACTERISTIC



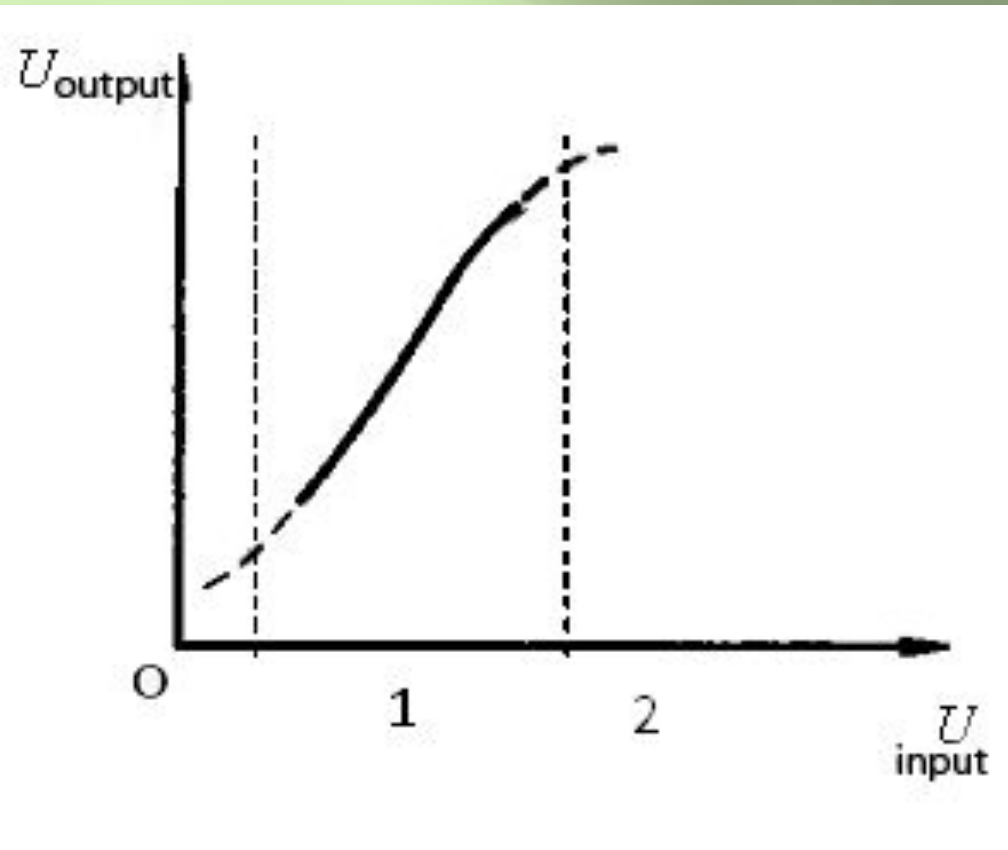
Frequency characteristic

- 1 - bandwidth, within which the amplification is the same for signals of different frequencies,
- 2 - low and high frequencies that are outside the bandwidth, since the amplification of the signal of frequency decreases (obstruction characteristics).

The frequency characteristic of the dc amplifier

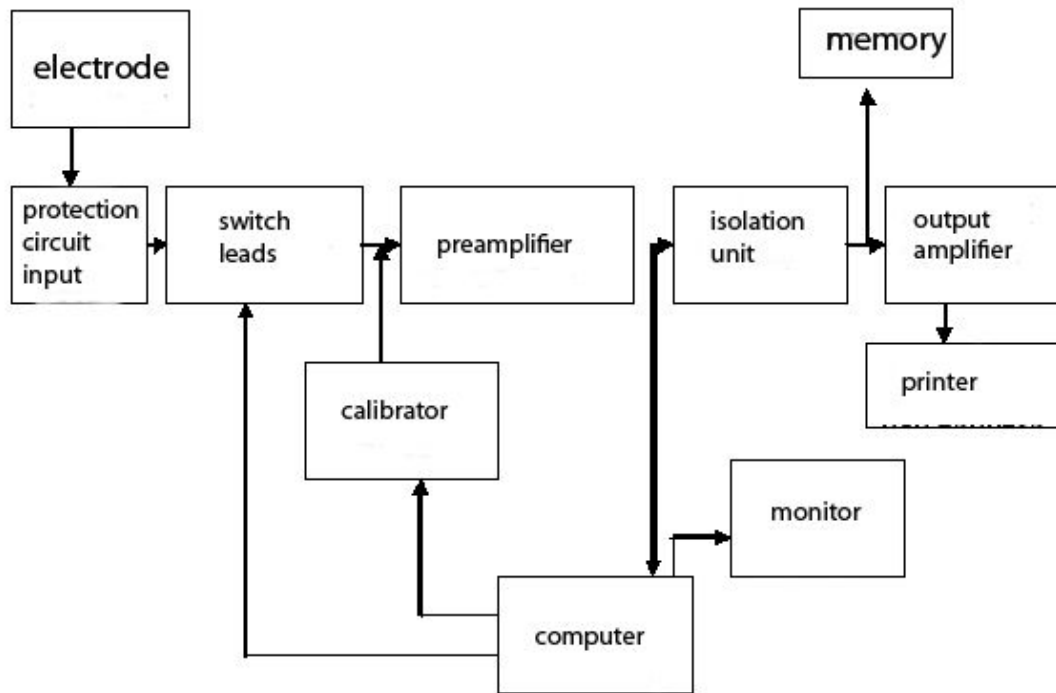


The frequency characteristic of the dc amplifier differs from the characteristics of an ac amplifier that has the obstruction at low frequencies up to a frequency equal to zero, which corresponds to the dc



Amplitude characteristic of the amplifier shows the dependence of the amplification coefficients on the amplitude of the input signals. Amplification characteristic requires the amplification was the same for any input signal amplitude. However, this requirement can be fulfilled only partially. Amplification can be only when the amplitude of the input signal is within a certain range, which is reflected in the amplitude characteristic of the amplifiers.

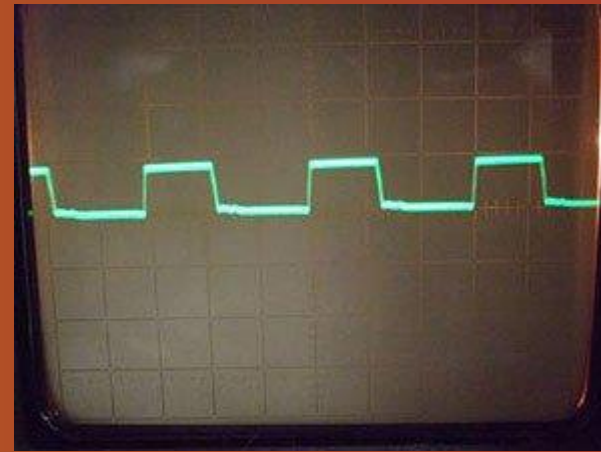
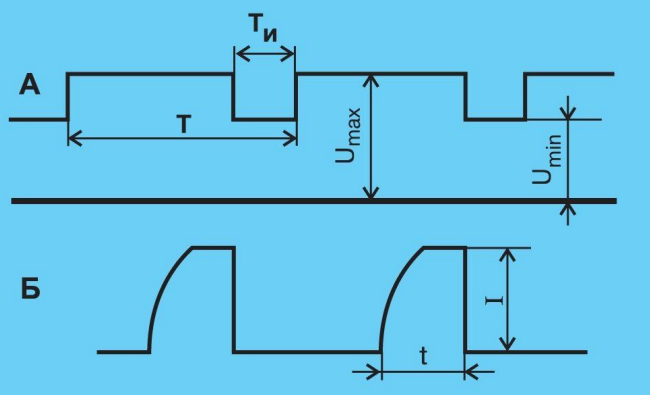
Block scheme of ECG



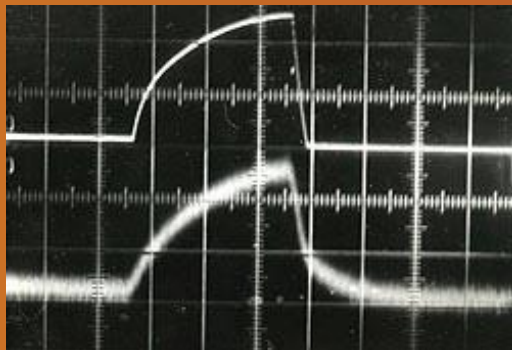
1. **Protection circuit** protects the input circuits of the instrument from the random effects of high voltage.
2. A **switch** lets you choose lead electrodes that are connected to different leads to the amplifier input.
3. **Calibrator** allows you to record the amplitude of 1 mV calibration signal.
4. The **preamplifier** is designed to enhance the initial ECG. Must have a high input impedance and bandwidth corresponding to the ECG.

5. **Block of insulation** creates a barrier to DC between the chains attached to the patient, and the rest of the circuit.
6. The **output amplifier** is designed to enhance the ECG to the level required for registration on the recorder and the input of the memory block.
7. The **memory** block is used to store the recorded ECG, which had previously converted into digital form.
8. **Recorder or printer** used to print the ECG recording
9. The **computer** controls the work of the electrocardiograph as a whole through appropriate programs.

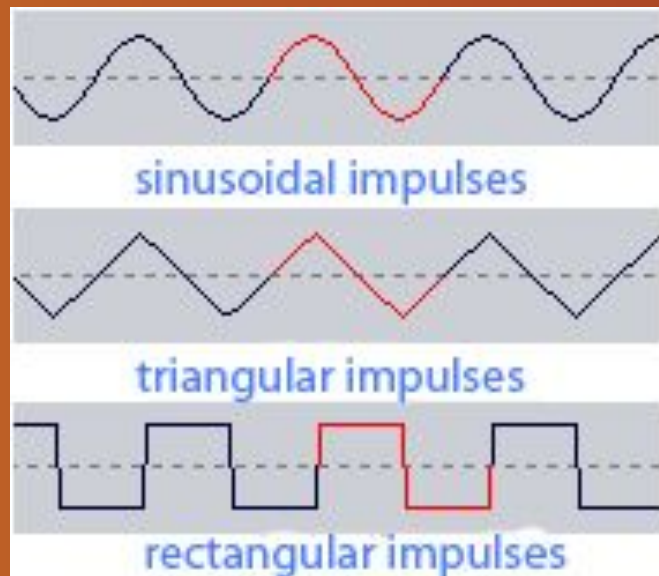
IMPULSE SHAPE



Electrical impulse – is a short burst of electrical voltage or current in a short period of time



Sawtooth impulses



Impulse shape:

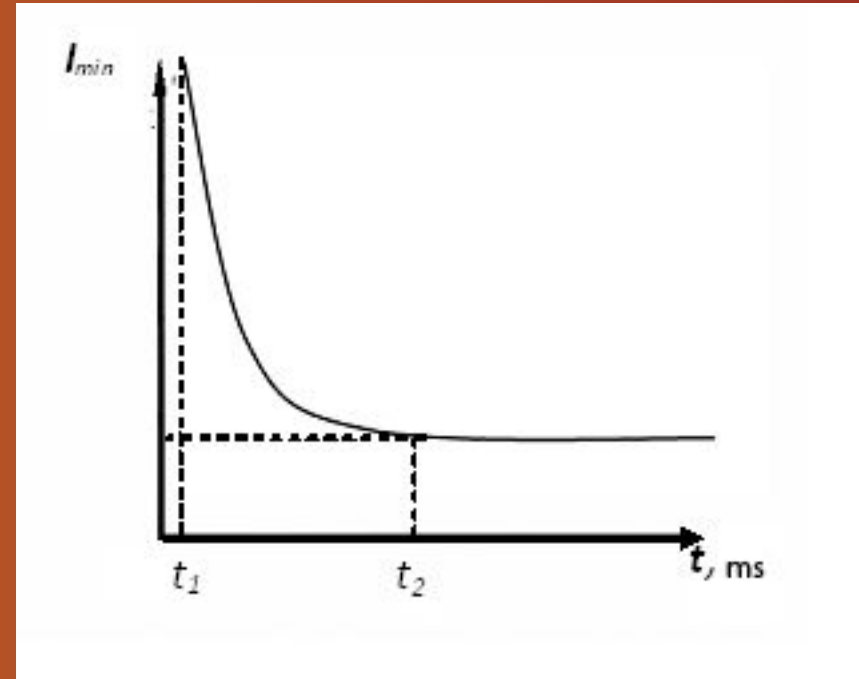
- Rectangular impulses
- sawtooth impulses
- triangular impulses
- trapezoidal impulses
- exponential impulses
- Bell (bell-shaped) impulses

IMPULSE

To excite nervous or muscular cells , an electrical impulse must have an amplitude exceeding the threshold of excitability, which is defined as the minimum current strength that is sufficient for the occurrence of Action Potential. In addition, to cause excitement, electrical impulse must have a certain minimum duration.

The relationship between the threshold of excitability and a minimum duration of the exciting pulse is reflected in the Weiss Lapik law:

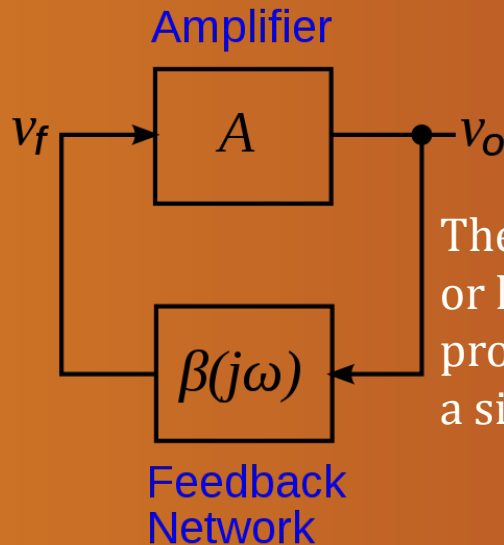
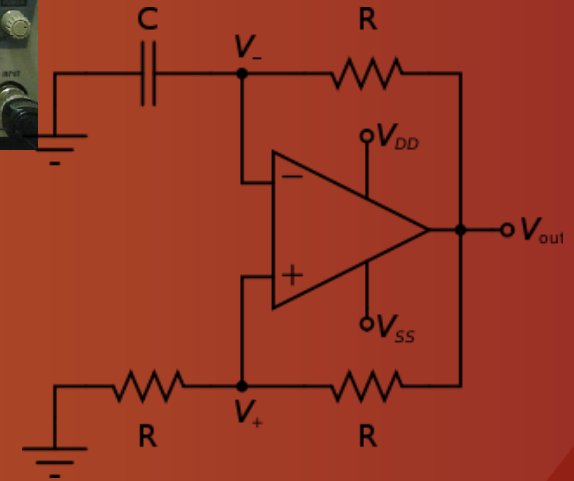
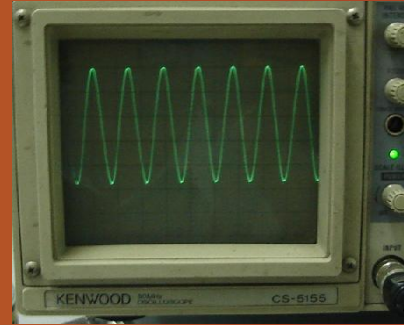
$$I_{\min} = \frac{a}{t} + b$$



where I_{\min} -threshold current,
 t - duration of impulse action,
 a and b -coefficients of
the resulting properties of the plasma
membrane of excitable cells.

ELECTRONIC OSCILLATOR

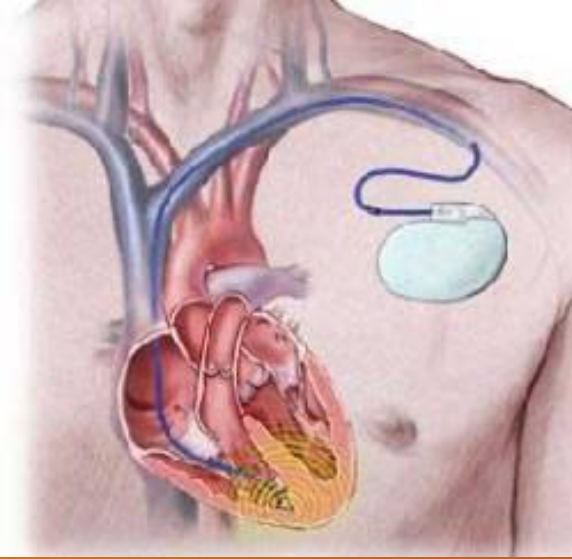
An **electronic oscillator** is an electronic circuit that produces a repetitive electronic signal, often a sine wave or a square wave. They are widely used in innumerable electronic devices. Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video games.



The **harmonic**, or linear, oscillator produces a sinusoidal output.

A **relaxation oscillator** produces a non-sinusoidal output, such as a square, sawtooth or triangle wave. It contains an energy-storing element (a capacitor or, more rarely, an inductor) and a nonlinear trigger circuit (a latch, Schmitt trigger, or negative resistance element) that periodically charges and discharges the energy stored in the storage element thus causing abrupt changes in the output waveform.

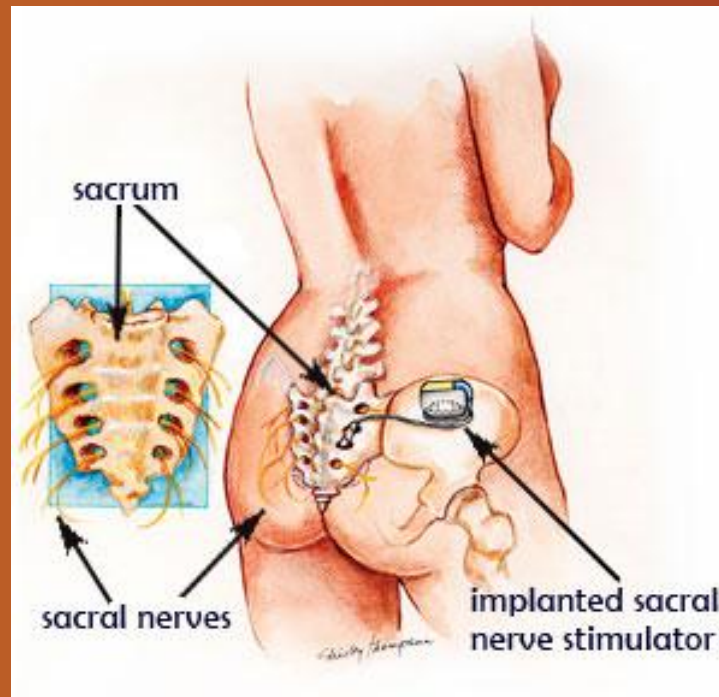
STIMULATORS



Cardio stimulators



Myostimulators



Nerve stimulator

ELECTRO PHYSIOTHERAPY

The use of electrotherapy has been researched and accepted in the field of rehabilitation¹ (electrical muscle stimulation). The American Physical Therapy Association acknowledges the use of Electrotherapy for:

1. **Pain management** Improves range of joint movement
2. **Treatment of neuromuscular dysfunction**: Improvement of strength; Improvement of motor control; Retards muscle atrophy; Improvement of local blood flow
3. **Improves range of joint mobility**: Induces repeated stretching of contracted, shortened soft tissues
4. **Tissue repair**: Enhances microcirculation and protein synthesis to heal wounds; Restores integrity of connective and dermal tissues
5. **Acute and chronic edema**: Accelerates absorption rate; Affects blood vessel permeability; Increases mobility of proteins, blood cells and lymphatic flow
6. **Peripheral blood flow**: Induces arterial, venous and lymphatic flow
7. **Iontophoresis**: Delivery of pharmacological agents
8. **Urine and fecal incontinence**: Affects pelvic floor musculature to reduce pelvic pain and strengthen musculature; Treatment may lead to complete continence

Electrotherapy is used for relaxation of muscle spasms, prevention and retardation of disuse atrophy, increase of local blood circulation, muscle rehabilitation and re-education electrical muscle stimulation, maintaining and increasing range of motion, management of chronic and intractable pain, post-traumatic acute pain, post surgical acute pain, immediate post-surgical stimulation of muscles to prevent venous thrombosis, wound healing and drug delivery.

ELECTRO PHYSIOTHERAPY

Electro physiotherapy – is a method of therapy using direct or alternating current. There are two kinds of electro physiotherapy: low frequency, high-frequency therapy and ultra-high frequency therapy.

Low-frequency therapy: diadynamic, amplipulse.

High-frequency therapy: diathermy, inductothermy, ultra-high-frequency therapy.



AMPLIPULSE THERAPY

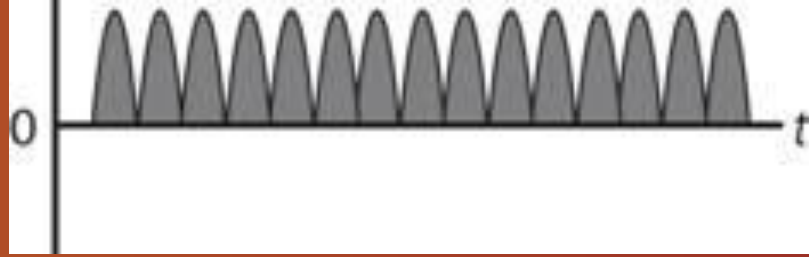
- analgesic effect;
- vasodilator action;
- hypotensive effect;
- anti-inflammatory effect;
- anti-edematous action;
- resolving the action;
- trophico stimulating effect;
- stimulation of striated and smooth muscles.



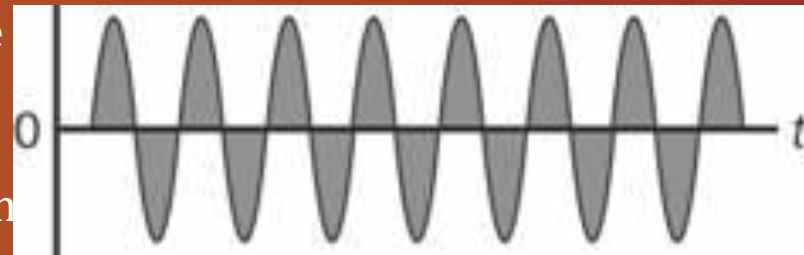
Amplipulse is a method of electro physiotherapy that effects on the body for therapeutic purposes with sinusoidal modulated currents. Sinusoidal modulated currents (SMC) is a mid-pulse AC (2-5 kHz)ting its amplitude. .

Diadynamic

Diadynamic - this method effects on organism with the low-frequency current. Current frequency at 50 Hz, obtained from the network through a half-wave rectification of the current and the current frequency of 100 Hz, obtained with the full-wave rectification. Its amplitude may change periodically (modulated). This current has an analgesic effect, activates blood circulation and stimulates the metabolic processes in tissues.



Example of $\frac{1}{2}$ Wave
Diadynamic Stimulation Pattern



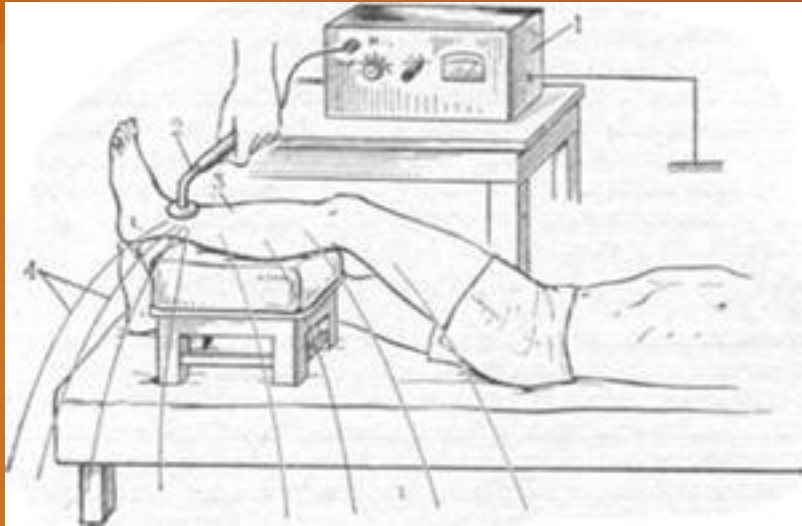
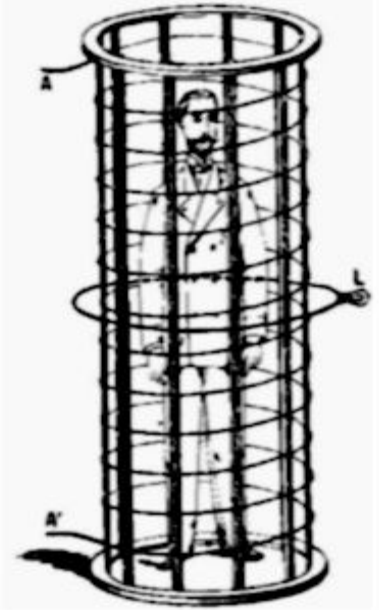
Example of Full Wave Diadynamic
Stimulation Pattern



Darsonvalization

Darsonvalization (named by one of the founders of Physiotherapy - D'Arsonval) - method of electro physiotherapy effects on the skin or mucous membranes of the weak high-frequency electrical impulses.

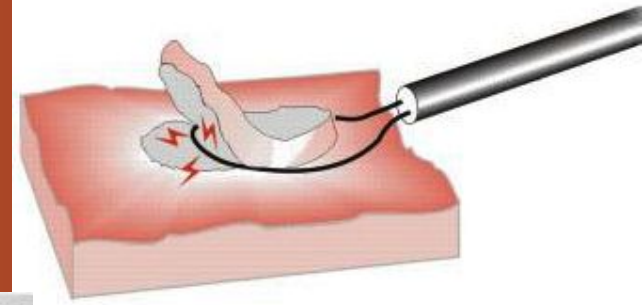
Jacques Arsene D Arsonval and < D'Arsonvalization >



Diathermy

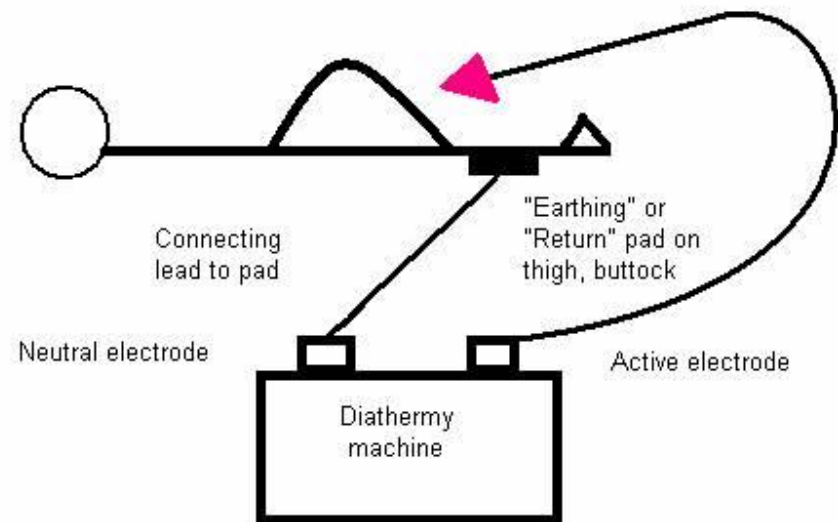
Diathermy (Greek *diathermaino* - heated) - this method of deep tissue heating by electric current of high frequency. The effect is achieved by passing through a patient's body current with frequency 1 - 2 MHz, which doesn't excite tissues. Through the use of metal electrodes without spacers current strength can reach 1.0 - 1.5 A, which provides large amounts of heat. However, direct contact with the electrodes is not fully secure, and therefore nowadays diathermy is not applied as a method of physical therapy but surgery.

diathermy



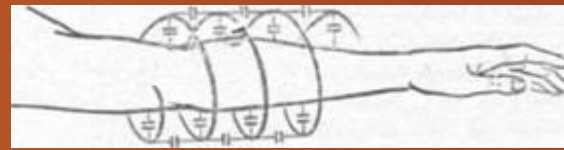
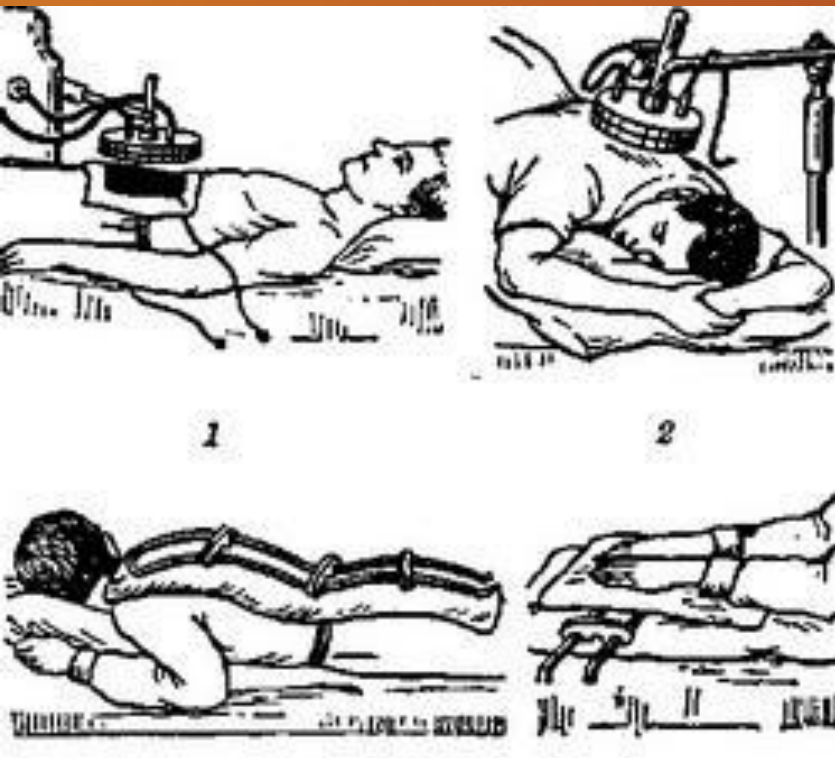
Cutting with a diathermy loop

Diathermy in surgery



Inductothermy

Inductothermy - method of Electro physiotherapy, which includes impact on patient's body with electromagnetic field of high frequency. The main advantage of this method is its harmlessness as it is noncontact.



Microwave therapy

Microwave (MW) - is a therapy effects on the body with electromagnetic waves of ultrahigh frequency UHF (100 cm - 10 cm) or cm (10 cm - 1 cm) range. Energy of electromagnetic waves is supplied to the patient and sent using special emitters -waveguides, which are tube shaped.

