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MEASUREMENT OF CURRENT CONDUCTIVITY EXCITED BY POLARIZED CURRENT

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At the beginning of the study of electromagnetism, M. Faraday wrote prophetically about the "**instantaneous current**" **propagating in a solitary conductor at the moment of connecting the conductor end to the battery pole** [1]. At this moment, obviously, free charges are shifted and atoms are polarized in the conductor. According to the modern view, the total current density in the conductor is:

$$j = j_c + d\mathbf{P}/dt + c \cdot \mathrm{rot}\,\mathbf{M}, \qquad (1)$$

where: j_c - free charge current density,
P - polarization,
M - magnetic moment of the conductor substance (for a unit of volume), c - speed of light.

Consequently, the last two terms are the current density j_{bc} of the bound charges [2].
Since $\mathbf{M} = \chi \cdot \mathbf{H}$, and $\chi = \mu - 1$ (if μ is the magnetic permeability), then, according to the equality $\mu = 1$ for ordinary conductors, j_{bc} is determined by the second term (1).

From the equality:

$$\mathbf{P} = (1/4\pi)\cdot\mathbf{D} - (1/4\pi)\cdot\mathbf{E},$$

where **D** is induction, it follows:

$$j_{bc} = (1/4\pi)\cdot\partial\mathbf{D}/\partial t - (1/4\pi)\cdot\partial\mathbf{E}/\partial t = (1/4\pi)\cdot(\varepsilon - 1)\cdot\partial\mathbf{E}/\partial t \qquad (2)$$

Here the second term is the displacement current in vacuum, the first term is the polarization current in the substance.
The existence of current j_{bc} in the metal is undoubted; then for $j_{bc} > 0$, according to [2], it must be $\varepsilon > 1$, which contradicts the generally accepted ideas for today.

However, the contradiction can be "bypassed", assuming that at **$\varepsilon = 1$** the current of the bounded charges coexists with the oppositely directed displacement current, so that there is no detectable magnetic field outside.

The current j_{bc} is always neglected, assuming $\partial P / \partial t \to 0$, that is, assuming the condition is satisfied:

$$\sigma\cdot E = j_c >> \varepsilon\cdot\partial E/\partial t - \varepsilon\cdot\omega\cdot E = j_p, \qquad (3)$$

where σ is conductivity [2].

According to (2):

$$j_{bc} = j_p - j_{disp}.$$

That is, the current density of bound charges is the difference between the polarization current densities in the substance and the displacement current in a vacuum. For $\varepsilon > 1$, $j_p > j_{disp}$.
The condition (3) is always satisfied for "good", according to (2), metals, because they have $\sigma \sim 10^{17}$, and $\varepsilon = 1$ conventionally.
Neither direct nor indirect measurements of the polarization currents in metals have ever been carried out by anyone before our work.

From (3) it follows:

$$j_c/j_p \sim \sigma/(\omega\cdot\varepsilon). \quad (4)$$

That is, the detection of $j_p > 0$ can indicate the presence in the metal $\varepsilon > 1$, and the measurement of j_p - can open the possibility of estimating the level of **effective dielectric permittivity of metals**, because from (4) it follows

$$\varepsilon \approx (\sigma\cdot j_p)/(\omega\cdot j_c) = (\sigma\cdot J_p)/(\omega\cdot J_c)$$

or from (3), assuming S is the sectional area of the conductor, it follows:

$$\varepsilon = (J_p/S)/(\omega\cdot E) = (J_p\cdot l)/(\omega\cdot S\cdot U),$$

where: U – potential difference across the generator winding,
l - length of the winding,
J_p - measured polarization current, more precisely: $j_{bc} = j_p - j_c$.

Despite the generally accepted $\varepsilon = 1$ for metals, so is the acceptable for them $\varepsilon = \infty$, which was proved in the last century. Boris Borisovich Golitsyn wrote this in detail in 1892, discussing the findings of E. Kon [3].

According to Golitsyn, in metals $\mathbf{1 \ll \varepsilon \ll \infty}$, that is, the value is uncertain. Pavel Alexandrovich Florensky returned to the question of **s** level in metals 30 years later. His research is comprehensively reasoned and leads to the conclusion that in metals $\mathbf{1 < \varepsilon < \infty}$ [4]. Here we should mention the modern method of calculating the effective permittivity of **ε**, the so-called **matrix systems**. For example, a dielectric with a value of $\mathbf{\varepsilon = 1 \div 5}$ contains, as a matrix, conducting spheres of very small diameter. The calculation takes their value as $\varepsilon \to \infty$; and the results of the calculation **ε** are in good agreement with the measured data [5].

It follows that the criterion for the legitimacy of neglect in accordance with (3) is too "optimistic," for it may turn out that $\varepsilon > 1$ and then the neglect of J_p is often illegal. **Measuring J_{disp} can clarify the age-old dispute about the nature of the dielectric permittivity of metals and, in addition, justify the possibility of energy transfer through a solitary conductor, without a galvanically closed current circuit.** Nikola Tesla demonstrated this on February 1, 1892 in London, but the description of the method of such transfer used by him has not survived [6].

Measurement

Figure 1 shows the five circuits used. All of them, in essence, are modifications of circuit 1 – "Avramenko's fork". It was proposed by S. V. Avramenko in 1978 (Application for invention ? 2610996/21, 10.01.1978).

All circuits are made using D208 diodes, conductors are made of copper, the conduction current in this closed circuit was measured with an M265M microammeter, cl. 1.5 (GOST 8711-60), “100-0-100”, μA, the internal resistance of the device is 600 Ohm. AC voltage source is a sound generator G3-56/1. As can be seen from scheme 1, the middle point between two diodes connected in series (“input”) is connected by one wire (copper, diameter 0.5 mm along the core, ~ 20 cm long) to one potential output terminal of the generator.

The voltage at the output of the generator U was measured by the generator voltmeter. The measurement method is based on the idea of the presence of a propagating “front” of atomic polarization (***“instantaneous current”*** according to Faraday) along a solitary conductor (connected at its one end to an alternating voltage generator terminal; to a ***“battery pole”*** according to M. Faraday). This “instantaneous current” creates a gas pressure of free charges (electrons) in a closed circuit, and the diodes act as valves, providing unidirectional circulation, – the charge current in this circuit.

Polarization of atoms takes place throughout the circuit, without being significantly lost on diodes or other elements of the circuit (resistors, capacitances, inductances). Therefore, it can be done "input" anywhere in the circuit 1, only the current in the circuit will be halved, compared to the "correct" input.

Figure 2 shows the results of measuring the current in a closed circuit of diodes - “fork” at a voltage of U = 50 V and frequencies from 2 to 100 kHz. Two linear sections are clearly visible; the change in the slope of the lines is apparently caused by the peculiarities of the diodes used. It is also visible that the use of a twin “fork” practically did not change either the type of dependence or the absolute values of the current. The same is noted when using the triple and quadruple "fork". If the circuit is assembled on high-voltage rectifier poles KTS106G (20 kV), then, although the type of dependence has hardly changed, but the absolute values of the current have decreased by 20%. This is due to the noticeable resistance of these high voltage poles in the forward direction.

It is clearly seen that the dual circuit 2 (compared with scheme 1) ensures the invariance of the result. At 20 kHz, the resistance of 10 kOhm between the input and the generator did not change the current: without resistance (at 20 kHz and 50 V) it was 20 μA, Fig. 2, **the same value** with a 10 kΩ resistor (Fig. 3).

The results of measurements according to the circuit 5 are informative. It has one "input" from the generator to circuit 2. The circuit 1 is connected by its input to the circuit 2 at an arbitrary point, and the circuit 4 input is connected to it, also at an arbitrary point. Of course, it would be possible to attach one more “fork” to “4”, and one more “fork” to it. This is not done for the sake of visibility of the results on this three-stage cascade. Note the features of the cascade. The first feature: shorting the load (device) on any circuit does not noticeably change the instrument readings on the other circuits. The second feature: changing schemes in places also has no effect on the measurement results.

Dependence of currents J_1, J_2, J_3, respectively, in the sequence of circuits 2, 1, 4 - in Fig. 4 - from the generator voltage at 20 kHz; Fig. 5 at 10 kHz; Fig. 6 - from the frequency at 50 V. For all of these dependencies are characterized by reduction of amperage as the circuit is removed from the potential wire, as power is removed by the loads (instruments). The increase in the absolute current intensity in the first circuit (“main circuit”), when it is in a cascade, as compared to the current, when this circuit is connected alone, is also noticeable. It is especially visible in Fig.6, which shows the frequency dependence of the current at 50 V. Attempts were repeatedly made to measure the current in a potential wire before entering the circuit. Magnetoelectric and thermal (on transformer-rectifier unit converters) devices were used. – No current detected.

Discussion of results

The possibility of energy transfer through a solitary conductor found in measurements can be explained by the presence of a current of bound charges according to (2), by the processes of dynamic polarization of atoms in all connected conductors.

As a working hypothesis, it can be assumed that the dielectric permittivity of the conductor varies from 1 to ∞ and again from ∞ to 1 for a half-period. To interpret the dependence of **ε** on time (more precisely, - on (**ωt**), the function **ch ωt** is useful. The integral in the interval (0 ÷ π / 2) and (π / 2 ÷ π) will give the effective value of **ε** for the half period.

From the results of measurements of the polarization current, the calculated upper level of the effective value (for a period) of dynamic permeability is $\boldsymbol{\varepsilon}_g \sim 10^8$. This confirms the long-standing assumptions of Golitsyn B.B. and Florensky P.A.

The polarization nature of the current in a solitary conductor is confirmed by the fact that the "input" in circuits 1, 2, 3, 4 could be any point of the circuit (with a decrease in current by half) and the fact that the shorting of the diode in circuit 1 (or circuits 2, 3 , 4 upper or lower group of diodes) does not exclude the current in the circuit, but only reduces it fourfold, and, finally, is confirmed by the fact of the cascade operation in circuit 5.

Moreover, in this cascade, the exclusion of one of the loads does not significantly affect the current in the other two circuits. The presence of a 10 kΩ resistor in the potential line does not make significant changes in the current in circuit 2.

Consequently, the Joule losses in the potential conductor are vanishingly small. This can explain the failure of attempts to measure the current in the potential line with a thermal ammeter.

The section *"generator winding - potential line - input of circuit 1 - etc."*, through which the polarization current flows, does not obey the Kirchhoff's law at the macroscale; This "non-Kirchhoff line" and the term "circuit" (implied to be closed galvanically or through capacitance or temporarily open) is unacceptable.

In a series of previous experiments, it was found that not only the resistor, but also the capacitance and inductance do not affect the magnitude of the polarization current in the potential line. The latter indicates the smallness of the effective magnetic field, in contrast to the magnetic field created by the displacement current. (It is **s** times smaller than the field from the current $\mathbf{I}_c$, as can be seen by considering the magnetic fields of the resulting dipole from the movement of both charges and from the change in the electric field between them.)

This can explain the insensitivity of the magnetoelectric microammeter to the polarization current in the potential line.

Estimation of the polarization current should be undertaken from the view of emergence at the flat end of the conductor of the generator windings (with length 1) of surface bounded charges with density of $\boldsymbol{\sigma}_{disp}$; the area of the flat end is $a^2\pi/4$, and U is the potential difference at the ends of windings, **A** is the atomic number of the element (for winding material), A_o is the Avogadro number, ρ is the material density, **M** is the mass number, f_o is the atomic resonant frequency, analogous to optical resonance.

Under the action of electromagnetic induction in the atoms of the winding are formed dipoles with a shoulder:

$$l_g = (e \cdot U)/(4\pi \cdot m_e \cdot l) \cdot (1/f_0^2 - f^2),$$

where: f - current frequency, e - electron charge, m_e - its mass.

If N is the concentration of charges (the ends of the dipoles) is represented by the expression $\mathbf{A_o \rho / M}$, then:

$$J = \sigma_{disp} \cdot ((d^2 \cdot \pi)/4) \cdot 2f, \text{ and } \sigma_{disp} = N \cdot e \cdot A \cdot l_g,$$

That is:

$$J_{disp} = (d^2 \cdot \pi/4) \cdot 2N \cdot l \cdot A \cdot l_g = (d^2 \cdot f \cdot \rho \cdot A_o \cdot A \cdot e^2 \cdot U) / (8M \cdot \pi \cdot m_e \cdot l \cdot (f_0^2 - f^2)).$$

It follows that the strength of the polarization current should depend directly on the frequency, the diameter of the generator winding wire, the density of the wire material, the atomic number of the wire material and inversely proportional to the length of the wire winding, and the mass number of the wire material. But the main dependence is the inverse proportionality from the difference of the squares of the oscillation frequencies, - its own and external. In forecasting and achieving very significant J_{disp} at $\mathbf{f \rightarrow f_0}$, in indicating the possibility of resonance and very large $\mathbf{J_{disp}}$ - the main value of this expression (8).

Let us in conclusion estimate the contribution of the third term to (1).

From the expressions $\mathbf{M = (B - H)}/4\pi$ and rot $\mathbf{H} = (4\pi/c) \cdot \mathbf{j_c} + (1/c) \cdot (\partial \mathbf{D}/\partial t)$ we find:

$$c \cdot \text{rot } \mathbf{M} = ((\mu - 1)/4\pi) \text{-} ((4\pi/c) \cdot \mathbf{J_c} + (1/c) \cdot \partial \mathbf{D}/\partial t).$$

But according to the condition $\mathbf{j_c = 0}$ (single line) and therefore:

$$c \cdot \text{rot } \mathbf{M} = ((\mu - 1)/4\pi c) \cdot (\partial \mathbf{D}/\partial t) = ((\mu - 1)/4\pi c) \cdot \partial/\partial t \, (4\pi \mathbf{P} + \mathbf{E}).$$

Consequently, the contribution of the third member to $(\partial P/\partial t - \mu/4\pi c)$ from the value of the latter is vanishingly small, because $\boldsymbol{\mu} \ll \mathbf{c}$ always.

Findings

1. A diode with a load forms a circuit for the conduction current (the current of free metal charges) arising in this circuit when it is in metal contact with one end of a potential line connected by its other end to the beginning (end) of the AC generator winding.

2. Two series-connected diodes, closed to the load, form a current circuit of free charges, but four times larger than that of claim 1, if the potential line is connected to a circuit section from the output of one diode to the input to the other (outside the load). This is how "Avramenko's fork" is made.

3. Measurements of the conduction current in the “Avramenko's fork” circuit showed its linear dependence on the frequency (5 ÷ 100 kHz) and voltage (5 ÷ 50 V).

4. If there is a current in the load of the “Avramenko's fork” - no current is detected in the potential line by either a thermal or a magnetoelectric ammeter.

5. From (4), it should be concluded that the polarization current does not emit Joule heat and has an immeasurably (by conventional methods) small magnetic field.

6. The presence in a potential line of series-connected capacitors, resistors, inductances, has an extremely small weakening effect on the strength of the polarization current in the “fork” circuit.

7. From now on, before finding a method for directly measuring the strength of a polarization current, its intensity must be judged indirectly, by the strength of the conduction current generated by it in the “Avramenko's fork” circuit.

8. The practical significance of the polarization current can be seen in the ability to transfer electricity through a single wire, the energy of signals, and the energy of turbine generators.

9. Of particular practical interest is the realization of the resonance condition according to (8), when the polarization current can become very large.

10. The measurement results reliably confirmed the assumption of USSR scientists that the dielectric constant in metals is $\mathbf{1} \ll \boldsymbol{\varepsilon} < \infty$.

11. The dielectric permittivity in a metal with an alternating current is not a constant, but a dynamic value, similar to the ch ωt (hyperbolic cosine) curve in the half-period; in the first quarter it grows from 1 to “∞”, in the second quarter it decreases from “∞” to 1. The effective value is $\varepsilon \sim 10^8$.

12. The occurrence of a polarization current is caused by charge shift processes (dipole formation) to one and the other side, which is caused by oscillatory motion of charges, with alternating accelerations. These forced oscillations are accompanied by radiation - monochromatic and coherent. Its power is proportional to the fourth power of the frequency and the square of the induced EMF in the generator winding.

13. The frequency of 2f oscillations of the dipoles may be in the frequency range of thermal vibrations of the atoms of the conductor winding - and therefore the polarization current can exchange energy with the crystal lattice of the conductor: take the energy from it, and give the energy to it.

14. From (1) and (2) it follows that the polarization current, the current of the associated charges, in the conductor winding with $\chi \gg 1$, will be greater than in the considered case $\chi = 1$. The verification of this conclusion should be carried out with the generator winding of iron or nickel wire, despite the small contribution of the third term in the expression (1), which follows from the theory.

In conclusion, we note that the predominant direction of further research of polarization currents should be considered the search for resonant situations in combination with high voltages. It is also necessary to check the feasibility of manufacturing the generator windings from copper, nickel, iron, lead wires, etc. All this, ultimately, should ensure the use of polarization currents in order to energy savings in transmission (and now at least 30 percent of it is lost in mains) and materials in the construction of power lines.

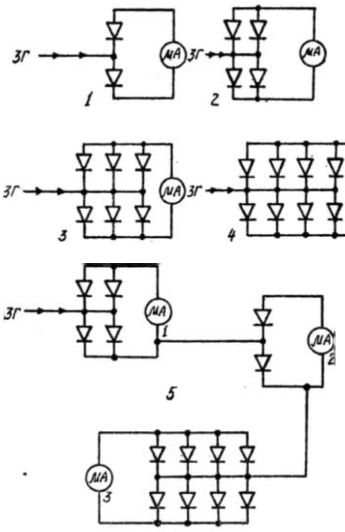

Fig. 1

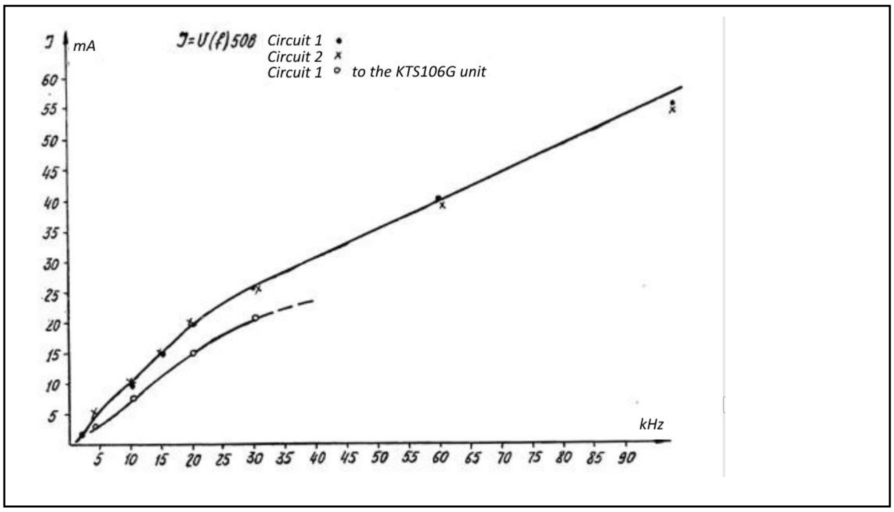

Fig. 2

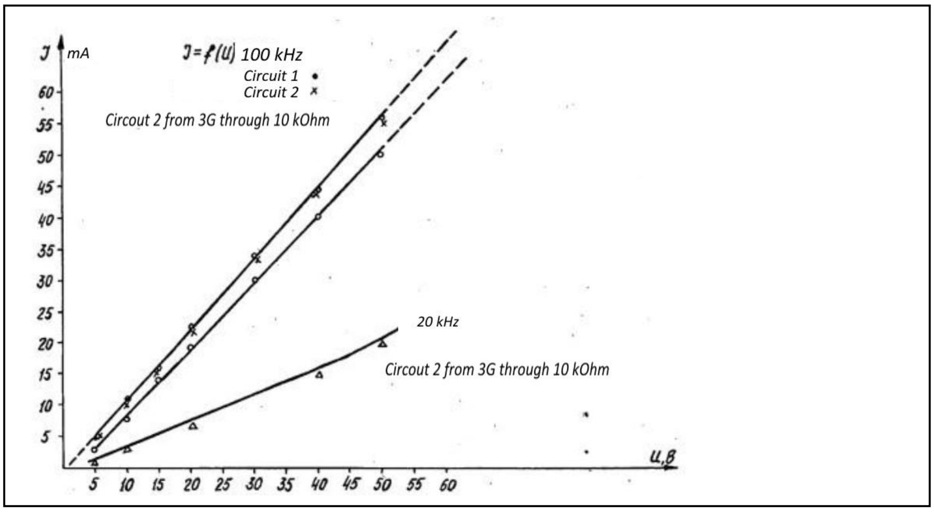

Fig. 3

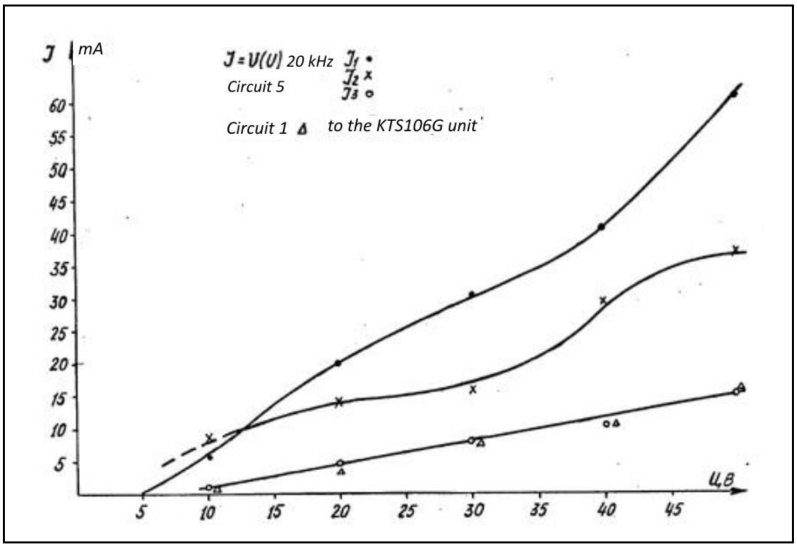

Fig. 4

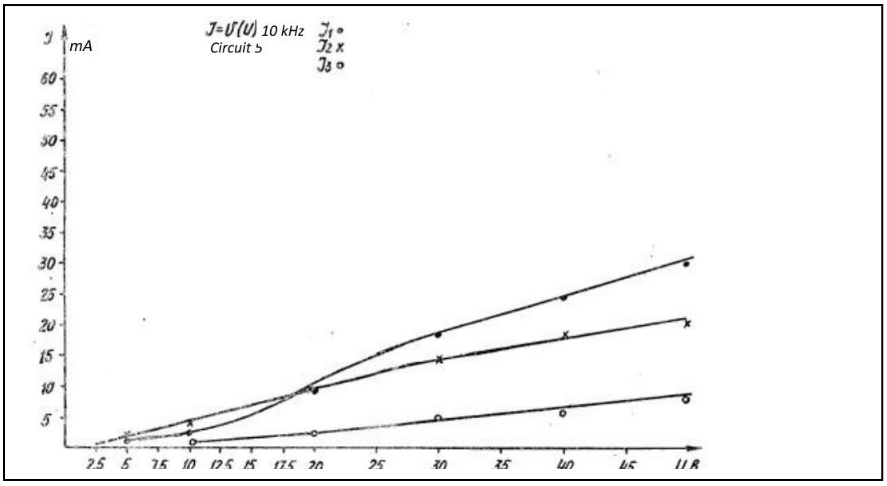

Fig. 5

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