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UTILIZATION OF GAS DISCHARGE IN ALTERNATING CURRENT FOR THE DETECTION AND STIMULATION OF BIOLOGICALLY ACTIVE POINTS

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Abstract – Acupuncture belongs to the non-pharmacological methods of Eastern medicine and it is a form of alternative reflexotherapy. In modern medicine, aside from needle therapy, other forms of acupuncture have gained recognition, such as electroacupuncture, laser and light acupuncture, magnetopuncture, thermopuncture, and high-frequency puncture. The effectiveness of treatment using these methods significantly depends on accurately locating the biological active points (BAP) and selecting the influencing factor. Therefore **the research aim** is to simplify the search for BAP on the human skin and transition to the mode of electroacupuncture stimulation. **The research subject** involves the processes of the gas discharge occurrence and luminescence upon contact with a sensor in the area of a biological active point. **The research topic** revolves around applying the properties of gas discharge under alternating current for electroacupuncture means. **Research findings:** A review of common acupuncture methods has been conducted, and the electro-physical peculiarities of BAP have been noted. To localize the positions of BAP, the luminescence of a gas discharge sensor in an alternating electric current circuit is proposed. The sensor enters an identification state when the search electrode makes contact with areas of the skin possessing lowered electrical resistance, a characteristic of these points. Equivalent circuitries of gas discharge currents have been constructed. At low frequencies, the use of an indifferent electrode is proposed, allowing the discharge current to flow to the search electrode. The equivalent circuit for high-frequency currents demonstrates the possibility of gas discharge occurrence in the sensor through displacement currents. For operation at high frequencies, the sensor can be designed in the form of a cylindrical glass bulb with a conical search tip, containing an internal metallic electrode and filled with inert gas. Two stimulation modes for BAP using gas discharge currents have been envisaged – low-frequency and high-frequency. In the former, the low-frequency range of 1…150 Hz is used, while the latter involves amplitude modulation of high frequencies (0.01…1 MHz) with a low-frequency signal. Effective stimulation current values can go up to 1 mA. An additional influencing factor in the BAP area is the broad-spectrum electromagnetic radiation of the gas discharge plasma in the visible, infrared, and radio frequency ranges. Estimated power values and spectral density of emission in the 60…70 GHz range correspond to the concept of information-wave therapy. The device structure was developed,which utilizes a gas discharge on alternating current for locating and stimulating biological active points. The main components of the device are an alternating voltage generator and a manipulator. The generator enables operation in both low-frequency and high-frequency modes, with adjustable amplitude, frequency, modulation depth, and harmonic oscillations output voltage. The key component of the manipulator is the gas discharge sensor, which simultaneously functions as an indicator of BAP location and performs stimulation. Other elements of the manipulator ensure the safety and usability of the device. **Conclusion**: The conducted research confirms the feasibility of constructing a straightforward device for locating, identifying, and therapeutically influencing biological active points on the patient's skin surface. A specialized gas discharge sensor serves as a logical element, indicator, and influencing factor. The application of the proposed technical solution expands the potential of acupuncture treatment methods, though it requires appropriate medical validation.
Keywords: biological active points, electroacupuncture, gas discharge, emission, localization, alternating electric current, stimulation, device structure.

I. INTRODUCTION

Classical acupuncture (needle therapy) is a therapeutic method involving the stimulation of peripheral nerve branches through punctures in specific points on the body [1]. These points are located on the surface of the human skin and are referred to as biological active points (BAP). While there are around 600 to 800 BAP in total, around 140 to 150 points are commonly used in practice. The physical properties of BAP are associated with the state and presence of pathologies in corresponding internal organs and systems. Acupuncture belongs to non-pharmacological methods of

Eastern medicine and is a form of alternative reflexotherapy. In modern medicine, alongside needle therapy, other forms of acupuncture have gained recognition, such as electroacupuncture, laser and light acupuncture, magnetopuncture, thermopuncture, and microwave (MW) puncture [2,4]. The results of treatment using these methods significantly rely on the accuracy of BAP localization and the choice of influencing factor. The spatial position of points usually does not coincide with the anatomical location of the related organs and systems. The generalized layout of BAP is presented in various manuals and atlases on acupuncture [2,3], (Fig. 1).

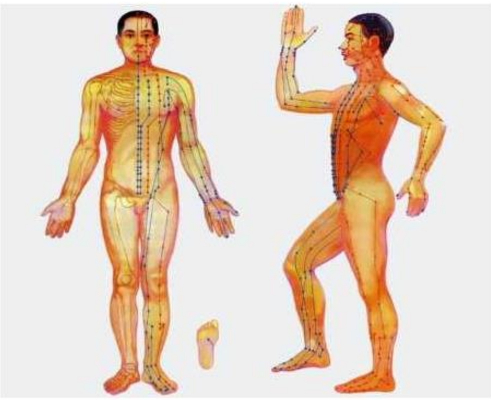

Fig. 1 – Anatomical location of biological active points [3]

These information sources also provide associations between specific BAP and organ functioning, system activity, and the presence of diseases. However, each individual exhibits unique characteristics that influence the location, shape, and size of these points [4,5]. The selection of the physical stimulus applied to BAP, which generates the greatest therapeutic effect, holds even greater importance. These circumstances lead to the requirement for medical practitioners to gain extensive practical experience and employ various technical means based on the principle of action in mastering the various methods of acupuncture.

Overview of Common Acupuncture Implementations

Viewing acupuncture as a component of reflexotherapy methods and, in a broader sense, physiotherapy, it is important to note that the uniqueness of this method lies in the application of a stimulating physical factor solely on the biological active point. The choice of a specific point is determined by medical indications. In this case, the treatment procedure must have mandatory stages: the first involves determining the location of BAP on the skin surface; the second entails applying a physical stimulus to the point.

At times, the first stage is combined with diagnosing an individual's condition by measuring physical parameters at BAP. These measurements are compared with the presence or absence of pathologies based on accurate medical statistics. The specific physical properties of BAP are determined by their anatomical structure. Biologically active points are morpho-functionally distinct areas located in the subcutaneous adipose tissue, containing rich fatty cells, and closely associated with proper nerve conductors [6]. In 42% of cases, subcutaneous nerves are identified within the BAP region, 40% contain subcutaneous veins, and 10% have subcutaneous arteries. Points of influence are characterized by a maximal concentration of nerve elements and clusters of fatty cells containing essential biological regulators.

The mentioned anatomical structure of BAP leads to an increase or decrease in the mechanical elasticity of these areas, which is utilized in their determination through palpation methods. Changes in thermal conductivity characteristics in BAP enable their localization based on temperature indicators. Another physical factor that can be used to detect the presence of BAP is electromagnetic radiation in the microwave range of 30...300 GHz. However, the power flux from these regions is approximately 10^{-19} W/cm^2, making the hardware registration of such a signal complicated [7].

A significant reduction in electrical resistance, both in direct and alternating currents, has gained particular importance for BAP localization. Methods of electroacupuncture diagnostics are based on these characteristics of BAP. The methods by Nakatani (Y. Nakatani) and Voll (R. Voll) have found the greatest realization in technical devices [1,8]. Practically all electroacupuncture devices in the BAP search mode use a test voltage of 1...12 V with a maximum current of 20...200 μA, respectively. The current value is measured proportionally to the resistance between a large-area electrode (for example, a brass cylinder with a diameter of 2 cm and a length of 10 cm) held by the patient and the contact of the search electrode (shaped like a hemisphere with a radius of 1.5...3 mm). The contact area of the search electrode corresponds to the area of the BAP region. By moving the search electrode over the skin surface in the expected BAP location (according to the topographic atlas), the physician determines the actual location of the point based on a substantial decrease in electrical resistance between the electrodes. To facilitate resistance reduction detection, it is transformed into an acoustic signal or optical indicator radiation. Among recent domestic developments of electroacupuncture devices is the reflexotherapy apparatus – the combined block of electroacupuncture diagnostics "MIT–1 EPD," designed to input information about the electrical conductivity of human energy channels into a personal computer, while working within the software-hardware diagnostic complex "Nakatani Test" [9]. Devices of earlier releases like "Prognosis," "Biomed-010," "Kurtid," "SVESA-1010," "Dermaton-50600" are built based on a similar working principle [8].

Following BAP localization, diagnostic measurements are performed or the stimulation mode using a corresponding physical factor is initiated. Among invasive methods is the classical therapy involving the insertion of special needles into selected BAP [1,2].

Most hardware solutions are based on non-invasive application of physical factors. For mechanical stimulation localization, low-intensity ultrasonic radiation is utilized. The use of laser light-emitting diodes has expanded the possibilities of light acupuncture [10]. For thermal stimulation of BAP, transducers based on the Peltier effect are applied, where changing the direction of the current transforms the contact junction from a heating mode to a cooling mode [11]. Special antenna applicators are used to influence BAP with electromagnetic radiation of ultra-low intensity in the millimeter range $10^{-19}…10^{-22}$ W/cm^2 (microwave puncture) [12]. Magnetopuncture devices apply a continuous and variable magnetic field with an induction of approximately 10^{-4} T for BAP stimulation [13]. The use of constant, pulsed, and modulated variable electrical currents as the stimulating factor gained considerable popularity in electroacupuncture devices. It is considered that electrical stimulation of BAP with effective values up to 1 mA best corresponds to the biophysical processes in the human body [14].

Undoubtedly, the choice of a specific influencing factor in the use of reflexotherapy tools is solely the prerogative of experienced medical practitioners. Proposed new technical directions with potential medical applications should be considered as engineering solutions.

Aim and Research Objectives

The aim of the research is to simplify the search for biologically active points (BAP) on the human skin and transition to the mode of electroacupuncture stimulation.

The research object is the processes of occurrence and glow of a gas discharge upon contact of the sensor with the location of the biologically active point.

The research subject is the application of the properties of gas discharge on alternating current for electroacupuncture devices. To achieve this aim, the following objectives are set:

Substantiate the possibility of localizing the position of the biologically active point based on the glow of the gas discharge sensor on alternating current. Construct a model of electrical circuits for gas discharge processes.

Identify the electrostimulation factors that correspond to the conditions of gas discharge occurrence. Develop the device structure using gas discharge on alternating current for the search and stimulation of biologically active points.

II. PRINCIPLES OF GAS DISCHARGE VISUALIZATION OF BAP

One of the peculiarities of biotissues in BAP is a significant difference in their mechanical, thermal, and electrical indicators compared to the surrounding areas of the skin surface. Table 1 provides comparative measurements of resistance in BAP for direct current in studies by various authors [8].

Table 1 **Electrical Resistance in BAP and Outside BAP**

Author of the Study (Year)	BAP Resistance, kOm	Resistance outside BAP, kOm
A.K. Podshebyakin (1960)	400 – 500	1000 – 2000
S. Krippner (1973)	100 – 200	Exceeds 1000
N. Wulfson (1976)	200 – 700	1500 – 2000
F.G. Portnov (1980)	600 – 1000	Exceeds 1000

For the technical implementation of BAP search, it is promising to use the specificity of the electrical impedance in these points on alternating current. The simplified equivalent circuit of the complex electrical impedance Z_{BAP} is shown in Figure 2, where R_{skin} is active skin resistance, R_{tissue}, C_{tissue} is active and capacitive components of internal tissue resistance [15]. When measuring impedance at frequencies up to hundreds of kilohertz, the inductive properties of biotissues do not manifest.

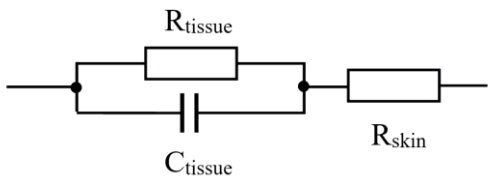

Figure 2 – Equivalent Circuit of Complex Impedance in BAP

From impedance measurements, it is known that $R_{skin} >> R_{tissue}$, and the modulus of the capacitive resistance depends on the frequency of the electric current. Another feature of BAP is the reduction of R_{skin} value by almost half (according to Table 1) compared to adjacent skin areas. These resistance properties in BAP can be utilized by including a threshold element in the circuit of alternating current, which would transition to an identification state upon contact of the sensor electrode with the skin area exhibiting anomalous conductivity.

As a necessary threshold element, the properties of gas discharge occurrence in a sealed glass bulb filled with inert gas at low pressure are proposed to be used [16]. The typical voltage-current characteristic of a glowing discharge is presented in Figure 3 [17].

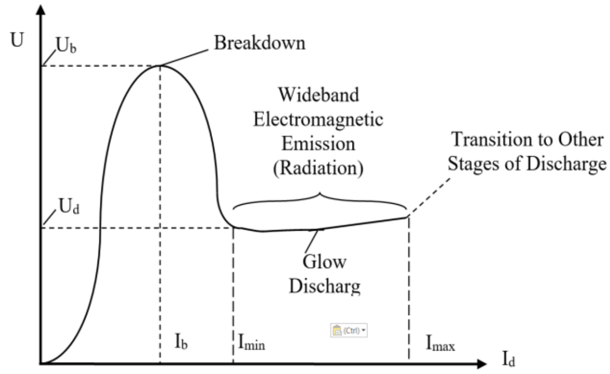

Figure 3 – Volt-Ampere Characteristic of Glowing Discharge on Direct Current

The discharge occurs in a glass bulb between two metal electrodes to which a voltage U is applied. When the voltage is increased to the level of U_b, an avalanche breakdown occurs in the interelectrode space. The voltage on the electrodes decreases to the ignition state level U_d, and a glowing discharge arises within the discharge current range $I_{min}…I_{max}$. The discharge is accompanied by electromagnetic radiation in a wide frequency range including the visible spectrum (glow). The occurrence of glow can be utilized for identifying the location of BAP on the skin surface. Similar physical processes of gas ionization and discharge occur on low-frequency alternating current. At low frequencies, the positions of cathode and anode regions periodically change. The only difference is a slightly higher degree of ionization at the beginning of each half-period due to the discharge that occurred during the previous half-period [17]. The equivalent circuit of the low-frequency discharge circuit for BAP search is shown in Figure 4.

Assuming that the power source generates a sinusoidal voltage $U(t) = U_a \sin(\omega t)$, the amplitude U_a should be insufficient for discharge to occur when the contact is outside the BAP zone. If the search electrode contact enters the BAP zone, the voltage drop is redistributed across the section: Z_{BAP} – Z_{DISCH} – R. With optimal device settings, the voltage drop on the gas discharge sensor is sufficient for breakdown conditions and discharge occurrence $I_p \cdot Z_{DISCH} > U_b$. The discharge is accompanied by radiation in the visible range. Thus, the location of BAP is indicated.

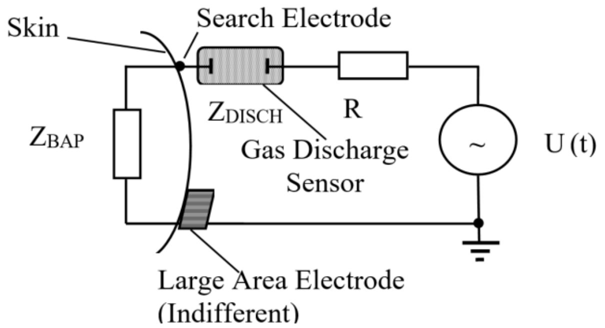

Figure 4 – Schematic of the Discharge Circuit at Low Frequencies

As the frequency of the power source voltage U(t) increases, the discharge nature changes. Starting from a certain critical frequency, different discharge regions do not have time to reconfigure during each half-period, and the discharge becomes symmetrical. It cannot be temporally decomposed into two oppositely oriented discharges in space. The critical frequency that corresponds to the transition to high-frequency discharge depends on the discharge type. For Townsend avalanche of the glowing discharge, it is approximately 10 kHz; for spark discharge, it's 10 MHz. A peculiarity of high-frequency discharge is its weak dependence on electrode processes. The discharge can occur even when the electrodes are outside the discharge tube [16,17].

Taking into account the characteristics of high-frequency discharge, at frequencies in the tens of kilohertz range, a single electrode connected to a high-frequency voltage source U(t) can be placed inside the glass discharge sensor bulb. With sufficient displacement currents, the BAP and the entire human body will function as a second electrode, located outside the glass bulb of the sensor, Figure 5. Thus, the search manipulator can be implemented in the form of a cylindrical glass bulb with a tapered search end, containing a single metal electrode inside and filled with inert gas.

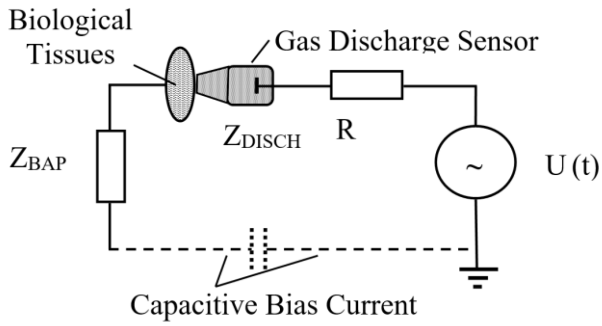

Figure 5 – High-Frequency Alternating Current Discharge Circuit

Real displacement current parameters can vary widely for each patient and measurement conditions. Therefore, alternative discharge circuit configurations are possible. For example, the displacement current capacitive region can be replaced by a conductor connecting the grounded output of the power source and a large-area electrode (indifferent). Additionally, at high frequencies (approximately 10 kHz to 1 MHz), the configuration shown in Figure 4 can be applied. This is particularly useful if the BAP areas have a small surface area, and the search electrode needs to have a proportionally sized contact.

III. STIMULATION FACTORS

Low-Frequency Mode:

After identifying the location of BAP through the glow of the gas discharge sensor, it transitions to a stimulation mode. The parameters of current stimulation are determined by the effective value of the discharge current, the pulse shape, and the frequency of the power source voltage. The magnitude of the discharge current depends on the composition and pressure of the gas mixture within the sensor's glass bulb cavity, the material and shape of internal electrodes, and the distance between them. These conditions are particularly important for the low-frequency range. For quantitative estimation, reference data for common types of single gas discharge indicators are used, as listed in Table 2 [18].

Indicators of the TN type operate in a glowing discharge mode (with a cold cathode). The indicator's glass bulb is filled with a mixture of helium and neon gases. The visible radiation of the electric discharge in this mixture is in the orange-red spectrum, at low inert gas pressures (around 40 mmHg). Notably, the ignition voltage is generally lower than the breakdown voltage by about 20…25%, which correlates with the change in BAP resistance compared to neighboring skin areas and is important for glow discharge. The effective value of the discharge current for TN-type indicators ranges from 200 to 1000 μA, which corresponds to common stimulation current values [14].

Table 2. **Main Electrical Characteristics of TN Indicator Lamps**

Type of Indicator	Initial Breakdown Voltage- U_b, V	Ignition Voltage– U_d, B	Operating Ignition Current– I_g, mA
TN - 0,2	85	65	0,2
TN - 0,3	85	65	0,3
TN - 0,5	90	55	0,5
TN - 0,9	200	150	0,9
TN - 1	140	90	1,0

In electroacupuncture devices, the stimulation mode utilizes a frequency interval of 1 to 150 Hz. The same frequencies should be provided by the variable voltage source. Even when using a sinusoidal voltage dependence U(t), the current waveform through the BAP will have a complex pulse character. This is due to the fact that the breakdown in the gas discharge sensor occurs when the voltage on it equals or exceeds U_b, and the discharge stops when the voltage drops below U_d. During the variable voltage period, two oppositely polarized pulse currents are generated. The shape of these pulses will also be influenced by the nonlinearity of both the discharge's volt-ampere characteristic and the nonlinear dependence of the electrical resistance of biotissues on the current magnitude. Thus, the frequency spectrum of the BAP stimulation current will be enriched with components of the form $f_n = f_1 \cdot n$, where n = 2, 3, 4…, and f_1 is the frequency of the power supply voltage.

In electroacupuncture practice, single-polarity pulses of different forms are also used for stimulation. When combined with a gas discharge sensor, the stimulation currents will acquire additional spectral components.

The phenomenon of flicker, occurring when the flash frequency is below 40…50 Hz, is part of the specifics of visually observing the glow of the gas discharge sensor in the low-frequency range. This phenomenon must be considered when practically applying the low-frequency mode.

High-Frequency Mode:

Convenient for locating BAP is the use of a variable voltage source with a frequency above 10 kHz. At these frequencies, it is fundamentally possible for the gas discharge sensor to operate without direct skin contact with a conducting probe (see Figure 5). The occurrence of discharge in the sensor and its glow is accompanied by the flow of high-frequency current with maximum density in the BAP location. It is known that the effect of biological structure stimulation by electric current significantly decreases with increasing frequency [19]. Starting from frequencies of 0.5…1 kHz, the energetic thermal influence of the electric current on biostuctures prevails.

For BAP stimulation in the high-frequency mode, it is proposed to apply a similar solution to that used in the amplipulse therapy method [19]. In this case, the power supply voltage should correspond to the law of amplitude modulation:

$$U_A(t) = U_a[1 + mS(t)]\cos(2\pi f_0 t + \varphi), \quad (1)$$

where f_0 is the frequency, φ is the initial phase, U_a is the amplitude of the high-frequency oscillation, S(t) is the modulation signal voltage, and m is the coefficient of amplitude modulation (modulation depth) [20]. Let's consider the case of modulation with a harmonic signal:

$$S(t) = U_M \cos(2\pi\Omega t), \quad (2)$$

where U_M is the modulation voltage amplitude, Ω is the modulation frequency. If Ω is chosen within the interval of 1…150 Hz, U_M < Ua, 0 < m < 1, then an amplitude-modulated power supply voltage for the gas discharge sensor will be obtained. In the case of contact with the BAP area, the amplitude of the high-frequency discharge current will vary at a frequency Ω corresponding to the effective range of biological stimulation. Similar to the low-frequency mode, the processes of electrical breakdown and the flow of high-frequency discharge have a nonlinear nature. This will result in the current stimulation having a pulsed character with a spectrum of combination frequencies multiples of Ω.

Plasma Emission:

Irrespective of the supply mode, a gas discharge occurs in the sensor's BAP area, accompanied by gas mixture ionization and plasma generation. Plasma is a source of broadband electromagnetic radiation, part of which lies in the visible spectrum and is directly used for visual BAP localization. However, due to complex physical processes occurring in the gas discharge plasma, radiation components also exist in the ultraviolet, infrared, and radiofrequency ranges [21]. For low-power discharges in neon gas mixtures, ultraviolet radiation is insignificant and is absorbed by the ordinary glass of the bulb. The effect on the BAP area of visible and infrared (thermal) radiation components has the same biophysical mechanisms as photopuncture.

Another physical factor that has enhanced biological effectiveness is the radiofrequency radiation of the millimeter-wave (MMW) range of 60…70 GHz with an ultra-low spectral power density of $\sim 10^{-25} \ldots 10^{-19}$ W/cm²Hz. The therapeutic effect of MMW radiation with these characteristics has been confirmed by the methods and tools of information-wave therapy (IWT) [22]. Let's estimate the radiating capabilities of the sensor's plasma in the frequency range of 60…70 GHz. For this purpose, we will use the approach laid out in [23], where it is indicated that the main plasma radiation component is determined by thermal radiation, and the power of the MMW component is calculated by the formula

$$P_{MMW} = (2\pi/\lambda_{AV}^2)kTS\Delta f \approx 10^{-39} f_{AV}^2 TS\Delta f, \quad (3)$$

where λ_{AV} is average wavelength, f_{AV} is average frequency, Δf – frequency bandwidth of radiation, k is Boltzmann constant, T is imaginary temperature of the plasma (radiobrightness temperature, accounting for plasma absorption and reflection properties), S is emission surface area. For the calculation: f_{AV} = 65 HHz, Δf = 10 HHz, T ≈ 30 K, assuming the average diameter of the BAP area to be 3 mm $S \approx 7 \cdot 10^{-6}$ m². Consequently, we obtain an approximate value of the power $\approx 9 \cdot 10^{-11}$ W and a corresponding spectral power density of about $\sim 10^{-20}$ W/cm².

The obtained estimations align with the concept of information-wave therapy [24]. It should be noted that the actual emission power of the discharge plasma under alternating current conditions will be influenced by the properties of the gas mixture, the chemical composition of the glass bulb and electrodes, their shape, and other factors.

IV. DEVICE STRUCTURE FOR BAP DETECTION AND STIMULATION

The structure of the device, in which the gas discharge sensor serves both as an indicator element and an influencing factor, is shown in Figure 6. The variable voltage source is a sine wave generator. The "mode selection" function enables either low-frequency mode (1–150 Hz) or high-frequency mode (0.01–1 MHz) with amplitude modulation. The choice of a specific frequency value depends on the search conditions in the BAP area, the required level of displacement currents, or the application of a circuit with an indifferent electrode.

The design of the search manipulator consists of a small glass cylindrical capsule (gas discharge sensor) containing a mixture of neon and other gases at low pressure and one or two internal electrodes where the glow discharge of orange-red luminescence occurs. One of the electrodes forms the search contact, while the other electrode is connected to the resistor R intended to limit the discharge current passing through the patient's body. For existing gas discharge indicators, the effective burning current does not exceed 1 mA [18].

In the case of a single-electrode gas discharge sensor device, the glass capsule in the search manipulator should have a conical truncation with a diameter of approximately 1–
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2 mm (see Figure 6).With the same accuracy, the contours of the biologically active zone are determined

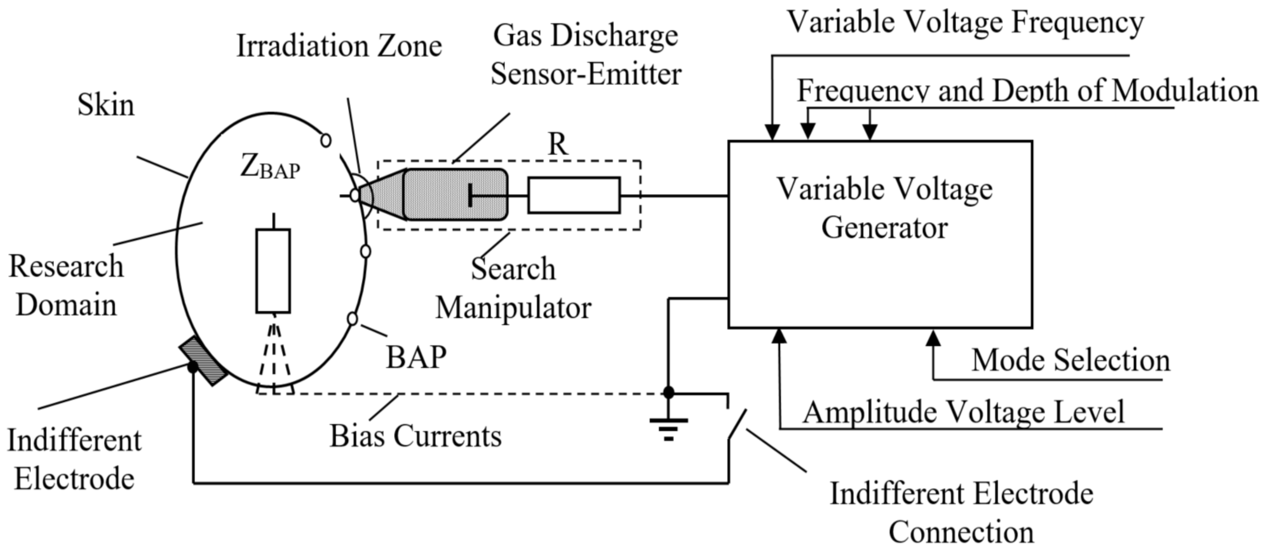

Figure 6 – Device Structure for BAP Detection and Therapeutic Impact

Amplitude of the output voltage for ensuring the conditions of electric stimulation in the gas discharge sensor should reach approximately 200 V with the possibility of smooth adjustment. Amplitude control is necessary to optimize the differentiation of BAP areas based on changes in electrical resistance. An additional requirement for the generator's output voltage is the stability of the set amplitude when a discharge occurs in the sensor. This requirement is fulfilled when the output resistance of the generator R_{out} is significantly lower than the load resistance $R_{out} << R$.

V. ANALYSIS OF RESEARCH RESULTS

Strengths: The conducted study is aimed at developing a new hardware component for electroacupuncture reflex therapy. Physiotherapy methods, with accessible technical provisions, partially reduce the intensity of using medicinal drugs for patient treatment. The proposed technical solution combines procedures: searching for BAPs, visual indication of BAP locations, and stimulation modes of human skin BAP areas. These capabilities are achieved by utilizing the properties of electrical gas discharge in alternating current. The discharge occurs directly in a glass cylindrical capsule (gas discharge sensor) containing a mixture of neon and other inert gases at low pressure. The stimulation mode starts simultaneously with the occurrence of glow in the gas discharge sensor upon reaching the BAP area.

Weaknesses: The modeling of the gas discharge revealed the dependence of electrical breakdown conditions in the sensor on voltage redistribution across the circuit elements in case of BAP localization. Substantial uncertainty is introduced by the complex resistance of biological structures and its variation during BAP stimulation. These circumstances necessitate adjusting the variable voltage generator considering the patient's individual characteristics. Furthermore, the initial ion concentration in the inert gas mixture affects the occurrence of gas discharge in the sensor. Ion concentration is influenced by the level of ionizing radiation from natural and technogenic sources. The significance of these factors on the electroacupuncture procedure can only be determined through experimental verification of the proposed solutions.

Opportunities: Undoubtedly, the potential advantage of using gas discharge in alternating current is not only the visualization of BAP locations with simultaneous broadband electromagnetic radiation but also stimulation with variable electric current. The utilization of two stimulation modes is proposed: low-frequency – with currents of 1–150 Hz, and high-frequency – 0.01–1 MHz, modulated by low-frequency currents in terms of amplitude. During electroacupuncture sessions, the search for BAPs is simplified in case of deviations from their locations as specified in specialized atlases.

Threats: One of the electronic safety concerns of the proposed solution is the use of variable voltage with an amplitude of approximately 200 V. To ensure safe device operation, the current passing through the human body is limited by a high-resistance resistor and should not exceed 1 mA. Another protective measure should be incorporated into the variable voltage generator, which disables voltage supply to the manipulator when the current exceeds the range of 3–5 mA. For powering the device from the mains, conventional galvanic separation solutions are employed.

VI. CONCLUSIONS

The glow of the gas discharge sensor in an alternating electric current circuit was utilized for localizing the positions of biologically active points (BAPs). The sensor enters an identification state when the search electrode contacts skin areas with reduced electrical resistance, which is characteristic of these points.

Equivalent circuit models for the flow of gas discharge currents were proposed. At low frequencies, the use of an indifferent electrode is suggested, which enables the flow of discharge current to the search electrode. The equivalent circuit for high-frequency currents demonstrates the possibility of gas discharge occurrence in the sensor through the flow of displacement currents. For operation at high frequencies, the sensor can be designed in the form of a cylindrical glass bulb with a conical search tip, housing a single metallic electrode and filled with inert gas.

Two stimulation modes for BAPs using gas discharge currents were introduced: a low-frequency mode within the range of 1–150 Hz, and a high-frequency mode modulated by low-frequency signals with amplitudes within the range of 0.01–1 MHz. The effective stimulation current level is up to 1 mA. Additionally, the BAP area is subjected to broadband electromagnetic radiation from the gas discharge plasma in the visible, infrared, and radiofrequency ranges. Estimated power values and spectral power densities in the 60–70 GHz range correspond to the concept of information-wave therapy.

A device structure was developed that employs gas discharge in alternating current for the search and stimulation of biologically active points. The main components of the device include a variable voltage generator and a manipulator. The generator operates in both low-frequency and high-frequency modes, with adjustable amplitude, frequency, and modulation depth of the output voltage's harmonic oscillations. The primary element of the manipulator is the gas discharge sensor, which simultaneously performs the functions of indicating BAP locations and their stimulation. Other manipulator elements ensure the device's safety and user-friendliness.

The conducted study confirms the possibility of constructing a straightforward device for locating, identifying biologically active points on the patient's skin surface, and applying therapeutic effects to them. A special gas discharge element fulfills the roles of a logical element, indicator, and influencing factor. The implementation of the proposed technical solution expands the possibilities of using acupuncture treatment methods, but it requires appropriate medical validation.

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ВИКОРИСТАННЯ ГАЗОВОГО РОЗРЯДУ НА ЗМІННОМУ СТРУМІ ДЛЯ ПОШУКУ ТА СТИМУЛЯЦІЇ БІОЛОГІЧНО АКТИВНИХ ТОЧОК

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Реферат *– Акупунктура належить до безмедикаментозних методів східної медицини і є різновидом нетрадиційної рефлексотерапії. У сучасній медицині, окрім голкотерапії, знайшли визнання інші різновиди акупунктури: електропунктура, лазерна та світлова пунктура, магнітопунктура, термопунктура, надвисокочастотна пунктура. Результати лікування цими методами суттєво залежать від точності визначення знаходження біологічно активних точок (БАТ) та обрання фактору впливу. Тому,* ***мета дослідження*** *полягає у спрощенні пошуку біологічно активних точок на шкірному покриві людини та переходу у режим електропунктурної стимуляції.* ***Об'єктом дослідження*** *є процеси виникнення та світіння газового розряду при контакті сенсора з ділянкою розташування біологічно активної точки.* ***Предмет дослідження*** *– застосування властивостей газового розряду на змінному струмі для засобів електропунктури. Результати дослідження. Проведено огляд поширених методів акупунктури та зазначені електрофізичні особливості БАТ. Запропоновано для локалізації розташування біологічно активних точок використовувати світіння газорозрядного сенсора в ланцюгу змінного електричного струму. Сенсор переходить в стан ідентифікації при контакті пошукового електрода з ділянками шкіри з пониженим електричним опором, що є властивістю цих точок. Побудовані еквівалентні схеми електричних ланцюгів протікання газорозрядних струмів. На низьких частотах пропонується використати індиферентний електрод, який забезпечує протікання струму розряду до пошукового електрода. Еквівалентна схема для високочастотних струмів доводить можливість виникнення газового розряду в сенсорі шляхом протікання струмів зміщення. Для роботи на високих частотах сенсор можна виконати у формі циліндричної скляної колби з конічним пошуковим закінченням, яка має всередині один металічний електрод і заповнена інертним газом. Передбачені два режими стимуляції БАТ газорозрядними струмами – низькочастотний і високочастотний. В першому режимі використовують низькочастотний діапазон 1…150 Гц. В другому – стимулювальний вплив забезпечує амплітудна модуляція високих частот 0,01…1 МГц сигналом низькочастотного діапазону. Ефективне значення струмів стимуляції – до 1 мА. Додатковим фактором впливу на ділянку БАТ є широкосмугове електромагнітне випромінювання плазми газового розряду у видимому, інфрачервоному та радіочастотному діапазонах. Оцінювальні значення потужності та спектральної густини випромінювання в діапазоні 60…70 ГГц відповідають концепції інформаційно-хвильової терапії. Розроблено структуру пристрою, в якому використовується газовий розряд на змінному струмі для пошуку та стимуляції біологічно активних точок. Основні складові пристрою – генератор змінної напруги та маніпулятор. Генератор забезпечує роботу в низькочастотному і високочастотному режимах з можливістю регулювання амплітуди, частоти, глибини модуляції та вихідної напруги гармонічних коливань. Основним елементом маніпулятора є газорозрядний сенсор, який одночасно виконує функції індикації розташування БАТ і її стимуляції. Інші елементи маніпулятора повинні забезпечувати безпеку та зручність використання пристрою. Висновки. Проведене дослідження підтверджує можливість побудови нескладного пристрою для пошуку, ідентифікації біологічно активних точок на поверхні шкіри пацієнта та терапевтичного впливу на них. Функцію логічного елемента, індикатора та фактору впливу виконує спеціальний газорозрядний сенсор. Застосування запропонованого технічного рішення розширює можливості використання лікувальних методів акупунктури, але потребує відповідної медичної апробації.*

Ключові слова: *біологічно активні точки, електропунктура, газовий розряд, випромінювання, локалізація, змінний електричний струм, стимуляція, структура пристрою*