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EXPERIMENTAL INVESTIGATION OF A PERSON'S BODY RESISTANCE

[1]AVGEN A. GASPARYAN, [1]MARINKA K. BAGHDASARYAN, [2]GAGIK CH. KAZARYAN

[1]Department of Electrical Engineering, State Engineering University of Armenia (Polytechnic), Yerevan, Armenia
[2]Electric Networks of Armenia, Yerevan Armenia
E-mail: [1]bmarinka@yandex.ru, [2]gagkent@mail.ru

ABSTRACT

The boundary values of the current flowing through the person's body are determined aimed at developing a device to protect a person from an electric shock. Experimental investigations are carried out, and the laws of the character of the change in the shocking current on the contact voltage are revealed.

Keywords*: *Experimental Investigations, Electric Current, Contact Voltage, Protecting Device, Person's Body.

INTRODUCTION

In recent years, works on studying the impact of electric current on the human organism are widespread based on which, facilities protecting from electric power are developed including, first of all, equipment for improving the protecting switching-off devices.

The impact of electric current on a human's organism has been investigated since ancient times. As a result of joint works carried out by engineers, electropathologists, and pathophysiologists, a great amount of statistical and experimental material is stored. However, the problem of admissible quantities of the current flowing through a man's body and the contact voltages has not been completely studied yet.

The effect of electric current on a living tissue, unlike the impact of other material factors (steam, chemical substances, radiation, etc), has a distinctive and versatile character. But in fact, passing through a man's organism, electric current produces thermal, electrical and mechanical effects. At the same time, electric current also has a biological impact which is a specific process peculiar only to a living tissue.

The biological effect of the electric current causes irritation and excitation of the living tissues, as well as disturbance of internal bioelectric processes. These processes go on normally in an active organism and are closely connected with its vital functions.

STATEMENT OF THE PROBLEM

The goal of the present work is to carry out experimental investigations for the determination of the dependence of the man's body resistance and the current flowing through it on the applied voltage, the determination of the quantities of threshold non-releasing currents, and, based on these data, the development of electroprotecting facilities, and first, the improvement of the produced protective switching-off devices.

THE IMPACT OF ELECTRIC CURRENT ON THE ORGANISM

The results of the electric current impact on a man's organism depends on a number of factors including the value and duration of the current flow through his body as well as on the state of the person's organism. The resistance of a man's body and the applied voltage also affect the lesion result, but so far as they determine the quantity of the current flowing through a person's body.

The electric shock, even it does not cause death, can bring about serious disturbances in the organism which are immediately revealed after the influence of the current, or in a few hours, days, and even months.

According to the data [1,2], the physiological impact of the electric current on the organism allows to assume that in most cases the impact of a deadly voltage on the person at alternating current of low voltage causes a disturbance in the heart functioning. This disturbance resides in the passage of the normal systoles onto disorderly, arrhythmic systoles of separate fibers of the cardiac muscle

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(fibrillation), depriving the heart of the ability to rhythmically pump blood into vessels, andleading to the blood circulation stoppage in the organism. The electric current exerts local impact by injuring the tissues and the reflex system. Besides, the current influences directly the muscle tissue causing convulsions [3,4].

Depending on the reaction of the organism to the current, some threshold quantities of the current flowing through a person's body are distinguished [5]:

- a threshold of sensation – the minimum quantities of current felt by the person;
- a threshold of releasing current – the maximum quantities of current at which the person is still able to get free from the voltage on his own by using the muscles through which the current flows. The quantity of the current lower than that threshold is called a releasing current, while the quantity of the current higher than that threshold - a non-releasing current;
- a threshold of deadly current – the person, through whose body a non-releasing current flows, is absolutely helpless and cannot get free from the voltage by himself, the current impact will be long. At this, the electric resistance of a man's body decreases, the current increases, and if there is no help, the mortal result will be unavoidable.

It is obvious that the releasing current is not dangerous as a person can get free quickly enough by himself. Only under some special conditions, at creating safety, we have to take into account not the releasing current threshold, but the sensation. Thus for instance, when a person is working at a height, the current equal or a little higher than the sensation threshold inducing abrupt involuntary movements can lead to a balance loss and a fall from the height. In this case, a long admissible current should be a little lower than the sensation threshold.

Thus, under normal conditions, we can assume the quantity of the releasing current admissible, and take the releasing current threshold as a maximally long admissible current.

To obtain the quantity of a long admissible current, it is necessary to determine the releasing current threshold, and for that, it is required to determine the corresponding electric resistance of a person's body.

ELECTRIC RESISTANCE OF A PERSON'S BODY

A person's body is a conductor of electric current. However, the conduction of a living tissue, unlike the common conductors, is conditioned by not only its physical properties but also most complex chemical and biophysical characteristics peculiar only to a living tissue. As a result, the person's body resistance is a variable quantity depending nonlinearly on numerous factors including the state of the skin, the parameters of the electric current, physiological factors, and the environment.

EXPERIMENTAL INVESTIGATION

The experimental investigations on determining a person's body resistance have been carried out at the SEUA Chair of Electric Machines and Apparatuses.

Fig. 1 shows the current determining the experimental resistance of a person's body.

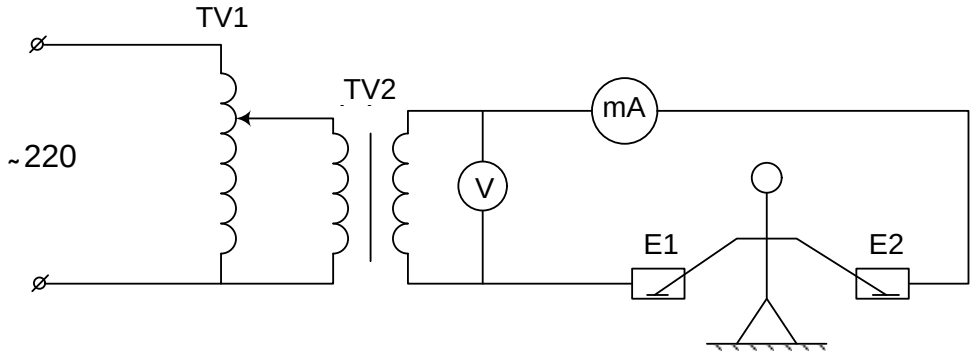

Fig. 1. The circuit determining the resistance of a person's body

With the help of an autotransformer (AT), the voltage value of the isolation transformer primary winding (IT) is regulated, while the voltage of the secondary winding of IT – through the measuring devices (voltmeter V and milliammeter мA), is given to the plane electrodes E1 and E2. According to the voltmeter indication, first a certain voltage is set, after which, a person leans on the electrodes with both hands. A current whose quantity is measured by the milliammeter flows through the person's body. The period of a person's leaning on the electrodes is not long, but it is enough to measure the current. The experiment was repeated at different values of voltage.

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The current flowing through the person's body increases up to the quantity at which the organism feels the current flow maximally, and the person takes his hands off the electrodes himself.

Several men older than 60 and younger than 35 took part in the experiment.

In the process of the person's contact to a part of an electric installation under the voltage (in this case the electrodes E1 and E2), as a rule a stable contact between the electrodes and the person's body does not arise. The average time of establishing a stable contact is 0,1 sec. At this, the resistance between the electric installation and the person's body changes and reaches the final value. As a result of the stable contact, the resistance of the person's body begins to decrease, and the current flowing through a person's body increases during that period at a certain speed depending on its initial value. The duration of the current increasing process through a person's body is not less than 0,4 sec.[4].

The final results of the experiments for adult males are introduced in Fig. 2.

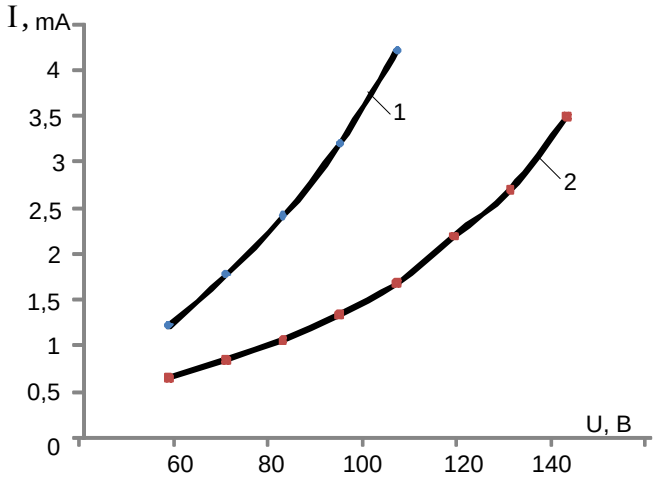

Fig. 2. Dependences of the current on the contact voltage according to the results of the experiments. 1 - for young people, 2 – for older people

As it can be seen in Fig. 2, older people endured voltage up to 120V, while the younger ones – up to 90V. Therefore, the threshold of the releasing voltage for a young person can be assumed 90V with the quantity of the current flowing through his body – 4,21 mA. The current above that value can be regarded as non-releasing at its long influence.

To set the quantity of the current flowing through the body of the testee at voltages up to 220V, the experiment results have statistically been worked out, and the probabilistic dependences of the current flowing through a person's body and the current resistances on the contact voltage are obtained:

- For older people – $I=0{,}2005e^{0{,}0238U}$
  $R= 4{,}987 * Ue^{-0{,}0238U}$
- For younger people – $I=0{,}2729e^{0{,}0307U}$
  $R= 3{,}664 * Ue^{-0{,}0307U}$

Based on the equations obtained, the corresponding diagrams of those dependences are developed (Fig. 3 and Fig. 4). As it can be seen in the figures, for an older person, the current at the voltage of 220V is 37,8mA, and for a young man – 233mA. In both cases, the quantity of the current flowing through the person's body is non-releasing, which at a long impact can bring about heart fibrillation.

In accordance with the diagrams (Fig. 3 and 4), it can be established that depending on the age and physical toughness of the person, at a contact voltage of 220V and a frequency of 50Hz, the resistance value of a young person's body is 950 Ohm, for an older person – 5800 Ohm, and the quantity of the current flowing through the body – is 232mA and 38mA respectively. It is obvious that at developing protective facilities from electric shock, it is necessary to take into account the parameters of a young person.

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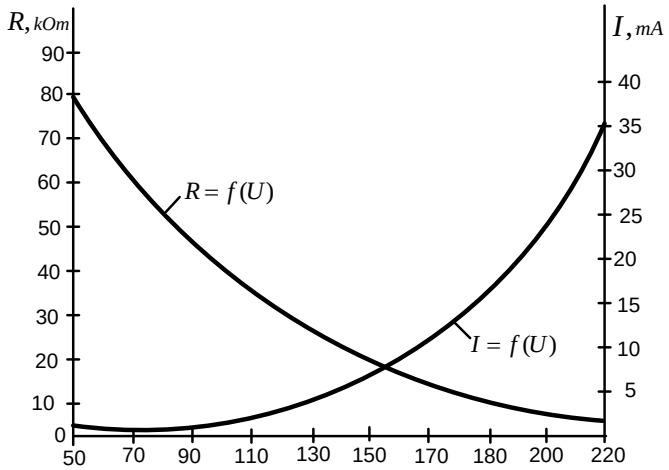

Fig. 3. Dependence of the quantity of the current flowing through an older person's body on the contact voltage

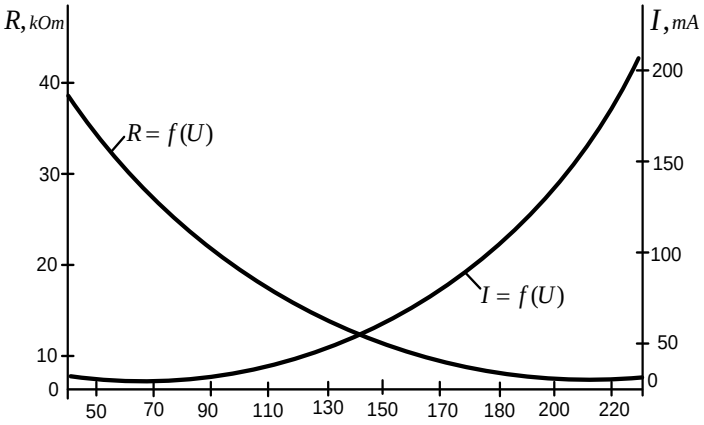

Fig. 4. Dependence of the quantity of the current flowing through a younger person's body on the contact voltage

CONCLUSION

As a result of investigations carried out, dependences of the current flowing through a person's body and the body resistance on the contact voltage are obtained. The obtained data allow to come to the following conclusions:

1. The maximum value of the current flowing through a person's body at a contact voltage of 220V and a frequency of 50Hz is 232mA, and the person's body resistance – 950 Ohm.

2. The maximum value of the releasing current flowing through a person's body for a long time can be determined as 5,0mA.

3. At developing new or improving the produced devices protecting a person from an electric shock, it is recommended that we be guided by the parameters introduced above.

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