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On Electric Charge Of Conductor With Alternative Current

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Abstract:
Sections of one conductor with alternating electric current located at a short distance, separated by electromechanical contacts, repel each other. The force of interaction is proportional to the square of the current and is quite large at high frequencies of alternating electric current. This is only possible if the conductor has a surface electric charge.
Key Words*: Alternative current, Charge, Frequency, Weight of conductor, Metal electrodes, Electric field*

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I. Introduction

Whether a conductor carrying an electric current is charged or not is a problem that has not yet been fully resolved. Theoretical physics states that the electrical charge of a conductor is so small that it can be ignored [1].This follows from Gauss's theorem, which is generally valid for charges at rest and the expression for the Lorentz force, which almost completely compensates for the electric field strength created by current carriers and stationary positive charges [2].In fact, the electric field created by current carriers differs from the electric field created by electrons at rest. At small distances, which occurs near the surface of a current-carrying conductor, the electric field created by moving charges can be very strong and sufficient to create a large surface density of electric charge.

The problem has not been completely solved experimentally. Some experimental results and demonstrations have been obtained at very high voltages [3,4]. Other results only confirm the weakness of the external electric field created by a conductor with a constant electric current [5]. Moreover, theoretical and experimental data on the electric charge of a conductor carrying alternating current are almost completely absent. This is somewhat reminiscent of a point charge whose intensity decreases very quickly with distance, but which can be repelled by other similar charges.

II. Weight Of Unclosed Conductor With Electric Current

If the electromechanical V-shaped contacts *K* and the Π-shaped metal electrode *E* (Fig. 1) with current are charged, the weight of the electrode should change when the current is turned on.

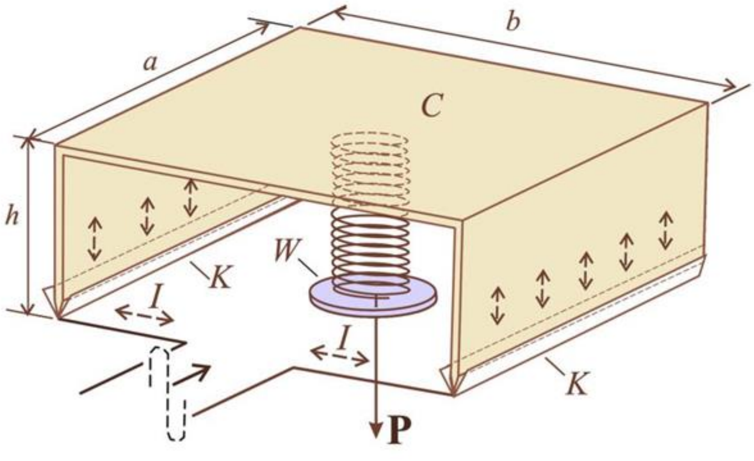

Fig.1. Weighing Π-shaped electrode with alternative electric current

A spring between the electrode *C* and the scales *W* is necessary to ensure reliable electrical contact of the Π-shaped electrode with the V-shaped copper electrodes *K* of the resting base of the experimental setup. Electrode dimensions: *a*=3 cm and *b*=6 cm. Measurements should be carried out at different heights *h*, but first you need to make sure that the weight of the electrode *C* changes and the alternating current of strength *I* is turned on. In order for the measurements to be the most accurate, measurements should be carried out in a periodic mode every 10 minutes including an alternating current for a short time, say 2 minutes. This allows not only to reduce the methodological error, but also to estimate the measurement error of average weight changes for each value of the frequency *f* of alternating electric current and for each value of the distance.

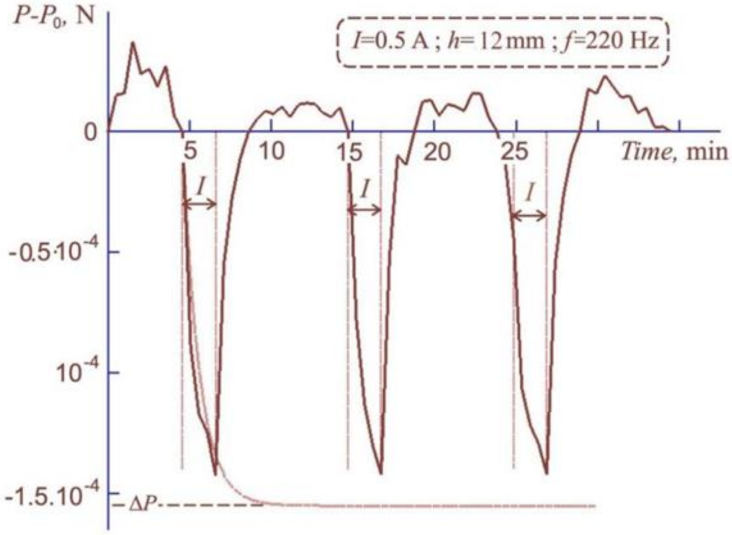

Fig. 2. Change in conductor weight when electric current is periodically switched on

Even with a relatively weak electric current, the decrease in the weight of the Π-shaped conductor turned out to be large and reaches 10^{-4} N. If this is the result of the interaction between charges created by an alternating electric current, then an increase in current strength by 10 times will lead to a change in weight by 100 times. The dependence of weight change on current strength is quadratic. This fully corresponds to an alternating electric current, as a result of the influence of which on the metal the surface charge density periodically changes in magnitude and sign.

It is not yet clear what and where creates such a large change in weight. Inside the V-shaped contacts, the electric field strength is extremely high. The role of other contact phenomena, such as contact potential difference and thermoelectricity, cannot be excluded, although all the details of the installation shown in Fig. 1, made of the same material.

There is another phenomenon that behaves electrodynamically in approximately the same way. This is the so-called self-action in which the electric current flowing in an open conductor acts on itself, creating a self-action force [6]. This force is also proportional to the square of the current in an unclosed conductor. As the size of the conductor increases, it increases. However, with a current of tens of amperes, it does not exceed 10^{-6} N [7].This means that the effect of conductor size and frequency of alternating electrical current in the conductor must be studied in detail. Without this, statements about the charge of a conductor with alternating electric current may seem dubious.

III. Size, Frequency And Charge Of Conductor

An electric field, which means the surface charge of a metal or dielectric, can be created by a time-varying magnetic field created by a current flowing in a conductor. The strength of such an electric field, called a vortex field, is proportional to the frequency. However, shown in Fig. 3 frequency dependences of weight changes exclude the contribution of the vortex electric field arising in the V-shaped contacts.

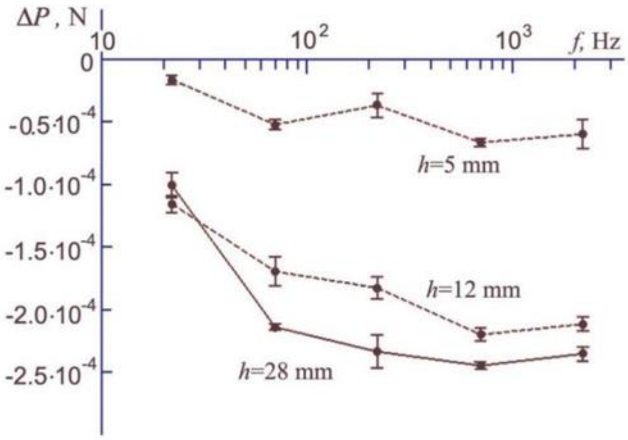

Fig. 3. Frequency dependences of weight changes at different heights of a Π-shaped conductor with alternative electric current

At the same time, an increase in height h is not accompanied by either a weak constancy of the dependence of ΔP on h, or a decrease in the repulsion force of the Π-shaped conductor from the V-shaped electromechanical contacts (Fig. 3). This means that a surface electric charge is created on the side ribs of the Π-shaped conductor. It follows that the change in weight when an electric current is turned on does not occur inside the electromechanical contacts, but a strong electric field inside them can create charges on the surface of the conductor.

Fig. 4 demonstrates the change in conductor weight that occurs at relatively low frequencies. It should be noted that a relatively slow change in the weight of the conductor when an alternating electric current is turned on occurs at all frequencies during the same time interval. This seems to be due to the slow response of the scales used in the measurements. This has nothing to do with the process of charge accumulation on the surface of the conductor.

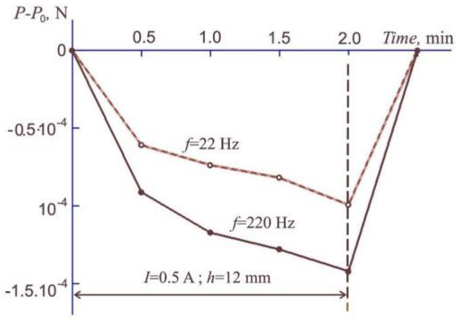

Fig. 4. Signal shape at low frequencies of electric current

IV. Conclusion

It is not the fields that interact, but what creates them. In electrodynamics, interaction forces are created either by currents or charges. Having considered conceivable or inconceivable processes in which two or more parts of a closed electrical circuit repel each other, we have to conclude that a conductor with alternating electric current contains a surface electric charge that varies with time. It was not possible to find any other explanation for this phenomenon.

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