Within the framework of the Galilean transformations are obtained conversions pour on upon transfer of one inertial to another. These conversions are obtained with the aid of the complete derived equations of induction. Is introduced the new concept of scalar- vector potential, which indicates that the scalar potential of charge depends on its relative speed. The introduction of this potential made it possible within the framework the conversions of Galileo to explain the phase aberration and the Doppler transverse effect, and also power interaction of the current carrying systems without the use of a postulate about the Lorentz force. The physical the bases of the work of unipolar generators are developed. It is shown what concept is, as the kinetic inductance of charges plays in the electrodynamics not less important role, than dielectric and magnetic constant. It is proven that the dielectric constant of plasma and dielectrics cannot depend on frequency. Provides a new way to display the wave equation. The physical causes for the Huygens principle are substantiated. The new diagnostic method of electric field thermokinetic spectroscopy is described.

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The problems of contemporary physics

Mende

Fedor Mende

The problems of contemporary physics and method of their solution

New approaches to the solution of the problems of contemporary physics

LAP LAMBERT Academic Publishing

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INTRODUCTION

All past century is marked by the most great crisis in physics, when for the change to the materialist understanding of physical processes is alien scholastic mathematics, which itself began to develop its own physical laws. The introduction was a typical example of such approaches concept the frequency dispersion of such the material parameters as the dielectric and magnetic constant of material media. These approaches have given rise to the whole direction in electrodynamics physical environments. These approaches gave birth to entire direction in the electrodynamics of material media. General with the theorists, for me it repeatedly was necessary to observe, that usually little interests physics of processes, mathematics is god for them and if with mathematics all in the order, then theory is accurate. But this approach has its underwater stones. Thus it occurred also with the dielectric constant of dielectrics when, after entangling concepts, they began to consider that this permeability depends on frequency. Even in the Great Soviet Encyclopedia it is written, that this dependence is located. But, if this was actually then, then would be possible perpetual motion machine, and this is convincingly shown in my works.

The special feature of contemporary physics is that that it is strongly politized and subordinated to the transnational clans, which took in it authority.

These negative phenomena gave birth to the personality cult of individual scientists, when they canonize, in contrast to the church, not only corpses, but also living. A typical example of this cult are Einstein and Hawking.

Still one whip of science is its bureaucratization, when to the foreground in the science leave not true scientists, but bureaucrats from the science. Are especially well visible the results of this scientific activity based on the example to the USSR. That command-administrative system, which ruled in the national economy of the country, was extended also to the science, when the director of any large scientific establishment in the required order became academician.

The science chained into the shackles of the yellow press, when on the covers of popular periodicals were depicted brilliant cripplescauses surprise. All this gave birth to the most severe crisis in the science. But this state of affairs cannot continue eternally. Now situation in physics greatly resembles that, which preceded the fall of the system of Ptolemy. But if we speak about the wreck of the old become obsolete ideas, then this cannot occur without the appearance of new progressive ideas and directions, which will arrive for the change to decrepit dogmas.

The special theory of relativity in its time arose for that reason, that in the classical electrodynamics there were no conversions pour on upon transfer of one inertial reference system (IRS) into another. This theory injected in physics known postulates and explained several important experimental data and it served its rapid acknowledgement. Way to the solution of this problem not on the basis of the postulates indicated still Maxwell and Hertz, which wrote the equations of electrodynamics in the total derivatives; however, subsequently no one attention turned to their this brilliant sagacity. Itself Hertz perished, when to him there were 36 years, and to bring its matter to the end not smog.

Relying on these ideas it is possible to receive such laws of electrodynamics , which explain the existing electrodynamic phenomena and give the possibility within the framework of the transformations Galileo to write down the rules of conversion pour on upon transfer of one [IRS] to another. It follows from such laws that the main basic law of electrodynamics, from which follow its all the remaining dynamic laws, is the dependence of the scalar potential of charge on its relative speed. And this is the radical step, which gives the possibility to obtain a number of the important systematic and practical results, which earlier in the classical electrodynamics are obtained be they could not. This approach made possible not only to create on the united basis one-piece electrodynamics, but also to explain power interaction of the current carrying systems without the use of a postulate about the Lorentz force, or to describe the phenomenon of phase aberration and the transverse Doppler effect. It also explained the phenomenon of the phase aberration and the transverse the Doppler effect, which in the classical electrodynamics did not have an explanation.

In this monograph is represented the extensive material, which is concerned the most varied sides of the use of electrodynamic laws and their interpretation, moreover today part of them they are questionable. And this is done specially in order to stimulate the attention of the readers in the not solved problems and to impel to an attempt at their solution.

I express large gratitude to the reviewers: to professor N. N. Gorobez and to professor A. A. Ruchadze for the fact that they took upon themselves the difficult labor of the review of this monograph. In their reviews are noted its positive sides, deficiencies and doubtful moments, which must impel the readers to further creative activity. Unfortunately, in the review A. A. Ruchadze from the numerous questions, examined in the monograph, estimation obtained only two, namely, the problem of the dispersion of dielectric permeability, and problem of Lorentz force. But this the most complex divisions they are examined in the review very thoroughly. By important circumstance, noted A. A. Ruchadze appears that which even Poincare and Bogolyubov could not base physical nature of Lorentz force and in their works they introduced it axiomatically. At the same time, for the author of monograph it was possible to make this. This became possible, since he wrote down the equations of induction in the total derivatives, and thus obtained the dependence of the scalar potential

of charge on its relative speed. This result proved to be especially valuable, since made possible to solve a whole series of the unresolved problems.

PART I

NEW PROCEDURES AND APPROACHES INTRODUCTION OF NEW CONCEPTS IN THE CLASSICAL ELECTRODYNAMICS

CHAPTER 1

LAWS OF INDUCTION AND THEIR ROLE IN THE CLASSICAL ELECTRODYNAMICS

§ 1. Maxwell equations and Lorentz force

The laws of classical electrodynamics they reflect experimental facts they are phenomenological. Unfortunately, contemporary classical electrodynamics is not deprived of the contradictions, which did not up to now obtain their explanation. In order to understand these contradictions, and to also understand those purposes and tasks, which are placed in this work, let us briefly describe the existing situation.

The fundamental equations of contemporary classical electrodynamics are the Maxwell equations. They are written as follows for the vacuum:

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}\ , \tag{1.1}$$

$$rot\ \vec{H} = \frac{\partial \vec{D}}{\partial t}, \tag{1.2}$$

$$div\ \vec{D} = 0, \tag{1.3}$$

$$div\ \vec{B} = 0\ , \tag{1.4}$$

where $\vec{E}$ and $\vec{H}$ - electric and magnetic force, $\vec{D} = \varepsilon_0 \vec{E}$ and $\vec{B} = \mu_0 \vec{H}$ - electrical and magnetic induction, μ_0 and ε_0 - magnetic and dielectric constant of vacuum. From these equations follow wave equations for the electrical and magnetic field

$$\nabla^2 \vec{E} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}, \tag{1.5}$$

$$\nabla^2 \vec{H} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial t^2}. \tag{1.6}$$

Ehese equations show that in the vacuum can be extended the plane electromagnetic waves, the velocity of propagation of which is equal to the speed of light

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}. \tag{1.7}$$

For the material media of the Maxwell equation they take the following form:

$$rot\ \vec{E} = -\tilde{\mu}\mu_0 \frac{\partial \vec{H}}{\partial t} = -\frac{\partial \vec{B}}{\partial t}, \tag{1.8}$$

$$rot\ \vec{H} = ne\vec{v} + \tilde{\varepsilon}\varepsilon_0 \frac{\partial \vec{E}}{\partial t} = ne\vec{v} + \frac{\partial \vec{D}}{\partial t}, \tag{1.9}$$

$$div\ \vec{D} = ne, \tag{1.10}$$

$$div\ \vec{B} = 0, \tag{1.11}$$

where $\tilde{\mu}$ and $\tilde{\varepsilon}$ - the relative magnetic and dielectric constants of the medium and n, e, $\vec{v}$ - density, value and charge rate.

The equation (1.1 - 1.11) are written in the assigned inertial measuring system (IMS), and in them there are no rules of passage of one (IMS) to another. These equations assume that the properties of charge do not depend on their speed.

The Maksvell equations are not contained indication that is the reason for power interaction of the current carrying systems; therefore to be introduced the experimental postulate about the force, which acts on the moving charge in the magnetic field.

$$\text{of } \vec{F}_L = e\left[\vec{v} \times \mu_0 \vec{H}\right]. \tag{1.12}$$

However in this axiomatics is an essential deficiency. If force acts on the moving charge, then in accordance with third Newton law must occur and reacting force. In this case the magnetic field is independent substance, comes out in the role of the mediator between the moving charges. Consequently, we do not have law of direct action, which would give immediately answer to the presented question, passing the procedure examined. I.e. we cannot give answer to the question, where are located the forces, the compensating action of magnetic field to the charge.

Relationship (1.12) from the physical point sight causes bewilderment. The forces, which act on the body in the absence of losses, must be connected either with its acceleration, if it accomplishes forward motion, or with the centrifugal forces, if body accomplishes rotary motion. Finally, static forces appear when there is the gradient of the scalar potential of potential field, in which is located the body. But in relationship (1.12) there is nothing of this. Usual rectilinear motion causes the force, which is normal to the direction motion. What some new law of nature? To this question there is no answer also.

The magnetic field is one of the important concepts of contemporary electrodynamics. Its concept consists in the fact that around any moving charge appears the magnetic field (the Amper law), whose circulation is determined by the relationship

$$\oint \vec{H} d\vec{l} = I, \tag{1.13}$$

where I - conduction current. Equation (1.9) is the consequence of relationship (1.13), if we to the conduction current add bias current. As is known, to make this Maxwell for the first time proposed.

Let us especially note that the introduction of the concept of magnetic field does not be founded upon any physical basis, but it is the statement of the collection of some experimental facts. Using this concept, it is possible with the aid of the specific mathematical procedures to obtain correct answer with the solution of practical problems. But, unfortunately, there is a number of the physical questions, during solution of which within the framework the concepts of magnetic field, are obtained paradoxical results. Here one of them.

Using relationships (1.12) and (1.13) not difficult to show that with the unidirectional parallel motion of two like charges, or flows of charges, between them must appear the additional attraction. However, if we pass into the inertial system, which moves together with the charges, then there magnetic field is absent, and there is no additional attraction. This paradox does not have an explanation.

Of force with power interaction of material structures, along which flows the current, are applied not only to the moving charges, but to the lattice, but in the concept of magnetic field to this question there is no answer also, since. in equations (1.1-1.13) the presence of lattice is not considered. At the same time, when current flows through the plasma, occurs its compression. This phenomenon is called pinch effect. In this case forces of compression act not only on the moving electrons, but also on the positively charged ions. And, again, the concept of magnetic field cannot explain this fact, since in this concept there are no forces, which can act on the ions of plasma.

As the fundamental law of induction in the electrodynamics is considered the Faraday law, consequence of whom is the first equation of Maksvell. However, here are problems. It is considered Until now that the unipolar generator is an exception to the rule of flow.

Let us give one additional statement of the work [1]: “The observations of Faraday led to the discovery of new law about the connection of electrical and magnetic pour on: in the field, where magnetic field changes in the course of time, is generated electric field”. But from this law also there is an exception. Actually, the magnetic fields be absent out of the long solenoid; however, electric fields are generated with a change of the current in this solenoid around the solenoid. Is explained this fact thereby that around the long solenoid there is a circulation of vector potential [1]. When the flow of the magnetic induction of solenoid changes, then a circulation control of vector potential appears. With this interpretation of this phenomenon these changes lead to the appearance of electrical pour on out of the solenoid. In the work [1] even it is indicated that into 1956 g of. Bohm and Aron experimentally detected this potential. But the point of view about existence of vector potential out of the long solenoid, where magnetic fields be absent, also runs into a number of the fundamental difficulties, which we will discuss with the examination of the law of the induction of Faraday.

In the classical electrodynamics does not find its explanation this well known physical phenomenon, as phase aberration of light.

From entire aforesaid it is possible to conclude that in the classical electrodynamics there is number of the problems, which still await their solution. But, before passing to the solution of these problems and outlining the methods of their solution, let us trace that way, which is past the classical electrodynamics from the day of its base to the present.

§ 2. Laws of the magnetoelectric induction

The primary task of induction is the presence of laws governing the appearance of electrical pour on, since. only electric fields exert power influences on the charge. Such fields can be obtained, changing the arrangement of other charges around this point of space or accelerating these charges. If around the point in question is some static configuration of charges, then the tension of electric field will be at the particular point determined by the relationship $\vec{E} = -grad\ \varphi$, where φ the scalar potential at the assigned point, determined by the assigned configuration of charges. If we change the arrangement of charges, then this new configuration will correspond other values of scalar potential, and, therefore, also other values of the tension of electric field. Acceleration or retarding of charges also can lead to the appearance in the surrounding space of induction electrical pour on.

Farrday law is written as follows:

$$\oint \vec{E}\, d\vec{l} = -\frac{\partial \Phi_B}{\partial t} = -\mu \int \frac{\partial \vec{H}}{\partial t}\, d\vec{s} = -\int \frac{\partial \vec{B}}{\partial t}\, d\vec{s}\,, \qquad (1.2)$$

where $\vec{B} = \mu \vec{H}$ - magnetic induction vector, $\Phi_B = \mu \int \vec{H}\, d\vec{s}$ - flow of magnetic induction, and $\mu = \tilde{\mu}\mu_0$ - magnetic permeability of medium. It follows from this law that the circulation integral of the vector of electric field is equal to a change in the flow of magnetic induction through the area, which this outline covers. From relationship (2.1) obtain the first equation of Maxwell

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}. \tag{2.2}$$

Let us immediately point out to the terminological error. The Farrday law should be called not the law of electromagnetic, as is customary in the existing literature, but by the law of magnetoelectric induction, since. a change in the magnetic pour on it leads to the appearance of electrical pour on, but not vice versa.

Let us introduce the vector potential of the magnetic field $\vec{A}_H$, which satisfies the equality

$$\mu \oint \vec{A}_H\, d\vec{l} = \Phi_B ,$$

where the outline of the integration coincides with the outline of integration in relationship (2.1), and the vector of is determined in all sections of this outline, then then $\vec{A}_H$

$$\vec{E} = -\mu \frac{\partial \vec{A}_H}{\partial t}. \tag{2.3}$$

Between the vector potential and the electric field there is a local connection. Vector potential is connected with the magnetic field with the following relationship:

$$rot\ \vec{A}_H = \vec{H}. \tag{2.4}$$

During the motion in the three-dimensional changing field of vector potential the electric fields find, using total derivative

$$\vec{E}' = -\mu \frac{d\vec{A}_H}{dt}. \tag{2.5}$$

prime near the vector $\vec{E}$ means that we determine this field in the moving coordinate system. This means that the vector potential has not only local, but also convection derivative. In this case relationship (2.5) can be rewritten as follows:

$$\vec{E}' = -\mu \frac{\partial \vec{A}_H}{\partial t} - \mu\left(\vec{v}\nabla\right)\vec{A}_H,$$

where $\vec{v}$ - speed of system. If vector potential on time does not depend, the force acts on the charge.

$$\vec{F}'_{v,1} = -\mu e\left(\vec{v}\nabla\right)\vec{A}_H \ .$$

This force depends only on the gradients of vector potential and charge rate.

The charge, which moves in the field of the vector potential of with the speed of , possesses potential energy [1] $\vec{A}_H$

$$W = -e\mu\left(\vec{v}\vec{A}_H\right).$$

Therefore must exist one additional force, which acts on the charge in the moving coordinate system, namely:

$$\vec{F}'_{v,2} = -grad\ W = e\mu\ grad\left(\vec{v}\vec{A}_H\right).$$

Thus, the value $e\mu\left(v\vec{A}_H\right)$ plays the same role, as the scalar potential φ, whose gradient also gives force. Consequently, the composite force, which acts on the charge, which moves in the field of vector potential, can have three components and will be written down as

$$\vec{F}' = -e\mu\frac{\partial\vec{A}_H}{\partial t} - e\mu\left(\vec{v}\nabla\right)\vec{A}_H + e\mu\ grad\left(\vec{v}\vec{A}_H\right). \qquad (2.6)$$

The first of the components of this force acts on the fixed charge, when vector potential changes in the time and has local time derivative. Second component is connected with the motion of charge in the three-dimensional changing field of this potential. Entirely different nature in force, which is determined by last term of relationship (2.6). It is connected with the fact that the charge, which moves in the field of vector potential, it possesses potential energy, whose gradient gives force. From relationship (2.6) follows

$$\vec{E}' = -\mu\frac{\partial\vec{A}_H}{\partial t} - \mu\left(\vec{v}\nabla\right)\vec{A}_H + \mu\ grad\left(\vec{v}\vec{A}_H\right). \qquad (2.7)$$

This is a complete law of mutual induction. It defines all electric fields, which can appear at the assigned point of space, this point can be both the fixed and that moving. This united law includes and Farrday law and that part of the Lorentz force, which is connected with the motion of charge in the magnetic field, and without any exceptions gives answer to all questions, which are concerned mutual magnetoelectric induction. It is significant, that, if we take rotor from both parts of equality (2.7), attempting to obtain the first equation of Maxwell, then it will be immediately lost the essential part of the information, since. rotor from the gradient is identically equal to zero.

If we isolate those forces, which are connected with the motion of charge in the three-dimensional changing field of vector potential, and to consider that

$$\mu\ grad\left(\vec{v}\vec{A}_H\right)-\mu\left(\vec{v}\nabla\right)\vec{A}_H=\mu\left[\vec{v}\times rot\ \vec{A}_H\right],$$

that from (2.6) we will obtain

$$\vec{F}_v'=e\mu\left[\vec{v}\times rot\ \vec{A}_H\right], \tag{2.8}$$

and, taking into account (2.4), let us write down

$$\vec{F}_v'=e\mu\left[\vec{v}\times\vec{H}\right], \tag{2.9}$$

or

$$\vec{E}_v'=\mu\left[\vec{v}\times\vec{H}\right], \tag{2.10}$$

and it is final

$$\vec{F}'=e\vec{E}+e\vec{E}_v'=-e\frac{\partial\vec{A}_H}{\partial t}+e\mu\left[\vec{v}\times\vec{H}\right]. \tag{2.11}$$

Can seem that relationship (2.11) presents Lorentz force; however, this not thus. In this relationship, in contrast to the Lorentz force both the field of

$\vec{E}$ and the field $\vec{E}'_v$ appear to obtain the total force, which acts on the charge, it is necessary to the right side of relationship (2.11) to add the term $-e\ grad\ \varphi$

$$\vec{F}'_{\Sigma} = -e\ grad\ \varphi + e\vec{E} + e\mu\left[\vec{v}\times\vec{H}\right],$$

where φ - scalar potential at the observation point. In this case relationship (2.5) can be rewritten as follows:

$$\vec{E}' = -\mu\frac{\partial\vec{A}_H}{\partial t} - \mu\left(\vec{v}\nabla\right)\vec{A}_H + \mu\ grad\left(\vec{v}\vec{A}_H\right) - grad\ \varphi \quad (2.12)$$

or

$$\vec{E}' = -\mu\frac{d\vec{A}_H}{dt} + grad\left(\mu\left(\vec{v}\vec{A}\right) - \varphi\right). \quad (2.13)$$

If both parts of relationship (2.12) are multiplied by the magnitude of the charge, then will come out the total force, which acts on the charge. From Lorentz force it will differ in terms of the force $-e\mu\frac{\partial\vec{A}_H}{\partial t}$. From relationship (2.13) it is evident that the value $\mu\left(\vec{v}\vec{A}\right) - \varphi$ plays the role of the generalized scalar potential. After taking rotor from both parts of relationship (2.13) and taking into account that $rot\ grad = 0$, we will obtain

$$rot\ E' = -\mu\frac{d\vec{H}}{dt}\ .$$

If we in this relationship replace total derivative by the quotient, then we will obtain the first equation of Maxwell.

This examination maximally explained the physical picture of mutual induction. We specially looked to this question from another point of view, in order to permit those contradictory judgments, which occur in the fundamental works according to the theory of electricity.

Previously Lorentz force was considered as the fundamental experimental postulate, not connected with the law of induction. By calculation to obtain last term of the right side of relationship (2.11) was only within the framework the special theory of relativity (STR), after introducing two postulates of this theory. In this case all terms of relationship (2.11) are obtained from the law of induction, using the conversions of Galileo. Moreover relationship (2.11) this is a complete law of mutual induction, if it are written down in the terms of vector potential. And this is the very thing rule, which gives possibility, knowing fields in one IMS, to calculate fields in another.

The structure of the forces, which act on the moving charge, is easy to understand based on the example of the case, when the charge moves between two parallel planes, along which flows the current (Fig. 1) Let us select for the coordinate axis in such a way that the axis of would be directed normal to planes, and the axis of was parallel of the planes.

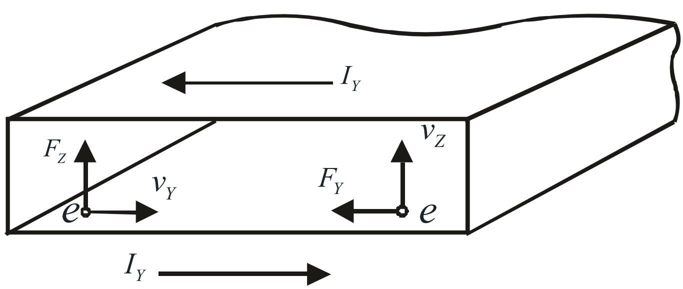

Fig. 1. Forces, which act on the charge, which moves in the field of vector potential.

Then the magnetic field H_x between them will be equal to the specific current I_y, which flows along the plates. If ghbyznm, that the vector potential on the lower plate is equal to zero, then its y - the component, calculated off the lower plate, will grow according to the law

$$A_y = I_y z\,.$$

If charge moves in the direction of the axis of y near the lower plate with the speed v_y, then the force F_z, which acts on the charge, is determined by last term of relationship (2.6) and it is equal

$$F_z = e\mu v_y I_y\,. \tag{2.14}$$

Is directed this force from the lower plate toward the upper.

If charge moves along the axis z from the lower plate to the upper with the speed $v_z = v_y$, then for finding the force should be used already second term of the right side of relationship (2.6). This force in the absolute value is again equal to the force, determined by relationship (2.14), and is directed to the side opposite to axis y. With any other directions of motion the composite force will be the vector sum of two forces, been last terms of relationship (2.6). However, the summary amount of this force will be determined by relationship (2.11), and this force will be always normal to the direction of the motion of charge. Earlier was considered the presence of this force as the action of the Lorentz force, whose nature was obscure, and it was introduced as experimental postulate. It is now understandable that it is the consequence of the combined action of two forces, different in their nature, whose physical sense is now clear.

Understanding the structure of forces gives to us the possibility to look to the already known phenomena from other side. With which is connected existence of the forces, which do extend loop with the current? In this case this circumstance can be interpreted not as the action of Lorentz force, but from an energy point of view. The current, which flows through the element of annular turn is located in the field of the vector potential, created by the remaining elements of this turn, and, therefore, it has it stored up potential energy. The force, which acts on this element, is caused by the presence of the potential gradient energy of this element and is proportional to the gradient to the scalar product of the current strength to the vector potential at the particular point. Thus, it is possible to explain the origin of ponderomotive (mechanical) forces. If current broken into the separate current threads, then they all will separately create the field of vector potential. Summary field will act on each thread individually, and, in accordance with last term of the right side of relationship (2.6), this will lead to the mutual attraction. Both in the first and in the second case in accordance with the general principles system is approached the minimum of potential energy.

One should emphasize that in relationship (2.8) and (2.9) all fields have induction origin, and they they are connected first with hp of the local derivative of vector potential, then hp by the motion of charge in the three-dimensional changing field of this potential. If fields in the time do not change, then in the right side of relationships (2.8) and (2.9) remain only last terms, and they explain the work of all existing electric generators with moving mechanical parts, including the work of unipolar generator. Relationship (2.7) gives the possibility to physically explain all composing tensions electric fields, which appears in the fixed and that moving the coordinate systems. In the case of unipolar generator in the formation of the force, which acts on the charge, two last addend right sides of equality (2.7) participate, introducing identical contributions.

With conducting of experiments Faraday established that in the outline is induced the current, when in the adjacent outline direct current is switched on or is turned off or adjacent outline with the direct current moves relative to the first outline. Therefore in general form the Faraday law is written as follows:

$$\oint \vec{E}' d\vec{l}' = -\frac{d\Phi_B}{dt} . \tag{2.15}$$

This writing of law indicates that with the determination of the circulation $\vec{E}$ in the moving coordinate system, near $\vec{E}$ and $d\vec{l}$ must stand primes and should be taken total derivative. But if circulation is determined in the fixed coordinate system, then primes near $\vec{E}$ and $d\vec{l}$ be absent, but in this case to the right in expression (2.15) must stand particular time derivative. Usually in the existing literature during the record the law of magnetoelectric induction in this fact attention they do not accentuate.

complete time derivative in relationship (2.15) indicates the independence of the eventual result of appearance of the electromotive force (EMF). in the outline from the method of changing the flow. Flow can change both due to the change $\vec{B}$with time and because the system, in which is measured the circulation $\oint \vec{E}' d\vec{l}'$, it moves in the three-dimensional changing field of $\vec{B}$. The value of magnetic flux in relationship (2.15) is determined from the relationship

$$\Phi_B = \int \vec{B}\, d\vec{s}' \tag{2.16}$$

where the magnetic induction $\vec{B} = \mu\vec{H}$ is determined in the fixed coordinate system, and the element $d\vec{s}'$ is determined in the moving system.

Taking into account relationship (2.15), from relationship (2.16) we obtain

$$\oint \vec{E}' d\vec{l}' = -\frac{d}{dt}\int \vec{B}\, d\vec{s}' .$$

and further, since $\frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v}\ grad$, let us write down

$$\oint \vec{E}' d\vec{l}' = -\int \frac{\partial \vec{B}}{\partial t}\, d\vec{s}' - \int \left[\vec{B} \times \vec{v} \right] d\vec{l}' - \int \vec{v}\ div\vec{B}\ d\vec{s}' . \quad (2.17)$$

In this case contour integral is taken on the outline $d\vec{l}'$, which covers the area $d\vec{s}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the conversions of Galileo, i.e., $d\vec{l}' = dl$ and $d\vec{s}' = d\vec{s}$. From (2.17) follows the well known result

$$\vec{E}' = \vec{E} + \left[\vec{v} \times \vec{B} \right], \quad (2.18)$$

from which follows that during the motion in the magnetic field the additional electric field, determined by last term of relationship appears (2.18). Let us note that this relationship is obtained not by the introduction of postulate about the Lorentz force, or from the conversions of Lorenz, but directly from the Faraday law, moreover within the framework the conversions of Galileo. Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

The relationship follows from the Ampere law

$$\vec{H} = rot\ \vec{A}_H .$$

Then relationship (2.17) can be rewritten

$$\vec{E}' = -\mu \frac{\partial A_H}{\partial t} + \mu \left[\vec{v} \times rot\ \vec{A} \right],$$

and further

$$\vec{E}' = -\mu \frac{\partial \vec{A}_H}{\partial t} - \mu \left(\vec{v} \nabla \right) \vec{A}_H + \mu\ grad \left(\vec{v} \vec{A}_H \right). \quad (2.19)$$

Again came out relationship (2.7), but it is obtained directly from the Faraday law. True, and this way thus far not shedding light on physical nature of the origin of Lorentz force, since the true physical causes for appearance and magnetic field and vector potential to us nevertheless are not thus far clear.

With the examination of the forces, which act on the charge, we limited to the case, when the time lag, necessary for the passage of signal from the source, which generates vector potential, to the charge itself was considerably less than the period of current variations in the conductors. Now let us remove this limitation.

The second equation of Maxwell in the terms of vector potential can be written down as follows:

$$rot\ rot \vec{A}_H = \vec{j} \left(\vec{A}_H \right), \quad (2.20)$$

where $\vec{j}(\vec{A}_H)$ - certain functional from $\vec{A}_H$, depending on the properties of the medium in question. If is carried the Ohm law $\vec{j} = \sigma \vec{E}$, then

$$\vec{j}(\vec{A}_H) = -\sigma\mu \frac{\partial \vec{A}_H}{\partial t}\ . \quad (2.21)$$

For the free space relationship (2.20) takes the form:

$$\vec{j}(\vec{A}_H) = -\mu\varepsilon \frac{\partial^2 \vec{A}_H}{\partial t^2}. \quad (2.22)$$

For the free charges, which can move without the friction, functional will take the form

$$\vec{j}(\vec{A}_H) = -\frac{\mu}{L_k}\vec{A}_H, \tag{2.23}$$

where $L_k = \dfrac{m}{ne^2}$ - kinetic inductance of charges [2]. In this relationship of m, the mass of charge, e the magnitude of the charge, n - charge density.

The relationship (2.21 - 2.23) reflect well-known fact about existence of three forms of the electric current: active and two reactive. Each of them has characteristic dependence on the vector potential. This dependence determines the rules of the propagation of vector potential in different media. Here one should emphasize that the relationships (2.21 - 2.23) assume not only the presence of current, but also the presence of those material media, in which such currents can leak. The conduction current, determined by relationships (2.21) and (2.23), can the leak through the conductors, in which there are free current carriers. Bias current, can penetrate the free space or the dielectrics. For the free space relationship (2.20) takes the form:

$$rot\ rot\vec{A}_H = -\mu\varepsilon\frac{\partial^2\vec{A}_H}{\partial t^2}.$$

This wave equation, which attests to the fact that the vector potential can be extended in the free space in the form of plane waves, and it on its informativeness does not be inferior to the wave equations, obtained from the Maxwell equations. This relationship on its informativeness does not be inferior to wave equations for the electrical and magnetic pour on, obtained from Maxwell's equations.

Everything said attests to the fact that in the classical electrodynamics the vector potential has important significance. Its use shedding light on many physical phenomena, which previously were not intelligible. And, if it will be possible to explain physical nature of this potential, then is solved the very important problem both of theoretical and applied nature.

§ 3. Laws of the electromagnetic induction

The Faraday law shows, how a change in the magnetic pour on it leads to the appearance of electrical pour on. However, does arise the question about that, it does bring a change in the electrical pour on to the appearance of magnetic pour on? Maxwell gave answer to this question, after introducing bias current into its second equation. In the case of the absence of conduction currents the second equation of Maxwell appears as follows:

$$rot\ \vec{H} = \varepsilon \frac{\partial \vec{E}}{\partial t} = \frac{\partial \vec{D}}{\partial t},$$

where $\vec{D} = \varepsilon \vec{E}$ - electrical induction.

and further

$$\oint \vec{H}\, d\vec{l} = \frac{\partial \Phi_E}{\partial t} \text{ of}, \qquad (3.1)$$

where $\Phi_E = \int \vec{D}\, d\vec{s}$ the flow of electrical induction.

However for the complete description of the processes of the mutual electrical induction of relationship (3.1) is insufficient. As in the case Faraday law, should be considered the circumstance that the flow of electrical induction can change not only due to the local derivative of electric field on the time, but also because the outline, along which is produced the integration, it can move in the three-dimensional changing electric field. This means that in relationship (3.1), as in the case Faraday law, should be replaced the partial derivative by the complete. Designating by the primes of field and circuit elements in moving (IMS) we will obtain:

$$\oint \vec{H}' d\vec{l}' = \frac{d\Phi_E}{dt},$$

and further

$$\oint \vec{H}' d\vec{l}' = \int \frac{\partial \vec{D}}{\partial t}\, d\vec{s}' + \oint \left[\vec{D} \times \vec{v} \right] d\vec{l}' + \int \vec{v}\; div\vec{D}\; d\vec{s}'. \qquad (3.2)$$

for the electrically neutral medium $div\vec{E} = 0$; therefore the last member of right side in this expression will be absent. For this case relationship (3.2) will take the form:

$$\oint \vec{H}' d\vec{l}' = \int \frac{\partial \vec{D}}{\partial t}\, d\vec{s}' + \oint \left[\vec{D} \times \vec{v} \right] d\vec{l}'. \qquad (3.3)$$

If we in this relationship pass from the contour integration to the integration for the surface, then we will obtain:

$$rot\ \vec{H}' = \frac{\partial \vec{D}}{\partial t} + rot\left[\vec{D} \times \vec{v} \right]. \qquad (3.4)$$

If we, based on this relationship, write down fields in this inertial system, then prime near $\vec{H}$ and second member of right side will disappear, and we will obtain the bias current, introduced by Maxwell. But Maxwell introduced this parameter, without resorting to the law of electromagnetic induction (3.2). If his law of magnetoelectric induction Faraday derived on the basis experiments with the magnetic fields, then experiments on the establishment of the validity of relationship (3.2) cannot be at that time conducted was, since for conducting this experiment sensitivity of existing at that time meters did not be sufficient.

Pour on from (16.3) we obtain for the case of constant electrical:

$$\vec{H}'_v = -\varepsilon \left[\vec{v} \times \vec{E} \right]. \qquad (3.5)$$

Relationship (3.4) taking into account (3.6) will be written down:

$$\vec{H}' = \varepsilon \frac{\partial \vec{A}_E}{\partial t} - \varepsilon \left[\vec{v} \times rot\ \vec{A}_E \right].$$

Further it is possible to repeat all those procedures, which has already been conducted with the magnetic vector potential, and to write down the following relationships:

$$\vec{H}' = \varepsilon \frac{\partial \vec{A}_E}{\partial t} + \varepsilon \left(\vec{v} \nabla \right) \vec{A}_E - \varepsilon \ grad \left(\vec{v} \vec{A}_E \right),$$

$$\vec{H}' = \varepsilon \frac{\partial \vec{A}_E}{\partial t} - \varepsilon \left[\vec{v} \times rot \ \vec{A}_E \right],$$

$$\vec{H}' = \varepsilon \frac{dA_E}{dt} - \varepsilon \ grad \left(\vec{v} A_E \right).$$

Is certain, the study of this problem it would be possible, as in the case the law of magnetoelectric induction, to begin from the introduction of the vector $\vec{A}_E$.

The introduction of total derivatives in the laws of induction substantially explains physics of these processes and gives the possibility to isolate the force components, which act on the charge. This method gives also the possibility to obtain transformation laws pour on upon transfer of one (IMS) to another. Of this consists the modernization of old electrodynamics, although the physical essence of the introduced potentials remains, as earlier, it is not clear.

§ 4. Plurality of the forms of the writing of the electrodynamic laws

In the previous paragraph it is shown that the magnetic and electric fields can be expressed through their vector potentials

$$\vec{H} = rot \ \vec{A}_H \ , \tag{4.1}$$

$$\vec{E} = rot \ \vec{A}_E . \tag{4.2}$$

Consequently, the Maxwell equations can be written down with the aid of these potentials:

$$rot\ \vec{A}_E = -\mu \frac{\partial \vec{A}_H}{\partial t} \qquad (4.3)$$

$$rot\ \vec{A}_H = \varepsilon \frac{\partial \vec{A}_E}{\partial t}. \qquad (4.4)$$

For each of these potentials it is possible to obtain wave equation, in particular

$$rot\ rot\ \vec{A}_E = -\varepsilon\mu \frac{\partial^2 \vec{A}_E}{\partial t^2}\ , \qquad (4.5)$$

and to consider that in the space are extended not the magnetic and electric fields, but the field of electrical vector potential.

In this case, as can easily be seen of the relationships (4.1 - 4.4), magnetic and electric field they will be determined through this potential by the relationships:

$$\begin{aligned} \vec{H} &= \varepsilon \frac{\partial \vec{A}_E}{\partial t}\ . \\ \vec{E} &= rot\ \vec{A}_E \end{aligned} \qquad (4.6)$$

gradient $rot\ \vec{A}_E$ and local time derivative $\frac{\partial \vec{A}_E}{\partial t}$ are connected with wave equation (4.5).

Thus, the use only of one electrical vector potential makes it possible to completely solve the task about the propagation of electrical and magnetic pour on. Taking into account (4.6), Poynting vector can be written down only through the vector $\vec{A}_E$:

$$\vec{P} = \varepsilon \left[\frac{\partial \vec{A}_E}{\partial t} \times rot\ \vec{A}_E \right].$$

Characteristic is the fact that with this method of examination necessary condition is the presence at the particular point of space both the time derivatives, and the gradients of one and the same potential.

This task can be solved by another method, after writing down wave equation for the magnetic vector potential:

$$rot\ rot\ \vec{A}_H = -\varepsilon\mu \frac{\partial^2 \vec{A}_H}{\partial t^2}. \qquad (4.7)$$

In this case magnetic and electric fields will be determined by the relationships

$$\vec{H} = rot\ \vec{A}_H$$
$$\vec{E} = -\mu \frac{\partial \vec{A}_H}{\partial t}.$$

The Poynting vector in this case can be found from the following relationship:

$$\vec{P} = -\mu \left[\frac{\partial \vec{A}_H}{\partial t} \times rot\ \vec{A}_H \right].$$

gradient $rot\ \vec{A}_H$ and local time derivative $\frac{\partial \vec{A}_H}{\partial t}$ are connected with wave equation (4.5).

But it is possible to enter and differently, after introducing, for example, the electrical and magnetic currents

$$\vec{j}_E = rot\ \vec{H},$$
$$\vec{j}_H = rot\ \vec{E}.$$

The equations also can be recorded for these currents:

$$rot\ \vec{j}_H = -\mu \frac{\partial \vec{j}_E}{\partial t},$$

$$rot\ \vec{j}_E = \varepsilon \frac{\partial \vec{j}_H}{\partial t}.$$

This system in its form and information concluded in it differs in no way from Maksvell equations, and it is possible to consider that in the space the magnetic or electric currents are extended. And the solution of the problem of propagation with the aid of this method will again include complete information about the processes of propagation.

The method of the introduction of new vector examined pour on it is possible to extend into both sides ad infinitum, introducing all new vectorial fields. Naturally in this case should be introduced additional calibrations. Thus, there is an infinite set of possible writings of the electrodynamic laws, but they all are equivalent according to the information concluded in them. This approach was for the first time demonstrated in the work [3].

CHAPTER 2

ROLE AND THE PLACE FOR THE KINETIC INDUCTANCE OF CHARGES IN THE CONTEMPORARY ELECTRODYNAMICS

Today classical electrodynamics presents the very important branch of physics, which on its practical significance occupies one of the key places. However, in spite of this, into the electrodynamics of material media stole in some fundamental errors, which should be corrected. These errors concern the introduction of this concept as the frequency dispersion of dielectric and magnetic constant. This is the very large division of electrodynamics, but, unfortunately, the introduction of such concepts relates faster to metaphysics, than to physics.

§ 5. Who and as introduced the frequency dispersion of the dielectric constant

By all is well known this phenomenon as rainbow. To any specialist in the electrodynamics it is clear that the appearance of rainbow is connected with the dependence on the frequency of the phase speed of the electromagnetic waves, passing through the drops of rain. Since water is dielectric, with the explanation of this phenomenon Heaviside and Vul assumed that this dispersion was connected with the frequency dispersion (dependence on the frequency) of the dielectric constant of water. Since then this point of view is ruling [4-9].

However very creator of the fundamental equations of electrodynamics Maksvell considered that these parameters on frequency do not depend, but they are fundamental constants. As the idea of the dispersion of dielectric and magnetic constant was born, and what way it was past, sufficiently colorfully characterizes quotation from the monograph of well well-known specialists in the field of physics of plasma [4]: “J. itself. Maxwell with the formulation of the equations of the electrodynamics of material media considered that the dielectric and magnetic constants are the constants (for this reason they long time they were considered as the constants). It is considerably later, already at the beginning of this century with the explanation of the optical dispersion phenomena (in particular the phenomenon of rainbow) of Heaviside and Vul showed that the dielectric and magnetic constants are the functions of frequency. But very recently, in the middle of the 50's, physics they came to the conclusion that these values depend not only on frequency, but also on the wave vector. On the essence, this was the radical breaking of the existing ideas. It was how a serious, is characterized the case, which occurred at the seminar l. D. Landau into 1954 g of. During the report Akhiezer on this theme of Landau suddenly exclaimed, after smashing the speaker: ” This is delirium, since the refractive index cannot be the function of refractive index”. Note that this said Landau - one of the outstanding physicists of our time”.

It is incomprehensible from the given quotation, that precisely had in the form Landau. However, its subsequent publications speak, that it accepted this concept [5].

That rights there was Maksvell, who considered that the dielectric and magnetic constant of material media on frequency they do not depend. However, in a number of fundamental works on electrodynamics [5-9] are committed conceptual, systematic and physical errors, as a result of which in physics they penetrated and solidly in it were fastened such metaphysical concepts as the frequency dispersion of the dielectric constant of material media and, in particular, plasma. The propagation of this concept to the dielectrics led to the fact that all began to consider that also the dielectric constant of dielectrics also depends on frequency. These physical errors penetrated in all spheres of physics and technology. They so solidly took root in the consciousness of specialists, that many, until now, cannot believe in the fact that the dielectric constant of plasma is equal to the dielectric constant of vacuum, but the dispersion of the dielectric constant of dielectrics is absent. There is the publications of such well-known scholars as the Drude, Vull, Heaviside, Landau, Ginsburg, Akhiezer, Tamm [4-9], where it is indicated that the dielectric constant of plasma and dielectrics depends on frequency. This is a systematic and physical error. This systematic and physical error became possible for that reason, that without the proper understanding of physics of the proceeding processes occurred the substitution of physical concepts by mathematical symbols, which appropriated physical, but are more accurate metaphysical, designations, which do not correspond to their physical sense.

§ 6. Plasma media

By plasma media we will understand such, in which the charges can move without the losses. To such media in the first approximation, can be related the superconductors, free electrons or ions in the vacuum (subsequently conductors). In the media indicated the equation of motion of electron takes the form:

$$\text{of } m\frac{d\vec{v}}{dt} = e\vec{E}, \tag{6.1}$$

where m - mass electron, e - the electron charge, $\vec{E}$ - the tension of electric field, $\vec{v}$ - speed of the motion of charge.

In the work [9] it is shown that this equation can be used also for describing the electron motion in the hot plasma. Therefore it can be disseminated also to this case.

Using an expression for the current density

$$\vec{j} = ne\vec{v}, \qquad (6.2)$$

from (6.1) we obtain the current density of the conductivity

$$\vec{j}_L = \frac{ne^2}{m}\int \vec{E}\,dt\ . \qquad (6.3)$$

in relationship (6.2) and (6.3) the value of n represents electron density. After introducing the designation of

$$L_k = \frac{m}{ne^2} \qquad (6.4)$$

find

$$\vec{j}_L = \frac{1}{L_k}\int \vec{E}\,dt\ . \qquad (6.5)$$

in this case the value L_k presents the specific kinetic inductance of charge carriers [2,10-13]. Its existence connected with the fact that charge, having a mass, possesses inertia properties. For the case, when electric field changes according to the law $\vec{E} = \vec{E}_0 \sin\omega t$, relationship (6.5) will be written down:

$$\vec{j}_L = -\frac{1}{\omega L_k}\vec{E}_0 \cos\omega t\,. \qquad (6.6)$$

For the mathematical description of electrodynamic processes the trigonometric functions will be here and throughout, instead of the complex quantities, used so that would be well visible the phase relationships between the vectors, which represent electric fields and current densities.

from relationship (6.5) and (6.6) is evident that $\vec{j}_L$ presents inductive current, since. its phase is late with respect to the tension of electric field to the angle $\frac{\pi}{2}$.

If charges are located in the vacuum, then during the presence of summed current it is necessary to consider bias current

$$\vec{j}_\varepsilon = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = \varepsilon_0 \vec{E}_0 \cos \omega t .$$

is evident that this current bears capacitive nature, since. its phase anticipates the phase of the tension of electrical to the angle $\frac{\pi}{2}$. Thus, summary current density will be written down [by 10-12]:

$$\vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt ,$$

or

$$\vec{j}_\Sigma = \left(\omega \varepsilon_0 - \frac{1}{\omega L_k} \right) \vec{E}_0 \cos \omega t . \qquad (6.7)$$

If electrons are located in the material medium, then should be considered the presence of the positively charged ions. However, the presence of ions usually is not considered, since their mass is considerably greater than in electrons.

In relationship (6.7) the value, which stands in the brackets, presents summary susceptance of this medium σ_Σ and it consists it, in turn, of the the capacitive σ_C and by the inductive σ_L of the conductivity of

$$\sigma_\Sigma = \sigma_C + \sigma_L = \omega \varepsilon_0 - \frac{1}{\omega L_k} .$$

Relationship (6.7) can be rewritten and differently:

$$\vec{j}_\Sigma = \omega \varepsilon_0 \left(1 - \frac{\omega_0^2}{\omega^2} \right) \vec{E}_0 \cos \omega t ,$$

where $\omega_0 = \sqrt{\frac{1}{L_k \varepsilon_0}}$ - plasma frequency of Langmuir vibrations.

And large temptation here appears to name the value

$$\varepsilon^*(\omega) = \varepsilon_0 \left(1 - \frac{\omega_0^2}{\omega^2}\right) = \varepsilon_0 - \frac{1}{\omega^2 L_k},$$

by the depending on the frequency dielectric constant of plasma, that also is made in all existing works on physics of plasma. But this is incorrect, since. This mathematical symbol is the composite parameter, into which simultaneously enters the dielectric constant of vacuum and the specific kinetic inductance of charges.

Let us introduce the determination of the concept of the dielectric constant of medium for the case of variables pour on for the purpose of further concrete definition of the study of the problems of dispersion.

If we examine any medium, including plasma, then current density (subsequently we will in abbreviated form speak simply current) it will be determined by three components, which depend on the electric field. The current of resistance losses will coincide in the phase with the phase of electric field. The permittance current, determined by first-order derivative of electric field from the time, will anticipate the tension of electric field on the phase $\frac{\pi}{2}$. This current is called bias current. The conduction current, connected with the motion of free charges and determined by integral of the electric field from the time, will lag behind the electric field on the phase $\frac{\pi}{2}$. All three components of current indicated will enter into the second Maxwell equation and others components of currents be it cannot. Moreover all these three components of currents will be present in any nonmagnetic regions, in which there are losses. Therefore it is completely natural, the dielectric constant of any medium to define as the coefficient, confronting that term, which is determined by the derivative of electric field by the time in the second Maxwell equation. In this case one should consider that the dielectric constant cannot be negative value. This connected with the fact that through this parameter is determined energy of electrical pour on, which can be only positive.

Without having introduced this clear determination of dielectric constant, Landau begins the examination of the behavior of plasma in the ac fields. In this case it does not extract separately bias current and conduction current, one of which is determined by derivative, but by another integral, but is introduced the united coefficient, which unites these two currents, introducing the dielectric constant of plasma. It makes this error for that reason, that in the case of harmonic oscillations the form of the function, which determine and derivative and integral, is identical, and they are characterized by only sign. Performing this operation, Landau does not understand, that in the case of harmonic electrical pour on in the plasma there exist two different currents. One of them is bias current in the vacuum and is determined by derivative of electric field. Another current is conduction current and is determined by integral of the electric field. Moreover these two currents differ in the phase to 180 degrees. But since both currents depend on frequency, between them occurs competition. The conduction current predominates with the low frequencies, the bias current, on the contrary, predominates with the high. However, in the case of the equality of these currents, which occurs at the plasma frequency, occurs current resonance.

Is accurate another point of view. Relationship (6.7) can be rewritten and differently:

$$\vec{j}_{\Sigma} = -\frac{\left(\frac{\omega^2}{\omega_0^2} - 1\right)}{\omega L}\ \vec{E}_0 \cos\omega t$$

and to introduce another mathematical symbol

$$L^*(\omega) = \frac{L_k}{\left(\frac{\omega^2}{\omega_0^2} - 1\right)} = \frac{L_k}{\omega^2 L_k \varepsilon_0 - 1}\quad .$$

In this case also appears temptation to name this bending coefficient on the frequency kinetic inductance. But this value it is not possible to call inductance also, since this also the composite parameter, which includes those not depending on the frequency kinetic inductance and the dielectric constant of vacuum.

Consequently, it is possible to write down:

$$\vec{j}_{\Sigma} = \omega\varepsilon^*(\omega)\ \vec{E}_0 \cos\omega t,$$

or

$$\vec{j}_{\Sigma} = -\frac{1}{\omega L^*(\omega)}\ \vec{E}_0 \cos\omega t\ .$$

but this altogether only the symbolic mathematical record of one and the same relationship (6.7). Both equations are equivalent. But view neither $\varepsilon^*(\omega)$ nor $L^*(\omega)$ by dielectric constant or inductance are from a physical point. The physical sense of their names consists of the following:

$$\varepsilon^*(\omega) = \frac{\sigma_X}{\omega}\ ,$$

i.e. $\varepsilon^*(\omega)$ presents summary susceptance of medium, divided into the frequency, and

$$L_k^*(\omega) = \frac{1}{\omega\sigma_X}$$

it represents the reciprocal value of the work of frequency and susceptance of medium.

As it is necessary to enter, if at our disposal are values $\varepsilon^*(\omega)$ and $L^*(\omega)$, and we should calculate total specific energy. Natural to substitute these values in the formulas, which determine energy of electrical pour on

$$W_E = \frac{1}{2}\varepsilon_0 E_0^2$$

and kinetic energy of charge carriers

$$W_j = \frac{1}{2} L_k j_0^2, \tag{6.8}$$

is cannot simply because these parameters are neither dielectric constant nor inductance. It is not difficult to show that in this case the total specific energy can be obtained from the relationship of

$$W_\Sigma = \frac{1}{2} \cdot \frac{d\left(\omega\varepsilon^*(\omega)\right)}{d\omega} E_0^2, \tag{6.9}$$

from where we obtain

$$W_\Sigma = \frac{1}{2}\varepsilon_0 E_0^2 + \frac{1}{2}\ \frac{1}{\omega^2 L_k}\ E_0^2 = \frac{1}{2}\varepsilon_0 E_0^2 + \frac{1}{2} L_k j_0^2 .$$

We will obtain the same result, after using the formula

$$W = \frac{1}{2}\ \frac{d\left[\dfrac{1}{\omega L_k{}^*(\omega)}\right]}{d\omega}\ E_0^2 .$$

The given relationships show that the specific energy consists of potential energy of electrical pour on and to kinetic energy of charge carriers.

With the examination of any media by our final task appears the presence of wave equation. In this case this problem is already practically solved. The Maxwell equations for this case take the form:

$$\begin{aligned} rot\ \vec{E} &= -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t}, \\ rot\ \vec{H} &= \varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\ dt, \end{aligned} \tag{6.10}$$

where ε_0 and μ_0 - dielectric and magnetic constant of vacuum.

System of equations (6.10) completely describes all properties of the conductors, in which be absent the ohmic losses. From (6.10) we obtain

$$rot\ rot\ \vec{H} + \mu_0\varepsilon_0 \frac{\partial^2 \vec{H}}{\partial\, t^2} + \frac{\mu_0}{L_k}\vec{H} = 0 \tag{6.11}$$

For the case pour on, time-independent, equation (2.11) passes into the equation of London

$$rot\ rot\ \vec{H} + \frac{\mu_0}{L_k}\vec{H} = 0\ ,$$

where $\lambda_L{}^2 = \frac{L_k}{\mu_0}$ - London depth of the penetration.

Thus, it is possible to conclude that the equations of London being a special case of equation (6.11), and do not consider bias currents on Wednesday. Therefore they do not give the possibility to obtain the wave equations, which describe the processes of the propagation of electromagnetic waves in the superconductors.

Pour on wave equation in this case it appears as follows for the electrical:

$$rot\ rot\ \vec{E} + \mu_0\varepsilon_0\frac{\partial^2\vec{E}}{\partial t^2} + \frac{\mu_0}{L_k}\vec{E} = 0\,.$$

For constant electrical pour on it is possible to write down

$$rot\ rot\ \vec{E} + \frac{\mu_0}{L_k}\vec{E} = 0\,.$$

Consequently dc fields penetrate the superconductor in the same manner as for magnetic, diminishing exponentially. However, the density of current in this case grows according to the linear law

$$\vec{j}_L = \frac{1}{L_k}\int \vec{E}\ dt\,.$$

The carried out examination showed that the dielectric constant of this medium was equal to the dielectric constant of vacuum and this permeability on frequency does not depend. The accumulation of potential energy is obliged to this parameter. Furthermore, this medium is characterized still and the kinetic inductance of charge carriers and this parameter determines the kinetic energy, accumulated on Wednesday.

Thus, are obtained all necessary given, which characterize the process of the propagation of electromagnetic waves in conducting media examined. However, in contrast to the conventional procedure [5-7] with this examination nowhere was introduced polarization vector, but as the basis of examination assumed equation of motion and in this case in the second equation of Maxwell are extracted all components of current densities explicitly. In this case in the second equation of Maxwell are extracted all components of current densities explicitly.

In radio engineering exists the simple method of the idea of radio-technical elements with the aid of the equivalent diagrams. This method is very visual and gives the possibility to present in the form such diagrams elements both with that concentrated and with the distributed parameters. The use of this method will make it possible better to understand, why were committed such significant physical errors during the introduction of the concept of that depending on the frequency dielectric constant.

In order to show that the single volume of conductor or plasma according to its electrodynamic characteristics is equivalent to parallel resonant circuit with the lumped parameters, let us examine parallel resonant circuit. In this case the capacity of C *of* and the inductance of L are connected in parallel. The connection between the voltage of U, applied to the outline, and the summed current of I_{Σ}, which flows through this chain, takes the form

$$I_{\Sigma} = I_C + I_L = C\frac{dU}{dt} + \frac{1}{L}\int U\ dt,$$

where $I_C = C\frac{dU}{dt}$ - current, which flows through the capacity, and $I_L = \frac{1}{L}\int U\ dt$ - current, which flows through the inductance.

For the case of the harmonic stress of $U = U_0 \sin \omega t$ we obtain

$$I_\Sigma = \left(\omega C - \frac{1}{\omega L} \right) U_0 \cos \omega t . \qquad (6.12)$$

The value, which stands in the brackets, presents summary susceptance σ_Σ the chain examined and consists. It consists the capacitive σ_C and by the inductive σ_L the conductivity

$$\sigma_\Sigma = \sigma_C + \sigma_L = \omega C - \frac{1}{\omega L} .$$

In this case relationship (2.5) can be rewritten as follows:

$$I_\Sigma = \omega C \left(1 - \frac{\omega_0^2}{\omega^2} \right) U_0 \cos \omega t ,$$

where $\omega_0{}^2 = \dfrac{1}{LC}$ - the resonance frequency of parallel circuit.

And here, just as in the case of conductors, appears temptation, to name the value

$$C^*(\omega) = C \left(1 - \frac{\omega_0^2}{\omega^2} \right) = C - \frac{1}{\omega^2 L} \qquad (6.13)$$

by the depending on the frequency capacity. Conducting this symbol it is permissible from a mathematical point of view; however, inadmissible is awarding to it the proposed name, since. this parameter of no relation to the true capacity has and includes in itself simultaneously and capacity and the inductance of outline, which do not depend on frequency. It includes in itself simultaneously and capacity and the inductance of outline, which do not depend on frequency.

Is accurate another point of view. Relationship (6.7) can be rewritten and differently:

$$I_\Sigma = - \frac{\left(\dfrac{\omega^2}{\omega_0^2} - 1 \right)}{\omega L} U_0 \cos \omega t ,$$

and to consider that the chain in question not at all has capacities, and consists only of the inductance depending on the frequency

$$L^*(\omega) = \frac{L}{\left(\frac{\omega^2}{\omega_0^2} - 1\right)} = \frac{L}{\omega^2 LC - 1}. \qquad (6.14)$$

Using expressions (6.13) and (6.14), let us write down:

$$I_\Sigma = \omega C^*(\omega)\ U_0 \cos\omega t, \qquad (6.15)$$

or

$$I_\Sigma = -\frac{1}{\omega L^*(\omega)}\ U_0 \cos\omega t. \qquad (6.16)$$

Relationship (6.15) and (6.16) are equivalent, and separately mathematically completely is characterized the chain examined. But view neither $C^*(\omega)$ nor $L^*(\omega)$ by capacity and inductance are from a physical point, although they have the same dimensionality. The physical sense of their names consists of the following:

$$C^*(\omega) = \frac{\sigma_X}{\omega},$$

i.e. $C^*(\omega)$ presents the relation of susceptance of this chain and frequency, and

$$L^*(\omega) = \frac{1}{\omega \sigma_X},$$

it is the reciprocal value of the work of summary susceptance and frequency.

Accumulated in the capacity and the inductance energy, is determined from the relationships

$$W_C = \frac{1}{2} C U_0^2, \qquad (6.17)$$

$$W_L = \frac{1}{2} L I_0^{\ 2}. \qquad (6.18)$$

How one should enter for enumerating the energy, which was accumulated in the outline, if at our disposal are $C^*(\omega)$ and $L^*(\omega)$? Certainly, to put these relationships in formulas (6.17) and (6.18) is impossible already at least because these values can be both the positive and negative, and energy in this case is positive value. However, it is not difficult to show that the summary energy, accumulated in the outline, is determined by the expressions:

$$W_\Sigma = \frac{1}{2}\,\frac{d\sigma_X}{d\omega}\,U_0^{\ 2}, \qquad (6.19)$$

or

$$W_\Sigma = \frac{1}{2}\,\frac{d\left[\omega C^*(\omega)\right]}{d\omega}\,U_0^{\ 2}, \qquad (6.20)$$

or

$$W_\Sigma = \frac{1}{2}\,\frac{d\left(\dfrac{1}{\omega L^*(\omega)}\right)}{d\omega}\,U_0^{\ 2}. \qquad (6.21)$$

If we paint equations (6.19) or (6.20) and (6.21), then we will obtain identical result, namely:

$$W_\Sigma = \frac{1}{2} C U_0^{\ 2} + \frac{1}{2} L I_0^{\ 2},$$

where U_0 - amplitude of stress on the capacity, and I_0- amplitude of the current, which flows through the inductance.

If we compare the relationships, obtained for the parallel resonant circuit and for the conductors, then it is possible to see that they are identical, if we make $E_0 \to U_0$, $j_0 \to I_0$, $\varepsilon_0 \to C$ and $L_k \to L$. Thus, the single volume of conductor, with the uniform distribution of electrical pour on and current densities in it, it is equivalent to parallel resonant circuit with the lumped parameters indicated. In this case the capacity of this outline is numerically equal to the dielectric constant of vacuum, and inductance is equal to the specific kinetic inductance of charges.

Thus, are obtained all necessary given, which characterize the process of the propagation of electromagnetic waves in the media examined, and it is also shown that in the quasi-static regime the electrodynamic processes in the conductors are similar to processes in the parallel resonant circuit with the lumped parameters. However, in contrast to the conventional procedure [5-7] with this examination nowhere was introduced polarization vector, but as the basis of examination assumed equation of motion and in this case in the second equation of Maxwell are extracted all components of current densities explicitly.

Based on the example of work [5] let us examine a question about how similar problems, when the concept of polarization vector is introduced are solved for their solution. Paragraph 59 of this work, where this question is examined, it begins with the words: "We pass now to the study of the most important question about the rapidly changing electric fields, whose frequencies are unconfined by the condition of smallness in comparison with the frequencies, characteristic for establishing the electrical and magnetic polarization of substance" (end of the quotation). These words mean that that region of the frequencies, where, in connection with the presence of the inertia properties of charge carriers, the polarization of substance will not reach its static values, is examined. With the further consideration of a question is done the conclusion that "in any variable field, including with the presence of dispersion, the polarization vector $\vec{P}=\vec{D}-\varepsilon_0\vec{E}$ (here and throughout all formulas cited they are written in the system SI) preserves its physical sense of the electric moment of the unit volume of substance" (end of the quotation). Let us give the still one quotation: "It proves to be possible to establish (unimportantly - metals or dielectrics) maximum form of the function $\varepsilon(\omega)$ with the high frequencies valid for any bodies. Specifically, the field frequency must be great in comparison with "the frequencies" of the motion of all (or, at least, majority) electrons in the atoms of this substance. With the observance of this condition it is possible with the calculation of the polarization of substance to consider electrons as free, disregarding their interaction with each other and with the atomic nuclei" (end of the quotation).

Further, as this is done and in this work, is written the equation of motion of free electron in the ac field

$$m\frac{d\vec{v}}{dt}=e\vec{E},$$

from where its displacement is located

$$\vec{r}=-\frac{e\vec{E}}{m\omega^2}$$

then is indicated that the polarization $\vec{P}$ is a dipole moment of unit volume and the obtained displacement is put into the polarization of

$$\vec{P}=ne\vec{r}=-\frac{ne^2\vec{E}}{m\omega^2}.$$

In this case point charge is examined, and this operation indicates the introduction of electrical dipole moment for two point charges with the opposite signs, located at a distance $\vec{r}$

$$\vec{p}_e=-e\vec{r}.$$

This step causes bewilderment, since the point electron is examined, and in order to speak about the electrical dipole moment, it is necessary to have in this medium for each electron another charge of opposite sign, referred from it to the distance. In this case is examined the gas of free electrons, in which there are no charges of opposite signs. Further follows the standard procedure, when introduced thus illegal polarization vector is introduced into the dielectric constant $\vec{r}$

$$\vec{D}=\varepsilon_0\vec{E}+\vec{P}=\varepsilon_0\vec{E}-\frac{ne^2\vec{E}}{m\omega^2}=\varepsilon_0\left(1-\frac{1}{\varepsilon_0 L_k\omega^2}\right)\vec{E}\ ,$$

and since plasma frequency is determined by the relationship

$$\omega_p{}^2=\frac{1}{\varepsilon_0 L_k},$$

the vector of the induction immediately is written

$$\vec{D}=\varepsilon_0\left(1-\frac{\omega_p{}^2}{\omega^2}\right)\vec{E}.$$

With this approach it turns out that constant of proportionality

$$\varepsilon(\omega)=\varepsilon_0\left(1-\frac{\omega_p{}^2}{\omega^2}\right),$$

between the electric field and the electrical induction, illegally named dielectric constant, depends on frequency.

Precisely this approach led to the fact that all began to consider that the value, which stands in this relationship before the vector of electric field, is the dielectric constant depending on the frequency, and electrical induction also depends on frequency. And this it is discussed in all, without the exception, fundamental works on the electrodynamics of material media [5-9].

But, as it was shown above this parameter it is not dielectric constant, but presents summary susceptance of medium, divided into the frequency. Thus, traditional approach to the solution of this problem from a physical point of view is erroneous. But from a mathematical point of view this approach let us assume however in this case there is no possibility of the calculation of initial conditions with the calculation of integral in the relationships, which determine conduction current.

Further into §61 of work [5] is examined a question about the energy of electrical and magnetic field in the media, which possess by the so-called dispersion. In this case is done the conclusion that relationship for the energy of such pour on

$$W=\frac{1}{2}\left(\varepsilon {E_0}^2+\mu {H_0}^2\right), \tag{6.22}$$

that making precise thermodynamic sense in the usual media, with the presence of dispersion so interpreted be cannot. These words mean that the knowledge of real electrical and magnetic pour on. Wednesday with the dispersion insufficiently for determining the difference in the internal energy per unit of volume of substance in the presence pour on in their absence. After such statements is given the formula, which gives correct result for enumerating the specific energy of electrical and magnetic pour on when the dispersion ofis present

$$W=\frac{1}{2}\frac{d\left(\omega\varepsilon(\omega)\right)}{d\omega}E_0^2+\frac{1}{2}\frac{d\left(\omega\mu(\omega)\right)}{d\omega}H_0^2 \tag{6.23}$$

but if we compare the first part of the expression in the right side of relationship (6.23) with relationship (6.9), then it is evident that they coincide. This means that in relationship (6.23) this term presents the total energy, which includes not only potential energy of electrical pour on, but also kinetic energy of the moving charges.

Therefore conclusion about the impossibility of the interpretation of formula (6.22), as the internal energy of electrical and magnetic pour on in the media with the dispersion it is correct. However, this circumstance consists not in the fact that this interpretation in such media is generally impossible. It consists in the fact that for the definition of the value of energy as the thermodynamic parameter is necessary to correctly calculate this energy. In this case it follows taking into account not only electric field, which accumulates potential energy, but also current of the conduction electrons, which accumulate the kinetic energy of charges (6.8).

The conclusion, which now can be made, consists of the following. The conclusion, which now can be made, consists in the fact that, introducing into the custom some mathematical symbols, without understanding of their true physical sense, and, all the more, the awarding to these symbols of physical designations unusual to them, it is possible in the final analysis to lead to the significant errors, that also occurred in the work [5].

Let us focus attention on the fact that with the study of this problem, were used only the equations of motion and the concept of polarization vector did not adapt.

§ 7. Transverse plasma resonance

Is known that the plasma resonance is longitudinal. But longitudinal resonance cannot emit transverse electromagnetic waves. However, with the explosions of nuclear charges, as a result of which is formed very hot plasma, occurs electromagnetic radiation in the very wide frequency band, up to the long-wave radio-frequency band. Today are not known those of the physical mechanisms, which could explain the appearance of this emission. There were no other resonances of any kind, except plasma, earlier known on existence in the nonmagnetic plasma. But it occurs that in the confined plasma can exist the transverse plasma resonance, whose frequency coincides with the frequency of longitudinal plasma resonance. Specifically, this resonance can be the reason for the emission of electromagnetic waves with the explosions of nuclear charges. For explaining the conditions for the excitation of this resonance let us examine the long line, which consists of two ideally conducting planes, as shown in Fig. 2

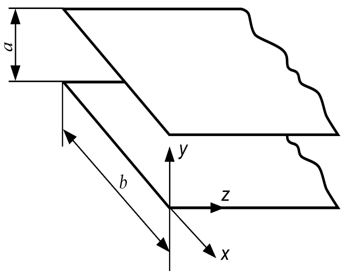

Fig. 2 The two-wire circuit, which consists of two ideally conducting planes.

Linear (falling per unit of length) capacity and inductance of this line without taking into account edge effects they are determined by the relationships [10,11]:

$$C_0 = \varepsilon_0 \frac{b}{a} \text{ and } L_0 = \mu_0 \frac{a}{b}$$

Therefore with an increase in the length of line its total capacitance $C_\Sigma = \varepsilon_0 \frac{b}{a} z$ and summary inductance $L_\Sigma = \mu_0 \frac{a}{b} z$ increase proportional to its length.

If we into the extended line place the plasma, charge carriers in which can move without the losses, and in the transverse direction pass through the plasma the current I, then charges, moving with the definite speed, will accumulate kinetic energy. Let us note that here are not examined technical questions, as and it is possible confined plasma between the planes of line how. In this case only fundamental questions, which are concerned transverse plasma resonance in the nonmagnetic plasma, are examined.

Since the transverse current density in this line is determined by the relationship

$$j=\frac{I}{bz}=nev,$$

that summary kinetic energy of the moving charges can be written down

$$W_{k\Sigma}=\frac{1}{2}\ \frac{m}{ne^2}\ abzj^2=\frac{1}{2}\ \frac{m}{ne^2}\ \frac{a}{bz}I^2. \qquad (7.1)$$

Relationship (7.1) connects the kinetic energy, accumulated in the line, with the square of current; therefore the coefficient, which stands in the right side of this relationship before the square of current, is the summary kinetic inductance of line.

$$L_{k\Sigma}=\frac{m}{ne^2}\cdot\frac{a}{bz}. \qquad (7.2)$$

Thus, the value

$$L_k=\frac{m}{ne^2} \qquad (7.3)$$

presents the specific kinetic inductance of charges. This value was already previously introduced by another method (see relationship (6.4)). Relationship (7.3) is obtained for the case of the direct current, when current distribution is uniform.

Subsequently for the larger clarity of the obtained results, together with their mathematical idea, we will use the method of equivalent diagrams. The section, the lines examined, long of dz can be represented in the form the equivalent diagram, shown in Fig. 3 (a).

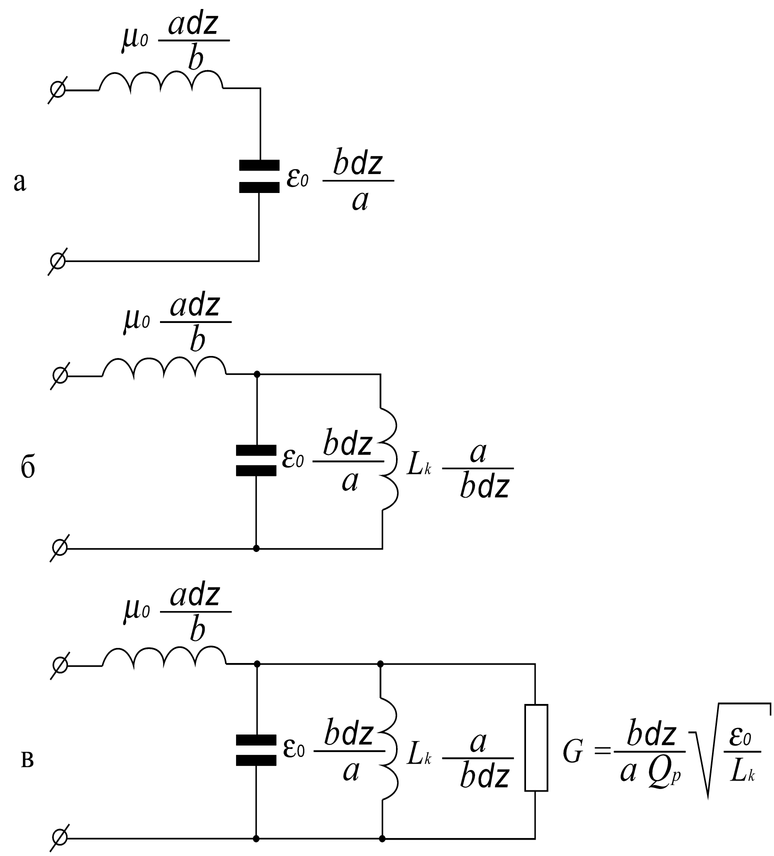

Fig. 3.

a - the equivalent the schematic of the section of the two-wire circuit;

б - the equivalent the schematic of the section of the two-wire circuit, filled with nondissipative plasma;

в - the equivalent the schematic of the section of the two-wire circuit, filled with dissipative plasma.

From relationship (7.2) is evident that in contrast to C_Σ and L_Σ the value of $L_{k\Sigma}$ with an increase in z does not increase, but it decreases.

Connected this with the fact that with an increase in z a quantity of parallel-connected inductive elements grows.

The equivalent the schematic of the section of the line, filled with nondissipative plasma, it is shown in Fig. 3 (б). Line itself in this case will be equivalent to parallel circuit with the lumped parameters:

$$C = \frac{\varepsilon_0 bz}{a},$$

$$L = \frac{L_k a}{bz},$$

in series with which is connected the inductance

$$\mu_0 \frac{adz}{b}.$$

But if we calculate the resonance frequency of this outline, then it will seem that this frequency generally not on what sizes depends, actually:

$$\omega_\rho^2 = \frac{1}{CL} = \frac{1}{\varepsilon_0 L_k} = \frac{ne^2}{\varepsilon_0 m}.$$

Is obtained the very interesting result, which speaks, that the resonance frequency macroscopic of the resonator examined does not depend on its sizes. Impression can be created, that this is plasma resonance, since. the obtained value of resonance frequency exactly corresponds to the value of this resonance. But it is known that the plasma resonance characterizes longitudinal waves in the long line they, while occur transverse waves. In the case examined the value of the phase speed in the direction z is equal to infinity and the wave vector $\vec{k} = 0$.

This result corresponds to the solution of system of equations (6.10) for the line with the assigned configuration. In this case the wave number is determined by the relationship:

$$k_z^2 = \frac{\omega^2}{c^2}\left(1 - \frac{\omega_\rho^2}{\omega^2}\right) \tag{7.4}$$

and the group and phase speeds

$$v_g^2 = c^2\left(1 - \frac{\omega_\rho^2}{\omega^2}\right), \tag{7.5}$$

$$v_F^2 = \frac{c^2}{\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)} \tag{7.6}$$

where $c = \left(\frac{1}{\mu_0 \varepsilon_0}\right)^{1/2}$ - speed of light in the vacuum.

For the present instance the phase speed of electromagnetic wave is equal to infinity, which corresponds to transverse resonance at the plasma frequency. Consequently, at each moment of time pour on distribution and currents in this line uniform and it does not depend on the coordinate z , but current in the planes z line in the direction of is absent. This, from one side, it means that the inductance L_Σ will not have effects on electrodynamic
processes in this line, but instead of the conducting planes can be used any planes or devices, which limit plasma on top and from below.

From relationships (7.4), (7.5) and (7.6) is evident that at the point $\omega = \omega_p$ occurs the transverse resonance with the infinite quality. With the presence of losses in the resonator will occur the damping, and in the long line in this case $k_z \neq 0$, and in the line will be extended the damped transverse wave, the direction of propagation of which will be normal to the direction of the motion of charges. It should be noted that the fact of existence of this resonance previously was not realized and in the literature it was not described.

Before to pass to the more detailed study of this problem, let us pause at the energy processes, which occur in the line in the case of the absence of losses examined.

Pour on the characteristic impedance of plasma, which gives the relation of the transverse components of electrical and magnetic, let us determine from the relationship

$$Z=\frac{E_y}{H_x}=\frac{\mu_0\omega}{k_z}=Z_0\left(1-\frac{\omega_\rho^2}{\omega^2}\right)^{-1/2},$$

where $Z_0=\sqrt{\frac{\mu_0}{\varepsilon_0}}$ - characteristic resistance of vacuum.

The obtained value of Z is characteristic for the transverse electrical waves in the waveguides. It is evident that when $\omega\to\omega_p$, then $Z\to\infty$, and $H_x\to 0$. When $\omega>\omega_p$ in the plasma there is electrical and magnetic component of field. The specific energy of these pour on it will be written down:

$$W_{E,H}=\frac{1}{2}\varepsilon_0 E_{0y}^2+\frac{1}{2}\mu_0 H_{0x}^2.$$

Thus, the energy, concluded in the magnetic field, in $\left(1-\frac{\omega_\rho^2}{\omega^2}\right)$ times is less than the energy, concluded in the electric field. Let us note that this examination, which is traditional in the electrodynamics, is not complete, since. in this case is not taken into account one additional form of energy, namely kinetic energy of charge carriers. Occurs that pour on besides the waves of electrical and magnetic, that carry electrical and magnetic energy, in the plasma there exists even and the third - kinetic wave, which carries kinetic energy of current carriers. The specific energy of this wave is determined from the relationship:

$$W_k = \frac{1}{2} L_k j_0^2 = \frac{1}{2} \cdot \frac{1}{\omega^2 L_k} E_0^2 = \frac{1}{2} \varepsilon_0 \frac{\omega_\rho^2}{\omega^2} E_0^2 .$$

Consequently, the total specific energy of wave is written as

$$W_{E,H,j} = \frac{1}{2} \varepsilon_0 E_{0y}^2 + \frac{1}{2} \mu_0 H_{0x}^2 + \frac{1}{2} L_k j_0^2 \ .$$

Thus, for finding the total energy, by the prisoner per unit of volume of plasma, calculation only pour on E and H it is insufficient.

At the point $\omega = \omega_p$ are carried out the relationship:

$$W_H = 0$$
$$W_E = W_k$$

i.e. magnetic field in the plasma is absent, and plasma presents macroscopic electromechanical resonator with the infinite quality, ω_p resounding at the frequency.

Since with the frequencies $\omega > \omega_p$ the wave, which is extended in the plasma, it bears on itself three forms of the energy: electrical, magnetic and kinetic, then this wave can be named the electric-magnetic-kinetic waves wave. Kinetic wave is the wave of the current density $\vec{j} = \frac{1}{L_k} \int \vec{E}\, dt$.

This wave is moved with respect to the electrical wave the angle $\frac{\pi}{2}$.

If losses are located, moreover completely it does not have value, by what physical processes such losses are caused, then the quality of plasma resonator will be finite quantity. For this case the Maxwell equation they will take the form:

$$rot\ \vec{E} = -\mu_0 \frac{\partial \vec{H}}{\partial t},$$
$$rot\ \vec{H} = \sigma_{p.ef}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt. \qquad (7.7)$$

The presence of losses is considered by the term $\sigma_{p.ef}\vec{E}$, and, using near the conductivity of the index ef, it is thus emphasized that us does not interest very mechanism of losses, but only very fact of their existence interests. The value σ_{ef} determines the quality of plasma resonator. For measuring σ_{ef} should be selected the section of line by the length z_0, whose value is considerably lower than the wavelength in the plasma. This section will be equivalent to outline with the lumped parameters:

$$C = \varepsilon_0 \frac{bz_0}{a}, \tag{7.8}$$

$$L = L_k \frac{a}{bz_0}, \tag{7.9}$$

$$G = \sigma_{\rho.ef} \frac{bz_0}{a}, \tag{7.10}$$

where G - conductivity, connected in parallel C and L.

Conductivity and quality in this outline enter into the relationship:

$$G = \frac{1}{Q_\rho}\sqrt{\frac{C}{L}},$$

where, taking into account (7.8 - 7.10), we obtain

$$\sigma_{\rho.ef} = \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}. \tag{7.11}$$

Thus, measuring its own quality plasma of the resonator examined, it is possible to determine $\sigma_{p.ef}$. Using (7.2) and (7.11) we obtain:

$$\begin{aligned} rot\ \vec{E} &= -\mu_0 \frac{\partial \vec{H}}{\partial t}, \\ rot\ \vec{H} &= \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k}\int \vec{E}\, dt. \end{aligned} \tag{7.12}$$

The equivalent the schematic of this line, filled with dissipative plasma, is represented in Fig. 3 (в).

Let us examine the solution of system of equations (7.12) at the point $\omega = \omega_p$, in this case, since

$$\varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt = 0,$$

we obtain

$$rot\ \vec{E} = -\mu_0 \frac{\partial \vec{H}}{\partial t},$$

$$rot\ \vec{H} = \frac{1}{Q_P} \sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E}.$$

These relationships determine wave processes at the point of resonance.

If losses in the plasma, which fills line are small, and strange current source is connected to the line, then it is possible to assume:

$$rot\ \vec{E} \cong 0,$$

$$\frac{1}{Q_p} \sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt = \vec{j}_{CT}, \qquad (7.13)$$

where $\vec{j}_{CT}$ - density of strange currents.

After integrating (7.13) with respect to the time and after dividing both parts to ε_0, we will obtain

$$\omega_p^2\, \vec{E} + \frac{\omega_p}{Q_p} \cdot \frac{\partial \vec{E}}{\partial t} + \frac{\partial^2 \vec{E}}{\partial t^2} = \frac{1}{\varepsilon_0} \cdot \frac{\partial \vec{j}_{CT}}{\partial t}. \qquad (7.14)$$

If we relationship (7.14) integrate over the surface of normal to the vector $\vec{E}$ and to introduce the electric flux $\Phi_E = \int \vec{E} d\vec{S}$, we will obtain:

$$\omega_p^2 \Phi_E + \frac{\omega_p}{Q_p} \cdot \frac{\partial \Phi_E}{\partial t} + \frac{\partial^2 \Phi_E}{\partial t^2} = \frac{1}{\varepsilon_0} \cdot \frac{\partial I_{CT}}{\partial t}, \qquad (7.15)$$

where I_{CT} - strange current.

Equation (7.15) is the equation of harmonic oscillator with the right side, characteristic for the two-level laser [15]. If the source of excitation was opened, then relationship (7.14) presents "cold" laser resonator, in which the fluctuations will attenuate exponentially

$$\Phi_E(t) = \Phi_E(0)\ e^{i\omega_P t} \cdot e^{-\frac{\omega_P}{2Q_P} t},$$

i.e. the macroscopic electric flux $\Phi_E(t)$ will oscillate with the frequency ω_p, relaxation time in this case is determined by the relationship:

$$\tau = \frac{2Q_P}{\omega_P}.$$

The problem of developing of laser consists to now only in the skill excite this resonator.

If resonator is excited by strange currents, then this resonator presents band-pass filter with the resonance frequency to equal plasma frequency and the passband $\Delta\omega = \frac{\omega_p}{2Q_p}$.

Another important practical application of transverse plasma resonance is possibility its use for warming-up and diagnostics of plasma. If the quality of plasma resonator is great, then can be obtained the high levels of electrical pour on, and it means high energies of charge carriers.

§ 8. Kinetic capacity

If we consider all components of current density in the conductor, then the second equation of Maxwell can be written down:

$$rot\vec{H}=\sigma_E\vec{E} + \varepsilon\frac{\partial\vec{E}}{\partial t} + \frac{1}{L_k}\int\vec{E}dt , \qquad (8.1)$$

where σ_E - conductivity of metal.

At the same time, the first Maxwell equation can be written down as follows:

$$rot\vec{E}=-\mu\frac{\partial\vec{H}}{\partial t}, \qquad (8.2)$$

where μ - magnetic permeability of medium. It is evident that equations (8.1) and (8.2) are asymmetrical.

To somewhat improve the symmetry of these equations are possible, introducing into equation (8.2) term linear for the magnetic field, that considers heat losses in the magnetic materials in the variable fields:

$$rot\vec{E}=-\sigma_H\vec{H}-\mu\frac{\partial\vec{H}}{\partial t}, \qquad (8.3)$$

where σ_H - conductivity of magnetic currents. But here there is no integral of such type, which is located in the right side of equation (8.1), in this equation. At the same time to us it is known that the atom, which possesses the magnetic moment $\vec{m}$, placed into the magnetic field, and which accomplishes in it precession motion, has potential energy $U_m=-\mu\vec{m}\vec{H}$. Therefore potential energy can be accumulated not only in the electric fields, but also in the precession motion of magnetic moments, which does not possess inertia. Similar case is located also in the mechanics, when the gyroscope, which precesses in the field of external gravitational forces, accumulates potential energy. Regarding mechanical precession motion is also noninertial and immediately ceases after the removal of external forces. For example, if we from under the precessing gyroscope, which revolves in the field of the earth's gravity, rapidly remove support, thus it will begin to fall, preserving in the space the direction of its axis, which was at the moment, when support was removed. The same situation occurs also for the case of the precessing magnetic moment. Its precession is noninertial and ceases at the moment of removing the magnetic field.

Therefore it is possible to expect that with the description of the precessional motion of magnetic moment in the external magnetic field in the right side of relationship (8.3) can appear a term of the same type as in relationship (8.1). It will only stand L_k, i.e., instead C_k the kinetic capacity, which characterizes that potential energy, which has the precessing magnetic moment in the magnetic field:

$$rot\vec{E} = -\sigma_H \vec{H} - \mu \frac{\partial \vec{H}}{\partial t} - \frac{1}{C_k} \int \vec{H} dt .$$

For the first time this idea of the first Maxwell equation taking into account kinetic capacity was given in the work [3].

Let us explain, can realize this case in practice, and that such in this case kinetic capacity. Resonance processes in the plasma and the dielectrics are characterized by the fact that in the process of fluctuations occurs the alternating conversion of electrostatic energy into the kinetic kinetic energy of charges and vice versa. This process can be named electrokinetic and all devices: lasers, masers, filters, etc, which use this process, can be named electrokinetic. At the same time there is another type of resonance - magnetic. If we use ourselves the existing ideas about the dependence of magnetic permeability on the frequency, then it is not difficult to show that this dependence is connected with the presence of magnetic resonance. In order to show this, let us examine the concrete example of ferromagnetic resonance. If we magnetize ferrite, after applying the stationary field of H_0 in parallel to the axis of z, the like to relation to the external variable field medium will come out as anisotropic magnetic material with the complex permeability in the form of tensor [16]

$$\mu = \begin{pmatrix} \mu_T*(\omega) & -i\,\alpha & 0 \\ i\,\alpha & \mu_T*(\omega) & 0 \\ 0 & 0 & \mu_L \end{pmatrix},$$

where

$$\mu_T*(\omega) = 1 - \frac{\Omega\ |\gamma|\ M_0}{\mu_0(\omega^2 - \Omega^2)}, \qquad \alpha = \frac{\omega\ |\gamma|\ M_0}{\mu_0(\omega^2 - \Omega^2)}, \qquad \mu_L = 1,$$

moreover

$$\Omega = |\gamma|\ H_0 \tag{8.4}$$

is natural frequency of precession and

$$M_0 = \mu_0(\mu - 1)H_0 \tag{8.5}$$

is a magnetization of medium. Taking into account (8.4) and (8.5) for $\mu_T*(\omega)$, it is possible to write down

$$\mu_T*(\omega) = 1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2}. \tag{8.6}$$

That magnetic permeability of magnetic material depends on frequency, and can arise suspicions, that, as in the case with the plasma, here is some misunderstanding.

If we consider that the electromagnetic wave is propagated along the axis x and there are components pour on H_y and H_z, then in this case the first Maksvell quation will be written down:

$$rot\ \vec{E} = \frac{\partial\ \vec{E}_Z}{\partial\ x} = \mu_0 \mu_T \frac{\partial\ \vec{H}_y}{\partial\ t}.$$

Taking into account (8.6), we will obtain

$$rot\ \vec{E} = \mu_0 \left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2} \right] \frac{\partial\ \vec{H}_y}{\partial\ t}.$$

For the case of ω>>Ω we will obtain

$$rot\ \vec{E} = \mu_0 \left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2} \right] \frac{\partial\ \vec{H}_y}{\partial\ t}. \qquad (8.7)$$

assuming $H_y = H_{y0} \sin \omega t$ and taking into account that in this case

$$\frac{\partial\ \vec{H}_y}{\partial\ t} = -\omega^2 \int \vec{H}_y\ d\ t,$$

we will obtain from (8.7)

$$rot\ \vec{E} = \mu_0 \frac{\partial\ \vec{H}_y}{\partial\ t} + \mu_0\ \Omega^2 (\mu - 1) \int \vec{H}_y\ d\ t,$$

or

$$rot\ \vec{E} = \mu_0 \frac{\partial\ \vec{H}_y}{\partial\ t} + \frac{1}{C_k} \int \vec{H}_y\ d\ t. \qquad (8.8)$$

For the case of ω<< Ω we will obtain

$$rot\ \vec{E} = \mu_0 \mu \frac{\partial\ \vec{H}_y}{\partial\ t}.$$

Value

$$C_k = \frac{1}{\mu_0\ \Omega^2(\mu - 1)},$$

which is introduced in relationship (8.8), let us name kinetic capacity.

With which is connected existence of this parameter, and its what physical sense? If the direction of magnetic moment does not coincide with the direction of external magnetic field, then the vector of this moment begins to precesse around the vector of magnetic field with the frequency Ω. The magnetic moment $\vec{m}$ possesses in this case potential energy $U_m = -\vec{m} \cdot \vec{B}$. This energy similar to energy of the charged capacitor is potential, because precessional motion, although is mechanical, however, it not inertia and instantly it does cease during the removal of magnetic field. However, with the presence of magnetic field precessional motion continues until the accumulated potential energy is spent, and the vector of magnetic moment will not become parallel to the vector of magnetic field.

The equivalent diagram of the case examined is given in Fig. 4.

Since parameter

$$\mu_H * (\omega) = \mu_0 \left[1 - \frac{\Omega^2 (\mu - 1)}{\omega^2 - \Omega^2} \right]$$

is not the frequency dependent magnetic permeability, but it is the combined parameter, including μ_0 , μ and C_k which are included on in accordance with the equivalent diagram, depicted in Fig. 4.

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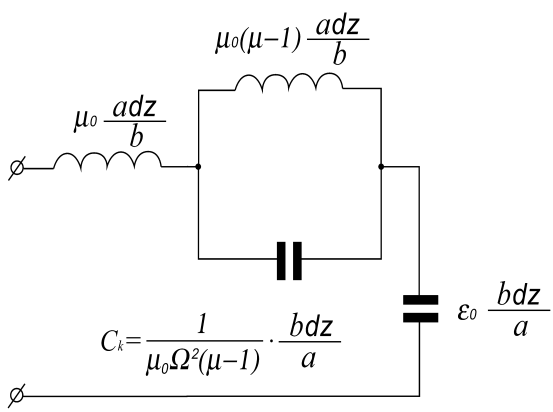

Fig. 4. Equivalent the schematic of the two-wire circuit of that filled with magnetic material.

Is not difficult to show that in this case there are three waves: electrical, magnetic and the wave, which carries potential energy, which is connected with the precession of magnetic moments around the vector H_0. For this reason such waves can be named the electric-magnetic-potential waves. Before the appearance of a work [3] in the electrodynamics this concept, as kinetic capacity it was not used, although this the real parameter has very intelligible physical interpretation.

§ 9. Dielectrics

In the existing literature there are no indications that the kinetic inductance of charge carriers plays some role in the electrodynamic processes in the dielectrics. This not thus. This parameter in the electrodynamics of dielectrics plays not less important role, than in the electrodynamics of conductors. Let us examine the simplest case, when oscillating processes in atoms or molecules of dielectric obey the law of mechanical oscillator [10]. Let us write down the equation of motion of

$$\left(\frac{\beta}{m}-\omega^2\right)\vec{r}_m=\frac{e}{m}\vec{E}, \tag{9.1}$$

where $\vec{r}_m$ - deviation of charges from the position of equilibrium, β - coefficient of elasticity, which characterizes the elastic electrical binding forces of charges in the atoms and the molecules. Introducing the resonance frequency of the bound charges

$$\omega_0=\frac{\beta}{m},$$

from (9.1) obtain

$$r_m = -\frac{e\ E}{m(\omega^2 - \omega_o^2)}. \tag{9.2}$$

Is evident that in relationship (9.2) as the parameter is present the natural vibration frequency, into which enters the mass of charge. This speaks, that the inertia properties of the being varied charges will influence oscillating processes in the atoms and the molecules.

Since the general current density on Wednesday consists of the bias current and conduction current

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + ne\vec{v},$$

that, finding the speed of charge carriers in the dielectric as the derivative of their displacement through the coordinate

$$\vec{v} = \frac{\partial r_m}{\partial t} = -\frac{e}{m(\omega^2 - \omega_o^2)} \frac{\partial \vec{E}}{\partial t},$$

from (9.2) obtain

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{1}{L_{kd}(\omega^2 - \omega_0^{\ 2})} \frac{\partial \vec{E}}{\partial t}. \tag{9.3}$$

Let us note that the value

$$L_{kd} = \frac{m}{ne^2}$$

presents the kinetic inductance of the charges, entering the constitution of atom or molecules of dielectrics, when to consider charges free. Therefore relationship (9.3) it is possible to rewrite

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{1}{\varepsilon_0 L_{kd}(\omega^2 - \omega_0^{\ 2})}\right) \frac{\partial \vec{E}}{\partial t}. \tag{9.4}$$

Since the value

$$\frac{1}{\varepsilon_0 L_{kd}} = \omega_{pd}{}^2$$

it represents the plasma frequency of charges in atoms and molecules of dielectric, if we consider these charges free, then relationship (9.4) takes the form:

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0{}^2)} \right) \frac{\partial \vec{E}}{\partial t}. \qquad (9.5)$$

To appears temptation to name the value

$$\varepsilon^*(\omega) = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0{}^2)} \right), \qquad (9.6)$$

by the depending on the frequency dielectric constant of dielectric. But this, as in the case conductors, cannot be made, since this is the composite parameter, which includes now those not already three depending on the frequency of the parameter: the dielectric constant of vacuum, the natural frequency of atoms or molecules and plasma frequency for the charge carriers, entering their composition.

Let us examine two limiting cases:

1) If $\omega \ll \omega_0$, then from (9.5) obtain

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 + \frac{\omega_{pd}{}^2}{\omega_0{}^2} \right) \frac{\partial \vec{E}}{\partial t}. \qquad (9.7)$$

in this case the coefficient, confronting the derivative, does not depend on frequency, and it presents the static dielectric constant of dielectric. As we see, it depends on the natural frequency of oscillation of atoms or molecules and on plasma frequency. This result is intelligible. Frequency in this case proves to be such low that the charges manage to follow the field and their inertia properties do not influence electrodynamic processes. In this case the bracketed expression in the right side of relationship (9.7) presents the static dielectric constant of dielectric. As we see, it depends on the natural frequency of oscillation of atoms or molecules and on plasma frequency. Hence immediately we have a prescription for creating the dielectrics with the high dielectric constant. In order to reach this, should be in the assigned volume of space packed a maximum quantity of molecules with maximally soft connections between the charges inside molecule itself.

2 The case, when $\omega \gg \omega_0$, is exponential. In this case

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{\omega_{pd}{}^2}{\omega^2} \right) \frac{\partial \vec{E}}{\partial t}$$

and dielectric became conductor (plasma) since, the obtained relationship exactly coincides with the equation, which describes plasma.

One cannot fail to note the circumstance that in this case again nowhere was used this concept as polarization vector, but examination is carried out by the way of finding the real currents in the dielectrics on the basis of the equation of motion of charges in these media. In this case as the parameters are used the electrical characteristics of the media, which do not depend on frequency.

From relationship (9.5) is evident that in the case of fulfilling the equality $\omega = \omega_0$, the amplitude of fluctuations is equal to infinity. This indicates the presence of resonance at this point. The infinite amplitude of fluctuations occurs because of the fact that they were not considered losses in the resonance system, in this case its quality was equal to infinity. In a certain approximation it is possible to consider that lower than the point indicated we deal concerning the dielectric, whose dielectric constant is equal to its static value. Higher than this point we deal already actually concerning the metal, whose density of current carriers is equal to the density of atoms or molecules in the dielectric.

Now it is possible to examine the question of why dielectric prism decomposes polychromatic light into monochromatic components or why rainbow is formed. So that this phenomenon would occur, it is necessary to have the frequency dispersion of the phase speed of electromagnetic waves in the medium in question. If we to relationship (9.5) add the first Maxwell equation, then we will obtain:

$$rot\vec{E} = -\mu_0 \frac{\partial \vec{H}}{\partial t}$$

$$rot\vec{H} = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0{}^2)} \right) \frac{\partial \vec{E}}{\partial t},$$

from where we immediately find the wave equation:

$$\nabla^2 \vec{E} = \mu_0 \varepsilon_0 \left(1 - \frac{\omega_{pd}{}^2}{\omega^2 - \omega_0{}^2} \right) \frac{\partial^2 \vec{E}}{\partial t^2}.$$

If one considers that

$$\mu_0 \varepsilon_0 = \frac{1}{c^2}$$

where c - speed of light, then no longer will remain doubts about the fact that with the propagation of electromagnetic waves in the dielectrics the frequency dispersion of phase speed will be observed. But this dispersion will be connected not with the fact that this material parameter as dielectric constant, it depends on frequency. In the formation of this dispersion it will participate immediately three, which do not depend on the frequency, physical quantities: the self-resonant frequency of atoms themselves or molecules, the plasma frequency of charges, if we consider it their free, and the dielectric constant of vacuum.

Now let us show, where it is possible to be mistaken, if with the solution of the examined problem of using a concept of polarization vector. Let us introduce this polarization vector

$$\vec{P} = -\frac{ne^2}{m}\cdot\frac{1}{(\omega^2-\omega_0^2)}\vec{E}.$$

Its dependence on the frequency, is connected with the presence of mass in the charges, entering the constitution of atom and molecules of dielectrics. The inertness of charges is not allowed for this vector, following the electric field, to reach that value, which it would have in the permanent fields. Since the electrical induction is determined by the relationship:

$$\vec{D}=\varepsilon_0\vec{E}+\vec{P}\vec{E}=\varepsilon_0\vec{E}-\frac{ne^2}{m}\cdot\frac{1}{(\omega^2-\omega_0^2)}\vec{E}, \qquad (9.8)$$

that, introduced thus, it depends on frequency.

If the vector $\vec{D}$ was introduced into the second Maksvell equation, then it will take the form:

$$rot\vec{H}=j_{\Sigma}=\varepsilon_0\frac{\partial\vec{E}}{\partial t}+\frac{\partial\vec{P}}{\partial t}$$

or

$$rot\vec{H}=j_{\Sigma}=\varepsilon_0\frac{\partial\vec{E}}{\partial t}-\frac{ne^2}{m}\frac{1}{(\omega^2-\omega_0{}^2)}\frac{\partial\vec{E}}{\partial t}, \qquad (9.9)$$

where j_{Σ} - the summed current, which flows through the model. In expression (9.9) the first member of right side presents bias current in the vacuum, and the second - current, connected with the presence of bound charges in atoms or molecules of dielectric. In this expression again appeared the specific kinetic inductance of the charges, which participate in the oscillating process

$$L_{kd} = \frac{m}{ne^2} .$$

This kinetic inductance determines the inductance of bound charges. Taking into account this relationship (9.9) it is possible to rewrite

$$rot\vec{H} = j_{\Sigma} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{1}{L_{kd}} \frac{1}{(\omega^2 - \omega_0^2)} \frac{\partial \vec{E}}{\partial t},$$

obtained expression exactly coincides with relationship (9.3). Consequently, the eventual result of examination by both methods coincides, and there are no claims to the method from a mathematical point of view. But from a physical point of view are large claims, which we already discussed. Is certain, this not electrical induction, but the certain composite parameter. But, without having been dismantled at the essence of a question, all, until now, consider that the dielectric constant of dielectrics depends on frequency. In the essence, physically substantiated is the introduction to electrical induction in the dielectrics only in the static electric fields.

Let us show that the equivalent the schematic of dielectric presents the sequential resonant circuit, whose inductance is the kinetic inductance L_{kd}, and capacity is equal to the static dielectric constant of dielectric minus the capacity of the equal dielectric constant of vacuum. In this case outline itself proves to be that shunted by the capacity, equal to the specific dielectric constant of vacuum. For the proof of this let us examine the sequential oscillatory circuit, when the inductance L and the capacity C are connected in series.

The connection between the current I_C, which flows through the capacity C, and the voltage U_C, applied to it, is determined by the relationships:

$$U_C = \frac{1}{C}\int I_C dt$$

and

$$I_C = C\frac{dU_C}{dt}. \qquad (9.10)$$

This connection will be written down for the inductance:

$$I_L = \frac{1}{L}\int U_L dt$$

and

$$U_L = L\frac{dI_L}{dt}.$$

If the current, which flows through the series circuit, changes according to the law $I = I_0 \sin \omega t$, then a voltage drop across inductance and capacity they are determined by the relationships

$$U_L = \omega L I_0 \cos \omega t$$

and

$$U_C = -\frac{1}{\omega C} I_0 \cos \omega t,$$

and total stress applied to the outline is equal

$$U_\Sigma = \left(\omega L - \frac{1}{\omega C}\right) I_0 \cos \omega t.$$

In this relationship the value, which stands in the brackets, presents the reactance of sequential resonant circuit, which depends on frequency. The stresses, generated on the capacity and the inductance, are located in the reversed phase, and, depending on frequency, outline can have the inductive, the whether capacitive reactance. At the point of resonance the summary reactance of outline is equal to zero.

It is obvious that the connection between the total voltage applied to the outline and the current, which flows through the outline, will be determined by the relationship

$$I=-\frac{1}{\omega\left(\omega L-\frac{1}{\omega C}\right)}\frac{\partial U_{\Sigma}}{\partial t}. \qquad (9.11)$$

The resonance frequency of outline is determined by the relationship

$$\omega_0=\frac{1}{\sqrt{LC}},$$

therefore let us write down

$$I=\frac{C}{\left(1-\frac{\omega^2}{\omega_0{}^2}\right)}\frac{\partial U_{\Sigma}}{\partial t}. \qquad (9.12)$$

Comparing this expression with relationship (9.10) it is not difficult to see that the sequential resonant circuit, which consists of the inductance L and capacity C, it is possible to present to the capacity ofin the form dependent on the frequency

$$C(\omega)=\frac{C}{\left(1-\frac{\omega^2}{\omega_0{}^2}\right)}. \qquad (9.13)$$

This idea does not completely mean that the inductance is somewhere lost. Simply it enters into the resonance frequency of the outline ω_0. Relationship (9.12) this altogether only the mathematical form of the record of relationship (9.11). Consequently, this is $C(\omega)$ the certain composite mathematical parameter, which is not the capacity of outline.

Relationship (6.7) can be rewritten and differently:

$$I = -\frac{1}{L\left(\omega^2 - \omega_0{}^2\right)}\frac{\partial U_\Sigma}{\partial t}$$

and to consider that

$$C(\omega) = -\frac{1}{L\left(\omega^2 - \omega_0{}^2\right)}. \tag{9.14}$$

is certain, the parameter $C(\omega)$, introduced in accordance with relationships (9.13) and (9.14) no to capacity refers.

Let us examine relationship (9.12) for two limiting cases:

1) When $\omega \ll \omega_0$, we have

$$I = C\frac{\partial U_\Sigma}{\partial t}.$$

This result is intelligible, since. at the low frequencies the reactance of the inductance, connected in series with the capacity, is considerably lower than the capacitive and it is possible not to consider it.

the equivalent the schematic of the dielectric, located between the planes of long line is shown in Fig. 5.

2 For the case when $\omega \gg \omega_0$, we have

$$I = -\frac{1}{\omega^2 L}\frac{\partial U_\Sigma}{\partial t}. \tag{9.15}$$

Taking into account that for the harmonic signal

$$\frac{\partial U_\Sigma}{\partial t} = -\omega^2 \int U_\Sigma dt,$$

from (9.1) obtain

$$I_L = \frac{1}{L}\int U_\Sigma dt.$$

In this case the reactance of capacity is considerably less than in inductance and chain has inductive reactance.

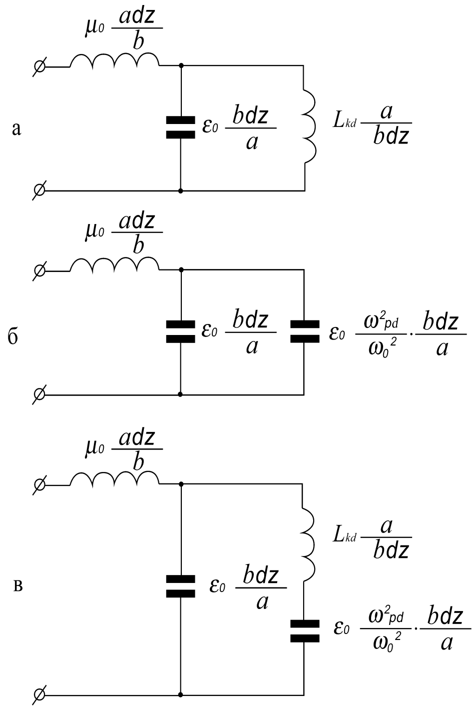

Fig. 5

а- equivalent the schematic of the section of the line, filled with dielectric, for the case $\omega \ll \omega_0$;

б - the equivalent the schematic of the section of line for the case $\omega \gg \omega_0$;

в - the equivalent the schematic of the section of line for entire frequency band.

The carried out analysis speaks, that is in practice very difficult to distinguish the behavior of resonant circuits of the inductance or of the capacity. In order to understand the true composition of the chain being investigated it is necessary to remove the amplitude and phase response of this chain in the range of frequencies. In the case of resonant circuit this dependence will have the typical resonance nature, when on both sides resonance the nature of reactance is different. However, this does not mean that real circuit elements: capacity or inductance depend on frequency.

in Fig. 5 (a) and 5 (б) are shown two limiting cases. In the first case, when $\omega \gg \omega_0$, dielectric according to its properties corresponds to conductor, in the second case, when $\omega \ll \omega_0$, it corresponds to the dielectric, which possesses the static dielectric constant $\varepsilon = \varepsilon_0 \left(1 + \frac{\omega_{pd}^2}{\omega_0^2} \right)$.

Thus, it is possible to make the conclusion that the introduction, the depending on the frequency dielectric constants of dielectrics, are physical and terminological error. If the discussion deals with the dielectric constant of dielectrics, with which the accumulation of potential energy is connected, then the discussion can deal only with the static permeability. And precisely this parameter as the constant, which does not depend on the frequency, enters into all relationships, which characterize the electrodynamic characteristics of dielectrics.

The most interesting results of applying such new approaches occur precisely for the dielectrics. In this case each connected pair of charges presents the separate unitary unit with its individual characteristics and its participation in the processes of interaction with the electromagnetic field (if we do not consider the connection between the separate pairs) strictly individually. Should be still one important circumstance, which did not up to now obtain proper estimation. With the examination of processes in the material media, which they are both conductors and dielectrics in all relationships together with the dielectric and magnetic constant figures the kinetic inductance of charges [13].

CHAPTER 3.
NEW PROCEDURES AND THE CONCEPTS

§ 10. Surface kinetic inductance

Until now, was considered that the kinetic inductance most effectively can appear only in the superconductors, and it was introduced by phenomenological method. But in the electrodynamics of conducting media, besides volumetric kinetic inductance, it is possible to introduce still and the concept of surface kinetic inductance, after enlarging by such means of the limit of the applicability of this term.

If there is a material medium, to boundary of which the plane electromagnetic wave will give, then some part of the energy of this wave passes into the material medium, and some is reflected. The process of the propagation of wave in medium itself is connected with its properties. For the introduction to surface kinetic inductance let us examine the case, when the frequency of the incident wave is considerably lower than the plasma [2].

The Maxwell equations for the complex amplitudes pour on in this case they will be written down as follows:

$$\begin{gathered} rot\vec{E} = -i\omega\mu_0\vec{H}, \quad rot\vec{H} = \vec{j} \\ div\vec{E} = 0, \quad div\vec{H} = 0 \end{gathered} . \qquad (10.1)$$

here and throughout the law of variation in the electromagnetic field is undertaken in the form $e^{i\omega t}$.

The surface resistance R and the surface reactance X are the numerical characteristics, which establish the connection between the tangential components of electrical and magnetic field on the surface, and those also determining the energy characteristics of interaction of surface with the electromagnetic field. They also determine the energy characteristics of interaction of surface with the electromagnetic field. The complex amplitudes of tangential components pour on on the surface they are connected with the relationship

$$E_T = ZH_T,$$

from which it is not difficult to obtain the connection between the real fields on the surface

$$|\tilde{E}_T| = |Z||\tilde{H}_T|\cos(\omega t + \varphi)$$

$$Z = \frac{E_x(0)}{H_y(0)} = i\omega\mu_0 \frac{1}{H_y(0)} \int_0^\infty H_y(z)dz$$

here Z - surface impedance of surface. It from this, that the module of surface impedance gives the ratio of the amplitudes of the tangential components of electrical and magnetic pour on on the surface, and phase - phase displacement between them.

For establishing the connection R and X with the energy characteristics of surface layer let us take the single section of surface, for which are the Leontovich valid boundary conditions. Let us multiply first equation (10.4) by $\vec{H}^*$, and the second to $\vec{E}$ and let us piecemeal deduct one of another. After simple conversions we will obtain

$$div\vec{P} = -\frac{1}{2}\vec{j}^*\vec{E} - i\omega\frac{\mu_0|\vec{H}|^2}{2}, \qquad (10.2)$$

where of $\vec{P} = \frac{1}{2}\left[\vec{E}\times\vec{H}^*\right]$ - complex the Poynting vector.

Integrating (10.2) by the volume, which lies under the single area after the conversion of left side from the formula of gauss let us find

$$\int_S \vec{P}d\vec{S} = -\frac{1}{2}\int_V \vec{j}^*\vec{E}dSdz - i2\omega\int_V \frac{\mu_0|\vec{H}|^2}{4}dSdz, \qquad (10.3)$$

where the integration is conducted according to the surface of the chosen area, and element of volume is recorded in the form $dSdz$.

We will consider that in the limits of the chosen area are small changes pour on in the tangential direction, and also that these fields become zero with $z \to \infty$.

In the surface integral in equation (10.3) is accepted $\vec{P}d\vec{S} = -\vec{P}\vec{n}dS = -P_n dS$, where the vector $\vec{n}$ is directed into the depths of the medium in question. In relationship (10.3) are essential only tangential components of $\vec{E}$ and $\vec{H}$ and, taking into account that

$$\left[\vec{E}_T \times H_T^{\ *}\right] = Z\,|\,\vec{H}_T\,|^2\,\vec{n},$$

this equation is reduced to the form:

$$\frac{1}{2}Z\,|\,\vec{H}_T(0)\,|^2 = \frac{1}{2}\int_0^\infty \vec{j}^{\,*}\vec{E}dz + i2\omega\int_0^\infty \frac{\mu_0\,|\,\vec{H}\,|^2}{4}dz. \quad (10.4)$$

After isolating the real part of this equality, we will obtain:

$$P_R = \frac{1}{2}R\,|\,H_T(0)\,|^2 = \mathrm{Re}\frac{1}{2}\int_0^\infty \vec{j}^{\,*}\vec{E}dz,$$

where P_R - average power of losses to the single square of surface.

Separating the imaginary part of equation (10.4), we find:

$$P_X = \frac{1}{2}X\,|\,\vec{H}_T(0)\,|^2 = \mathrm{Im}\frac{1}{2}\int_0^\infty \vec{j}^{\,*}\vec{E}dz + 2\omega\int_0^\infty \frac{\mu_0\,|\,\vec{H}\,|^2}{4}dz,$$

where P_X - average reactive power, which falls to the single square of surface.

Is evident that the reactive power consists of two members. The first of them represents the reactive power, connected with the kinetic energy of current carriers, and the second - gives the reactive power, connected with the presence on Wednesday of magnetic field.

Boundary conditions:

$$\vec{E}_T(0) = Z\left[\vec{H}_T(0)\times\vec{n}\right],$$

where $Z = R + iX$, if we count $\tilde{E}_T$ and $\tilde{H}_T$ by real values pour on, it is possible to write down in the form:

$$\tilde{E}_T = R\tilde{H}_T + L\frac{d\tilde{H}}{dt},$$

where $L = \dfrac{X}{\omega}$ - there is surface inductance of surface.

Now it is possible to introduce still and such new concepts as the kinetic and field surface of the inductance

$$L_K = \frac{1}{\omega |\vec{H}_T(0)|^2}\operatorname{Im}\int_0^\infty \vec{j}^{\,*}\vec{E}dz,$$

$$L_\Pi = \frac{1}{|\vec{H}_T(0)|^2}\int_0^\infty |\vec{H}_T|^2\, dz.$$

These relationships are valid for the case of the arbitrary connection between the current and the field both in the normal metals and in the superconductors.

The examination of kinetic processes in the conductors and the dielectrics revealed one interesting special feature. If the charges are free, then in this system only collective fluctuations can exist, with which all charges, which participate in the oscillating process, are completely equal. They all are found in one and the same energy state and, if we do not consider loss, then the sum of kinetic and potential energy at any moment of time in them is identical. This conclusion is completely valid for the case of superconductors and cold plasma.

§ 11. Electrical self-induction

To the laws of self-induction should be carried those laws, which describe the reaction of such elements of radio-technical chains as capacity, inductance and resistance with the galvanic connection to them of the sources of current or voltage. These laws are the basis of the theory of electrical chains. The results of this theory can be postponed also by the electrodynamics of material media, since. such media can be represented in the form equivalent diagrams with the use of such elements.

the motion of charges in any chain, which force them to change their position, is connected with the energy consumption from the power sources. The processes of interaction of the power sources with such structures are regulated by the laws of self-induction.

Again let us refine very concept of self-induction. By self-induction we will understand the reaction of material structures with the constant parameters to the connection to them of the sources of voltage or current. to the self-induction let us carry also that case, when its parameters can change with the presence of the connected power source or the energy accumulated in the system. This self-induction we will call parametric [11]. Subsequently we will use these concepts: as current generator and the voltage generator. By ideal voltage generator we will understand such source, which ensures on any load the lumped voltage, internal resistance in this generator equal to zero. By ideal current generator we will understand such source, which ensures in any load the assigned current, internal resistance in this generator equally to infinity. The ideal current generators and voltage in nature there does not exist, since both the current generators and the voltage generators have their internal resistance, which limits their possibilities.

If we to one or the other network element connect the current generator or voltage, then opposition to a change in its initial state is the response reaction of this element and this opposition is always equal to the applied action, which corresponds to third Newton's law.

if at our disposal is located the capacity C, and this capacity is charged to a potential difference U, then the charge Q, accumulated in the capacity, is determined by the relationship:

$$Q_{C,U} = CU. \tag{11.1}$$

The charge $Q_{C,U}$, depending on the capacitance values of capacitor and from a voltage drop across it, we will call still the flow of electrical self-induction.

When the discussion deals with a change in the charge, determined by relationship (11.1), then this value can change with the method of changing the potential difference with a constant capacity, either with a change in capacity itself with a constant potential difference, or and that and other parameter simultaneously.

If capacitance value or voltage drop across it depend on time, then the current strength is determined by the relationship:

$$I = \frac{dQ_{C,U}}{dt} = C\frac{\partial U}{\partial t} + U\frac{\partial C}{\partial t}.$$

This expression determines the law of electrical self-induction. Thus, current in the circuit, which contains capacitor, can be obtained by two methods, changing voltage across capacitor with its constant capacity either changing capacity itself with constant voltage across capacitor, or to produce change in both parameters simultaneously.

For the case, when the capacity C_1 is constant, we obtain known expression for the current, which flows through the capacity:

$$I = C_1\frac{\partial U}{\partial t}. \tag{11.2}$$

When capacity with the constant stress on it changes, we have:

$$I = U_1 \frac{\partial C}{\partial t}. \qquad (11.3)$$

This case to relate to the parametric electrical self-induction, since the presence of current is connected with a change in this parameter as capacity.

Let us examine the consequences, which escape from relationship (11.2). If we to the capacity connect the direct-current generator I_0, then stress on it will change according to the law:

$$U = \frac{I_0 t}{C_1}. \qquad (11.4)$$

Thus, the capacity, connected to the source of direct current, presents for it the effective resistance

$$R = \frac{t}{C_1}, \qquad (11.5)$$

which linearly depends on time. The it should be noted that obtained result is completely obvious; however, such properties of capacity, which customary to assume by reactive element they were for the first time noted in the work [11].

This is understandable from a physical point of view, since in order to charge capacity, source must expend energy.

The power, output by current source, is determined in this case by the relationship:

$$P(t) = \frac{I_0^2 t}{C_1}. \qquad (11.6)$$

The energy, accumulated by capacity in the time t, we will obtain, after integrating relationship (11.6) with respect to the time:

$$W_C = \frac{I_0^2 t^2}{2C_1}.$$

Substituting here the value of current from relationship (11.4), we obtain the dependence of the value of the accumulated in the capacity energy from the instantaneous value of stress on it:

$$W_C = \frac{1}{2} C_1 U^2 .$$

Using for the case examined a concept of the flow of the electrical induction

$$\Phi_U = C_1 U = Q(U) \tag{11.7}$$

and using relationship (11.2), obtain:

$$I_0 = \frac{d\Phi_U}{dt} = \frac{\partial Q(U)}{\partial t} , \tag{11.8}$$

i.e., if we to a constant capacity connect the source of direct current, then the current strength will be equal to the derivative of the flow of capacitive induction on the time.

Now we will support at the capacity constant stress U_1, and change capacity itself, then

$$I = U_1 \frac{\partial C}{\partial t} . \tag{11.9}$$

It is evident that the value

$$R_C = \left(\frac{\partial C}{\partial t} \right)^{-1} \tag{11.10}$$

plays the role of the effective resistance [11]. This result is also physically intelligible. This result is also physically intelligible, since. with an increase in the capacitance increases the energy accumulated in it, and thus, capacity extracts in the voltage source energy, presenting for it resistive load. The power, expended in this case by source, is determined by the relationship:

$$P(t) = \frac{\partial C}{\partial t} U_1^2 \qquad (11.11)$$

from relationship (11.11) is evident that depending on the sign of derivative the expendable power can have different signs. When the derived positive, expendable power goes for the accomplishment of external work. If derived negative, then external source accomplishes work, charging capacity.

Again, introducing concept the flow of the electrical induction

$$\Phi_C = CU_1 = Q(C),$$

obtain

$$I = \frac{\partial \Phi_C}{\partial t} \ . \qquad (11.12)$$

Relationships (11.8) and (11.12) indicate that regardless of the fact, how changes the flow of electrical self-induction (charge), its time derivative is always equal to current.

Let us examine one additional process, which earlier the laws of induction did not include, however, it it falls under for our extended determination of this concept. From relationship (11.7) it is evident that if the charge, left constant (we will call this regime the regime of the frozen electric flux), then stress on the capacity can be changed by its change. In this case the relationship will be carried out:

$$CU = C_0 U_0 = const\,,$$

where C and U - instantaneous values, and C_0 and U_0 - initial values of these parameters.

The stress on the capacity and the energy, accumulated in it, will be in this case determined by the relationships:

$$U = \frac{C_0 U_0}{C}, \qquad (11.13)$$

$$W_C = \frac{1}{2}\ \frac{\left(C_0 U_0\right)^2}{C}\ .$$

It is natural that this process of self-induction can be connected only with a change in capacity itself, and therefore it falls under for the determination of parametric self-induction.

Thus, are located three relationships (11.8), (11.12) and (11.13), which determine the processes of electrical self-induction. We will call their rules of the electric flux. Relationship (11.8) determines the electrical self-induction, during which there are no changes in the capacity, and therefore this self-induction can be named simply electrical self-induction. Relationships (11.3) and (11.9-11.11) assume the presence of changes in the capacity; therefore the processes, which correspond by these relationships, we will call electrical parametric self-induction.

§ 12. Current self-induction

Let us now move on to the examination of the processes, proceeding in the inductance. Let us introduce the concept of the flow of the current self-induction

$$\Phi_{L,I} = LI\ .$$

If inductance is shortened outed, and made from the material, which does not have effective resistance, for example from the superconductor, then

$$\Phi_{L,I} = L_1 I_1 = const\ ,$$

where L_1 and I_1- initial values of these parameters, which are located at the moment of the short circuit of inductance with the presence in it of current. This regime we will call the regime of the frozen flow [11]. In this case the relationship is fulfilled:

$$I = \frac{I_1 L_1}{L}, \qquad (12.1)$$

where I and L - the instantaneous values of the corresponding parameters.

In flow regime examined of current induction remains constant, however, in connection with the fact that current in the inductance it can change with its change, this process falls under for the determination of parametric self-induction. The energy, accumulated in the inductance, in this case will be determined by the relationship

$$W_L = \frac{1}{2}\frac{\left(L_1 I_1\right)^2}{L} = \frac{1}{2}\frac{(const)^2}{L}.$$

Stress on the inductance is equal to the derivative of the flow of current induction on the time:

$$U = \frac{d\Phi_{L,I}}{dt} = L\frac{\partial I}{\partial t} + I\frac{\partial L}{\partial t}.$$

let us examine the case, when the inductance of is constant. L_1

$$U = L_1 \frac{\partial I}{\partial t}. \qquad (12.2)$$

designating $\Phi_I = L_1 I$, we obtain $U = \frac{d\Phi_I}{dt}$. After integrating expression (12.2) on the time, we will obtain:

$$I = \frac{Ut}{L_1}. \qquad (12.3)$$

Thus, the capacity, connected to the source of direct current, presents for it the effective resistance

$$R = \frac{L_1}{t}, \tag{12.4}$$

which decreases inversely proportional to time.

The power, expended in this case by source, is determined by the relationship:

$$P(t) = \frac{U^2 t}{L_1} \ . \tag{12.5}$$

This power linearly depends on time. After integrating relationship (12.5) on the time, we will obtain the energy, accumulated in the inductance of

$$W_L = \frac{1}{2}\frac{U^2 t^2}{L_1}. \tag{12.6}$$

After substituting into expression (12.6) the value of stress from relationship (12.3), we obtain:

$$W_L = \frac{1}{2} L_1 I^2 .$$

This energy can be returned from the inductance into the external circuit, if we open inductance from the power source and to connect effective resistance to it.

Now let us examine the case, when the current I_1, which flows through the inductance, is constant, and inductance itself can change. In this case we obtain the relationship

$$U = I_1 \frac{\partial L}{\partial t}. \tag{12.7}$$

Thus, the value

$$R(t) = \frac{\partial L}{\partial t} \tag{12.8}$$

plays the role of the effective resistance [11]. As in the case the electric flux, effective resistance can be (depending on the sign of derivative) both positive and negative. This means that the inductance can how derive energy from without, so also return it into the external circuits.

Introducing the designation $\Phi_L = LI_1$ and, taking into account (12.7), we obtain:

$$U = \frac{d\Phi_L}{dt}. \qquad (12.9)$$

Of relationship (12.1), (12.6) and (12.9) we will call the rules of current self-induction, or the flow rules of current self-induction. From relationships (12.6) and (12.9) it is evident that, as in the case with the electric flux, the method of changing the flow does not influence eventual result, and its time derivative is always equal to the applied potential difference. Relationship (12.6) determines the current self-induction, during which there are no changes in the inductance, and therefore it can be named simply current self-induction. Relationships (12.7,12.8) assume the presence of changes in the inductance; therefore we will call such processes current parametric self-induction.

§ 13. New method of obtaining the wave equation, the potential and kinetic flows of charges

The processes, examined in two previous paragraphs, concern chains with the lumped parameters, when the distribution of potential differences and currents in the elements examined can be considered uniform. However, there are chains, for example the long lines, into which potential differences and currents are not three-dimensional uniform. These processes are described by the wave equations, which can be obtained from Maxwell equations or with the aid of the telegraphic equations, but physics of phenomenon itself in these processes to us is not clear.

We will use the results, obtained in the previous paragraph, for examining the processes, proceeding in the long lines, in which the capacity and inductance are the distributed parameters. Let us assume that linear (falling per unit of length) capacity and inductance of this line are equal C_0 and L_0. If we to this line connect the dc power supply U_1, then its front will be extended in the line some by the speed v, and the moving coordinate of this front will be determined by the relationship $z = vt$. In this case the summary charged capacity and the summary inductance, along which flows the current, will change according to the law [11]:

$$C(t) = zC_0 = vt\ C_0,$$

$$L(t) = zL_0 = vt\ L_0.$$

The source of voltage U_1 will in this case charge the being increased capacity of line, for which from the source to the charged line in accordance with relationship (11.9) must leak the current:

$$I_1 = U_1 \frac{\partial C(t)}{\partial t} = vU_1C_0. \tag{13.1}$$

This current there will be the leak through the conductors of line, that possess inductance. But, since the inductance of line in connection with the motion of the front of stress, also increases, in accordance with relationship (12.7), on it will be observed a voltage drop:

$$U = I_1 \frac{\partial L(t)}{\partial t} = vI_1L_0 = v^2U_1C_0L_0.$$

But a voltage drop across the conductors of line in the absolute value is equal to the stress, applied to its entrance; therefore in the last expression should be placed $U = U_1$. We immediately find taking this into account that the rate of the motion of the front of stress with the assigned linear parameters and when, on, the incoming line of constant stress of is present, must compose

$$v = \frac{1}{\sqrt{L_0C_0}}. \tag{13.2}$$

This expression corresponds to the signal velocity in line itself. Consequently, if we to the infinitely long line connect the voltage source, then in it will occur the self-expansion of electrical pour on and the currents, which fill line with energy. It is interesting to note that the obtained result does not depend on the form of the function U_1, i.e., to the line can be connected both the dc power supply and the source, whose voltage changes according to any law. In all these cases the value of the local value of voltage on incoming line will be extended along it with the speed, which follows from relationship (13.2). This result was obtained previously only by method of solution of wave equation. This examination indicates the physical cause for this propagation, and it gives the physical picture of process itself. Examination shows that very process of propagation is connected with the energy processes of the filling of line with electrical and current energy. This process occurs in such a way that the wave front, being extended with the speed of v, leaves after itself the line, charged to a potential difference U_1, which corresponds to the filling of line with electrostatic electric field energy. However, in the section of line from the voltage source also to the wave front flows the current I_1, which corresponds to the filling of line in this section with energy, which is connected with the motion of the charges along the conductors of line, which possess inductance.

The current strength in the line can be obtained, after substituting the values of the velocity of propagation of the wave front, determined by relationship (13.2), into relationship (13.1). After making this substitution, we will obtain

$$I_1 = U_1\sqrt{\frac{C_0}{L_0}},$$

where $Z = \sqrt{\frac{L_0}{C_0}}$ - line characteristic.

In this case

$$U_1 = I\ \frac{\partial L}{\partial t} = \frac{d\Phi_L}{dt}.$$

So accurately

$$I_1 = U_1 \frac{\partial C}{\partial t} = \frac{d\Phi_C}{dt}.$$

It is evident that the flow rules both for the electrical and for the current self-induction are observed also in this case.

Thus, the processes of the propagation of a potential difference along the conductors of long line and current in it are connected and mutually supplementing each other, and to exist without each other they do not can. This process can be called electric-current spontaneous parametric self-induction. This name connected with the fact that flow expansion they occur arbitrarily and characterizes the rate of the process of the filling of line with energy. From the aforesaid the connection between the energy processes and the velocity of propagation of the wave fronts in the long lines becomes clear.

That will, for example, when as one of the conductors of long line take it did compress? Obviously, in this case the velocity of propagation of the front of stress in this line will decrease, since the linear inductance of line will increase. This propagation will accompany the process of the propagation not only of external with respect to the solenoid pour on and currents, but both the process of the propagation of magnetic flux inside the solenoid itself and the velocity of propagation of this flow will be equal to the velocity of propagation of electromagnetic wave in line itself.

Knowing current and voltage in the line, it is possible to calculate the specific energy, concluded in the linear capacity and the inductance of line. These energies will be determined by the relationships:

$$W_C = \frac{1}{2} C_0 U_1^2, \qquad (13.3)$$

$$W_L = \frac{1}{2} L_0 I_1^{\,2} . \qquad (13.4)$$

it is not difficult to see that $W_C = W_L$.

Now let us discuss a question about the duration of the front of electric-current wave and about which space will occupy this front in line itself. Answer to the first question is determined by the properties of the very voltage source, since local derivative $\frac{\partial U}{\partial t}$ at incoming line depends on transient processes in the source itself and in that device, with the aid of which this source is connected to the line. If the process of establishing the voltage on incoming line will last some time Δt, then in the line it will engage section with the length $v\Delta t$. If we to the line exert the stress, which is changed with the time according to the law $U(t)$, then the same value of function will be observed at any point of the line at a distance z rel.un. of beginning with the delay $t = \frac{z}{v}$. Thus, the function of

$$U(t,z) = U\left(t - \frac{z}{v}\right) \qquad (13.5)$$

can be named propagation function, since. it establishes the connection between the local temporary and three-dimensional values of function in the line. Long line is the device, which converts local derivative stresses on the time on incoming line into the gradients in line itself. On the basis propagation function (13.5) it is possible to establish the connection between the local and gradients in the long line. It is obvious that

$$\frac{\partial U(z)}{\partial z} = \frac{1}{v} \frac{\partial U(t)}{\partial t} .$$

Let us note the fact that for solving the wave equations of the long lines

$$\frac{\partial^2 U}{\partial z^2} = \frac{1}{v^2}\ \frac{\partial^2 U}{\partial t^2}$$
$$\frac{\partial^2 I}{\partial z^2} = \frac{1}{v^2}\ \frac{\partial^2 I}{\partial t^2} \qquad (13.6)$$

obtained from the telegraphic equations

$$\frac{\partial U}{\partial z} = -L\ \frac{\partial I}{\partial t}$$
$$\frac{\partial I}{\partial z} = -C\ \frac{\partial U}{\partial t},$$

the knowledge second derivative voltages and currents is required.

But what is to be done, if to incoming line is supplied voltage, whose second derivative is equal to zero (case, when the voltage of source it does change according to the linear law)? Answer to this question equation (13.6) they do not give. The utilized method gives answer also to this question.

With the examination of processes in the long line figured such concepts as linear capacity and inductance, and also currents and stress in the line. However, in the electrodynamics, based on the Maxwell equations, there are no such concepts as capacity and inductance, and there are concepts of the electrical and magnetic permeability of medium. In the carried out examination such concepts as electrical and magnetic fields also was absent. Let us show how to pass from such categories as linear inductance and capacity, current and stress in the line to such concepts as dielectric and magnetic constant, and also electrical and magnetic field. For this let us take the simplest construction of line, located in the vacuum, as shown in Fig. 2. We will consider that $b \gg a$ and edge effects it is possible not to consider. Then the following connection will exist between the linear parameters of line and the magnetic and dielectric constants:

$$L_0 = \mu_0 \frac{a}{b} \qquad (13.7)$$

$$C_0 = \varepsilon_0 \frac{b}{a}, \tag{13.8}$$

where μ_0 and ε_0 - dielectric and magnetic constant of vacuum.

The phase speed in this line will be determined by the relationship:

$$v = \frac{1}{\sqrt{L_0 C_0}} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = c,$$

where c - velocity of propagation of light in the vacuum.

The wave drag of the line examined will be equal

$$Z = \frac{a}{b}\sqrt{\frac{\mu_0}{\varepsilon_0}} = \frac{a}{b} Z_0,$$

where $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ - wave drag of free space.

This with the observance of the condition $a = b$ we obtain the equality $L_0 = \mu_0$. This means that magnetic permeability μ_0 plays the role of the longitudinal specific inductance of vacuum. In this case is observed also the equality $C_0 = \varepsilon_0$. This means that the dielectric constant ε_0 plays the role of the transverse specific capacity of vacuum. In this interpretation both μ_0 and ε_0 acquire clear physical sense.

The examination of electromagnetic wave in the long line can be considered as filling of space, which is been located between its conductors, special form of material, which present the electrical and magnetic fields. Mathematically it is possible to consider that these fields themselves possess specific energy and with their aid it is possible to transfer energy by the transmission lines.

If we to the examined line of infinite length, or of line of that loaded with wave drag, connect the dc power supply U, then the field strength in the line will comprise:

$$E_y = \frac{U}{a},$$

and the current, which flows into the line from the power source, will be determined by the relationship:

$$I = \frac{U}{Z} = \frac{aE_y}{Z}. \quad (13.9)$$

Magnetic field in the line will be equal to the specific current, flowing in the line

$$H_x = \frac{I}{b} = \frac{aE_y}{bZ}.$$

substituting here the value Z, we obtain

$$H_x = \frac{E_y}{Z_0}. \quad (13.10)$$

The same connection between the electrical and magnetic field exists also for the case of the transverse electromagnetic waves, which are extended in the free space.

Comparing expressions for the energies, it is easy to see that the specific energy can be expressed through the electrical and magnetic fields

$$\frac{1}{2}\mu_0 H_x{}^2 = \frac{1}{2}\varepsilon_0 E_y{}^2. \quad (13.11)$$

This means that the specific energy, accumulated in the magnetic and electric field in this line is identical. If the values of these energies are multiplied by the volumes, occupied by fields, then the obtained values coincide with expressions (13.3-13.4).

thus, it is possible to make the conclusion that in the line examined are propagated the same transverse plane waves, as in the free space. Moreover this conclusion is obtained not by the method of solution the Maxwell equations, but by the way of examining the dynamic processes, which are related to the discharge of parametric self-induction. The special feature of this line will be the fact that in it, in contrast to the free space, the stationary magnetic and electric fields can be extended, but this case cannot be examined by the method of solution of Maxwell's equations.

If we to the line exert the stress, which is changed in the course of time according to any law $U(t) = aE_y(t)$, the like of analogy (13.5) it is possible to write down

$$E_y(z) = E_y\left(t - \frac{z}{c}\right). \qquad (13.12)$$

Analogous relationship will be also pour on for the magnetic.

Is obvious that the work $I(t)U(t)$ represents the power P, transferred through the cross section of line in the direction z. If in this relationship current and stress was replaced through the tensions of magnetic and electrical pour on, then we will obtain $P = abE_y H_x$. The work $E_y H_x$ represents the Poynting vector. Certainly, all these relationships can be written down also in the vector form.

Thus, all conclusions, obtained on the basis of the examination of processes in the long line by two methods, coincide. Therefore subsequently, without risking to commit the errors of fundamental nature, it is possible for describing the processes in the long lines successfully to use such parameters as the distributed inductance and capacity. Certainly, in this case one should understand that C_0 and this L_0 some integral characteristics, which do not consider structure pour on. It should be noted that from a practical point of view, the application of the parameters C_0 and L_0 has important significance, since. can be approximately solved the tasks, which with the aid of Maxwell equations cannot be solved. This, for example, the case, when spirals are the conductors of transmission line.

The importance of the obtained results consists in the fact that it is possible, without resorting to the Maxwell's equations, to solve the problems of propagation, is also shown that in the long lines and in the free space the electromagnetic processes are extended with the final speed.

The regularities indicated apply to all forms of transmission lines. For different types of lines the linear parameters depend on their sizes. For an example let us examine the coaxial line, whose linear capacity and inductance are expressed by the relationships:

$$C_0 = \frac{2\pi\varepsilon_0}{\ln\left(\frac{D}{d}\right)} \qquad L_0 = \frac{\mu_0}{2\pi}\ln\left(\frac{D}{d}\right)$$

where D and d the inside diameter of the cylindrical part of the coaxial and the outer diameter of central core respectively. The introduced linear parameters, can be named field, since the discussion deals with that energy, which is stored up in the electrical and magnetic fields. However, the circumstance is not considered with this approach that besides field inductance there is still a kinetic inductance, which is obliged to kinetic energy of the moving charges. In the real transmission lines kinetic inductance is not calculated on the basis of that reason, that their speed is small in view of the very high density of current carriers in the conductors and therefore field inductance always is considerably greater than kinetic.

with the current I, which flows along the center conductor of coaxial line, energy accumulated in the specific inductance and linear inductance are connected with the relationship

$$W_L = \frac{1}{2} L_0 I^2 = \frac{\mu_0}{4\pi} \ln\left(\frac{D}{d}\right) I^2$$

We will consider that the current is evenly distributed over the section of center conductor. Then kinetic energy of charges in the conductor of unit length composes

$$W_k = \frac{\pi d^2 nmv^2}{8} ,$$

where n, m, v - electron density, their mass and speed respectively.

If one considers that $I = \frac{nev\pi d^2}{4}$, then it is possible to write down

$$W_L = \frac{1}{2} L_0 I^2 = \frac{\mu_0}{4\pi} \ln\left(\frac{D}{d}\right) \frac{n^2 e^2 v^2 \pi^2 d^4}{16} .$$

From these relationships we obtain, that to the case, when

$$W_k \geq W_L ,$$

the condition corresponds

$$\frac{m}{ne^2} \geq \frac{\mu_0}{8} \ln\left(\frac{D}{d}\right) d^2$$

where $L_k = \frac{m}{ne^2}$ - specific kinetic inductance of charges.

Hence we find that the fulfillment of conditions is necessary for the kinetic beams

$$n \leq \frac{8m}{d^2 e^2 \mu_0}$$

in such a way that the flow would be kinetic, is necessary that the specific kinetic inductance would exceed linear inductance, which is carried out with the observance of the given condition. From this relationship it is possible to estimate, what electron density in the flow corresponds to this of the case.

Let us examine the concrete example: $d = 1\text{мм}$, $\ln\left(\frac{D}{d}\right) = 2$, then for the electron density in the beam must be satisfied the condition of

$$n \le \frac{8m}{e^2\mu_0 \ln\left(\frac{D}{d}\right) d^2} \approx 10^{-20}\frac{1}{\text{м}^3}.$$

Such densities are characteristic to electron beams, and they are considerably lower than electron density in the conductors. Therefore electron beams should be carried to the kinetic flows, while electronic current in the conductors they relate to the potential flows. Therefore for calculating the energy, transferred by electromagnetic fields they use the Poynting vector, and for calculating the energy, transferred by electron beams is used kinetic energy of separate charges. This all the more correctly, when the discussion deals with the calculation of the energy, transferred by ion beams, since. the mass of ions many times exceeds the mass of electrons.

Thus, the reckoning of the flows of charges to one or the other form depends not only on density and diameter of beam itself, but also on the diameter of that conducting tube, in which it is extended. It is obvious that in the case of potential beam, its front cannot be extended at a velocity, which exceeds the speed of light. It would seem that there are no such limitations for the purely kinetic beams. There is no clear answer to this question as yet. The mass of electron to usually connect with its electric fields and if we with the aid of the external conducting tube begin to limit these fields, then the mass of electron will begin to decrease, but the decrease of mass will lead to the decrease of kinetic inductance and beam will begin to lose its kinetic properties. And only when the part of the mass of electron does not have electrical origin, there is the hope to organize the purely kinetic electron beam, whose speed can exceed the speed of light. If we take the beam of protons, then picture will be the same. But here, if we take, for example, the nuclei of deuterium, which contain the neutron, whose mass is located, but electrical pour on no, then with the aid of such nuclei it is possible to organize purely kinetic beams, and it is possible to design for the fact that such beams can be driven away to the speeds of the large of the speed of light. If we let out this beam from the limiting tube into the free space, i.e. to attempt to convert it from the kinetic into the potential, then Cerenkov radiation of the type of that can be obtained, when electronic flux falls on Wednesday, where the phase speed of electromagnetic wave is lower than the speed of electron beam.

§ 14. Transient processes in the sections of the long lines

Faradey established the law of induction, carrying out experiments on the solenoids, including turning off in them current, or moving with respect to the solenoids the turns of the wire, to which was connected the galvanometer. Its point of view, which is considered accurate and today, was reduced to the fact that with the connection to the solenoid of the dc power supply U, then current in all its turns increases according to the linear law of

$$I = \frac{Ut}{L}, \tag{14.1}$$

where L - inductance of solenoid.

Consequently, magnetic field with this interpretation for entire elongation of solenoid will increase synchronous. However, so whether this in reality? In order to understand, so this, let us examine a question about how swelling current in the shortened out section of long line will.

If we the line, depicted to Fig. 2, short out at a distance z_1 of beginning, i.e. summary inductance will compose the value $L_\Sigma = z_1 L_0 = z_1 \frac{a}{b}\mu_0$. If we connect to the line dc power supply, in it will begin to be extended the wave of the voltage U and current $I = \frac{U}{Z}$ as shown in Fig. 6 . The wave of stress in its right part has the transition section z_2, which is named the front of the wave of stress. This section corresponds to the transit time $\tau = \frac{z_2}{c}$, for which the voltage of the source, connected to the line, attains its nominal value.

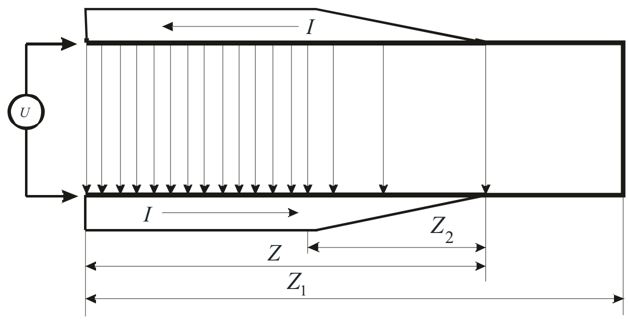

Fig. 6 . Propagation of the current wave and voltage in the long line.

Simultaneously with the wave of stress in the line will move current wave. Specifically, in this transition section proceeds the acceleration of the charges from the zero speed in its beginning, to the values necessary for creating the rated current in the line, whose value is determined by the relationship $I = \frac{U}{Z}$. To this section is applied the voltage of the power source. In this case it is accepted that during the voltage transient increases according to the linear law. It is accepted also that the time of this transient process is considerably less than the time, for which the front of stress passes along the line to one side. It is assumed that z_1 is considerably greater than z_2. At the moment of the time, when on the cross connection in the end of the line appears the front of the stress of appears the wave with the stress of reflected, which runs in the opposite direction. Since current in the wave reflected is equal to stress with the negative sign and it moves in the opposite direction, then the summed current, created by this wave will be equal $-\left(-\frac{U}{Z}\right)=\frac{U}{Z}$, i.e., it there will be leak in the same direction as the current of the incident wave. Thus, the wave reflected, moving in the opposite direction, will leave after itself current, equal $\frac{2U}{Z}$, and zero voltage. When the front of stress to return at the beginning to line, it brings with itself the state of the doubled initial current and zero voltage. Source will again send into the front line of the stress U and current $\frac{U}{Z}$. This current will be formed with the current $\frac{2U}{Z}$, and summed current in the line will compose $\frac{3U}{Z}$. Current will further increase by steps, adding each sequential time to its previous value the value $\frac{2U}{Z}$. This process is depicted in Fig. 7. In this figure the time

$$T=\frac{z_1}{c}=z_1\sqrt{L_0C_0}=z_1\sqrt{\mu_0\varepsilon_0}$$

it is equal to the time, for which the front of stress passes along the line to one side of beginning to the shortened out section.

The special feature of this process is that that the selection of energy from the voltage source will not be subordinated to linear law, but it will have spasmodic nature. The power, selected in the range of time from zero to $2T$, will be equal $\frac{U^2}{Z}$. But in each subsequent interval of the time, equal $2T$, it will grow already to the value $\frac{2U^2}{Z}$. Thus, the growth of current bears completely not linear, but spasmodic nature. The process indicated occurs with any length of line. With the small length of gallop they follow through the small time intervals and the dependence of current on the time approximately it is possible to consider it linear that also is characteristic for the elements with the lumped parameters.

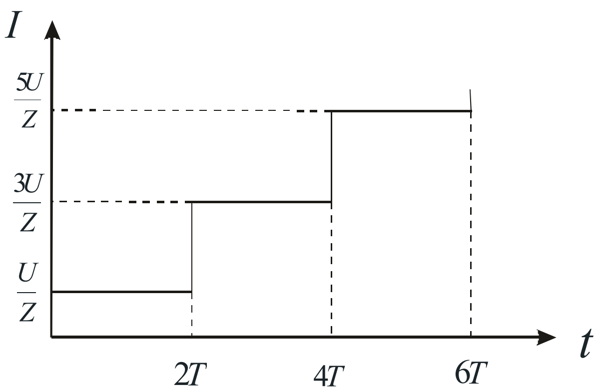

Fig. 7. Dependences of input current on the time for the shortened transmission line.

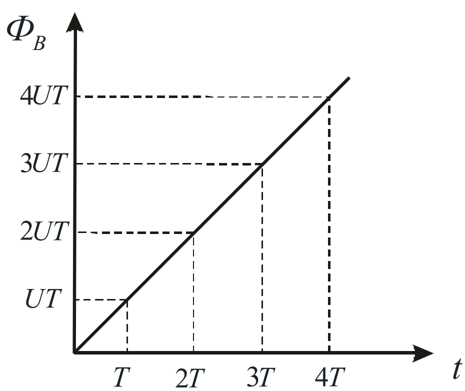

Fig. 8. Dependence of magnetic flux on the time for the shortened transmission line.

should be focused attention on the fact that, the power, selected by the shortened out line in the source of voltage (Fig. 7), it is not linear function, but after the time equal $2T$ abruptly it increases by $\frac{2U^2}{Z}$, the first of gallops corresponding to the selected power $\frac{U^2}{Z}$.

Is not difficult to show that the magnetic flux in this case changes according to the linear law (Fig. 8). Actually, during the forward stroke, to the moment of reaching by the wave of the shortened out section, flow will increase in the linear law, and up to the moment T it will reach the value

$$\Phi_B = \frac{z_1}{c} U .$$

When, after being reflected from the shortened out section, the front of stress will begin to move in the opposite direction, then flow will continue to grow according to the linear law, and up to the moment of the arrival of the front of stress at the voltage source it will conversely reach the value

$$\Phi_B = \frac{2z_1}{c} U .$$

Thus, with the connection of the shortened out line to the voltage source is carried out the law of induction $U = \frac{d\Phi_B}{dt}$.

The electric flux in the line will also change, but according to another law (Fig. 9

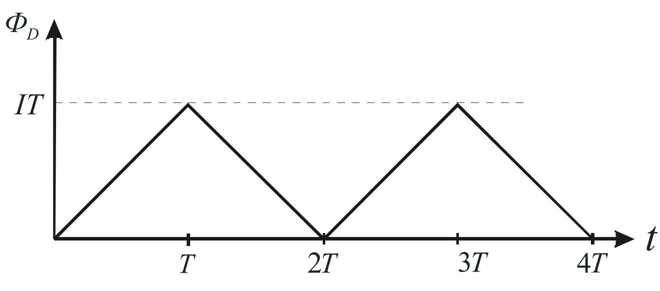

Fig. 9. Dependence of the electric flux on the time for the shortened transmission line.

In contrast to the magnetic flux it will change periodically, first, growing, then, diminishing, according to the linear law. When wave moves in the positive direction, simultaneously grows magnetic and electric flux. In this case, both in the magnetic and in the electric field stored energy grows. When wave begins to move in the opposite direction, then electric field begins to disappear, and its energy passes into the magnetic energy of reverse current wave. After the front of the wave of stress reaches incoming line, magnetic field and current in it doubles, and electric field disappears. Further cycle is repeated. Consequently, the process of the growth of magnetic flux in that shortened outed by long line, in the required order accompanies the process of an alternation in the flow of electrical induction, as a result of which between the planes of line periodically it appears and it disappears electric field.

Let us assume that line is made from superconductor and loss-free. Then after replacing at the specific moment the voltage generator with the superconductive cross connection, it is possible to freeze current in the line. The moment, when in the line electric field completely is absent is favorable moment for this procedure. Then in the line is frozen the flow $\Phi_B = \frac{2Nz_1}{c}U$, to which will correspond the current $I = \frac{2NU}{Z}$. What will be, if the voltage source by the superconductive cross connection was replaced at that moment of the time, when in the line is found the front of stress and what- t. e section it is filled with electric fields? In this case this section will move in the line, being alternately reflected thus one, thus another end of the shortened out line, until it spends its energy for the emission. Only integral (quantized) value of flow and current in accordance with the given relationships can be frozen for this reason in the line shortened out from both sides.

This phenomenon is an example of the macroscopic quantization of flow in the macroscopic structures, which have the specific sizes. The same quantization of flow occurs also in the microscopic structures, which the atoms are.

From the point of view of chains with the lumped parameters, growth of current in the solenoid with the connection to it of the voltage source occur according to the linear law, moreover in all its turns simultaneously. But so whether this? For explaining this question let us replace the upper plane of the two-wire circuit (Fig. 10) by long solenoid. If we to this line connect the voltage source, then the process of the growth of current in it will in no way differ from that examined. The linear inductance of line will be now in essence determined by the linear inductance of solenoid and the velocity of propagation and current wave, and the wave of the stress (stress now it will be applied between the solenoid and the lower conductor of line) it will be less than in the preceding case.

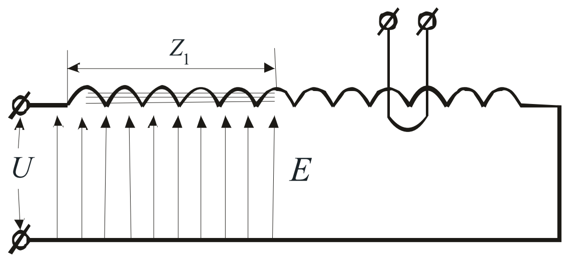

Fig. 10. The diagram of the propagation of magnetic and electrical pour on in the long solenoid.

When in the line examined wave will reach the point with the coordinate z_1, then magnetic field fill only the part of the solenoid, located between the power source and the point z_1. When wave reaches its end, then magnetic field fill entire solenoid. The magnetic field in the solenoid will be doubled with the back stroke of wave, and process will begin first.

Let us place now that the solenoid in the specific place is envelopped by turn. This process is such to mechanical dressing of the covering turn to the end of the solenoid with the only difference that in this case magnetic flux, being moved inside the solenoid, itself it pierces its covering turn. Moreover the speed of the motion of the front of magnetic flux in this case is incommensurably more than during mechanical dressing. But both processes have identical nature. By these processes is explained the phenomenon of the mutual induction between the solenoid and the covering turn. The pulse separation is small with the small length of solenoid; therefore they, merging, is formed almost constant stress. Stress in the turn will be induced only at the moment of the intersection with the magnetic flux of the solenoid of the environments of the cross section, envelopped by turn. In the environments of the covering turn will at this moment appear both the vector potential and the magnetic field. And, precisely, the intersection of the covering turn with the magnetic fields of the scattering (the same, as at the end of the solenoid with the direct current) leads to the induction in it emf. This moment will begin both with the straight line and with the back stroke of wave; moreover the polarity of the voltage pulses, induced in the turn, in both cases will be one and the same. The frequency of these pulses will depend on the length of solenoid, and it will be the greater, the shorter the solenoid. Consequently, the average value of the induced stress will be grow with the decrease of the length of solenoid, i.e., its quantity of turns, that also determines the transformation ratio of this transformer. This coefficient is equal to the relation of a quantity of turns of solenoid and ironclad.

After examining the process of the growth of currents pour on in the long solenoid, let us return to the problem of the presence of the circulation of vector potential around the long solenoid. Let us give the existing point of view on this question, represented in the work [1]. The value of vector potential in the space, which surrounds solenoid, is found from the relationship

$$A(r) = \frac{nIr_0^{\ 2}}{2\varepsilon_0 c^2 r} \qquad (14.2)$$

where n - quantity of turns, which falls per unit of the length of solenoid, I - the current, which flows through the solenoid, r_0 - diameter of solenoid, r - distance from the axis of solenoid to the observation point. It is assumed during the record of this relationship that $r \geq r_0$.

The inductance of solenoid is determined by the expression

$$L = \frac{n^2 \pi r_0^{\ 2} z_0}{\varepsilon_0 c^2}, \qquad (14.3)$$

where z_0 - length of solenoid.

If we to the solenoid connect the dc power supply U, then taking into account relationships (14.1 -14.3), we obtain

$$A(r,t) = \frac{Ut}{2\pi Nr},$$

where N - total number of turns in the solenoid, and since

$$E = -\mu_0 \frac{\partial A}{\partial t},$$

that the tension of electric field in the environment of solenoid at the moment of the connection to it of dc power supply will comprise

$$E(r) = \frac{\mu_0 U}{2\pi Nr}.$$

The tension of electric field in accordance with the version in question appears at the moment of connection to the solenoid of the power source instantly for entire its elongation. If the solenoid lacks resistance, then the tension of electric field will be constant during entire period of the time of connection to the solenoid of dc power supply. What here do appear contradictions? First, electric fields possess energy, and instantly they cannot appear. The second contradiction escapes from the first and consists in the fact that, since the electric fields possess energy, this energy must be included in the general energy, accumulated in the solenoid. But only magnetic fields inside the solenoid are considered with the calculation of this energy.

Thus, very process of inducting the electrical pour on around the long solenoid it occurs in no way in the manner that this represented in the existing literature [1], when it is considered that the circulation of magnetic vector potential for entire its elongation grows simultaneously, that also leads to the induction electromotive force (EMF) in the covering turn.

From the aforesaid it is possible to conclude that the point of view about the appearance of electrical pour on inductions around the solenoid in that place, where the rotor of vector potential is equal to zero, it does not correspond to reality, and very process of the formation of vector potential outside the solenoid and magnetic pour on inside it it does not correspond to those ideas, which exist today. The rotor of vector potential outside the solenoid is equal to zero, and this field possesses no energy; therefore to reveal it in the static behavior is impossible. For this reason the Aronov and Bohm experiments for the detection of vector potential outside the long solenoid, as which was used the magnetized ferromagnetic cylindrical model of small diameter, should be considered erroneous.

§ 15. Again about the law of the Faraday induction

Soon to be carried out of 200 of years since into of 1831 to year Faradey opened his famous law of the induction, which is up to now one of the fundamental laws of the classical electrodynamics. But this law is up to now one of the contradictory, first of all for that reason, that from it are exceptions (for example, homopolar induction). In § 2 we already examined basic consequences of this law, but not all underwater stones, which in it are located, then they were noted, and it was required to write fourteen paragraphs in order close to approach their detection. This circumstance up to now causes in physicists and anxiety and bewilderment. Let us give on to this to the occasion the quotation from the sixth the volume of Feynman the lectures [1]." flow rule", according to which EMP in the outline it is equal to the speed undertaken with the opposite sign, with which changes magnetic flux through the outline, when flow changes due to field change or when outline moves (or when it occurs and that and, etc). Two the possibility - "the outline moves" or "the field changes" - are not distinguished into to the formulation of the rule. Nevertheless, for explaining the rule in these two cases we used two completely different laws: $\left[\vec{V}\times\vec{B}\right]$ for "moving outline" and $\nabla\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$ for "changing field".

And further "We know in physics not one such example, if simple and precise general law required for its present understanding analysis in the terms of two different phenomena. Usually so beautiful of the generalization proves to be of outgoing from the united the deep that being basic the principle of. But in this case of any separately deep principle it is not evident" (end of the quotation).

But physics this is not grammar, and if from the law are exceptions, then law either is not accurate or not complete. When Faraday opened his law, still were not known the Maxwell equations, were not known electromagnetic waves, those more were known the laws of the propagation of electromagnetic waves in the long lines. And now, when these equations and laws are known, came the time of the examination of the contradictions indicated. To there remains only be surprised, why the questions indicated, which lie practically on the surface, are up to now examined they were not examined.

Relationship (2.1), which presents the law of the Faradey induction, does not contain information about how arose fields in initial fixed IMS. They describe only laws governing the propagation and conversion pour on in the case of motion with respect to the already existing fields. let us demonstrate, as behaves relationship (15.4) in practice.

Let us take long the solenoid (Fig. 11.), diameter which considerably less than its length let us introduce into its winding current.

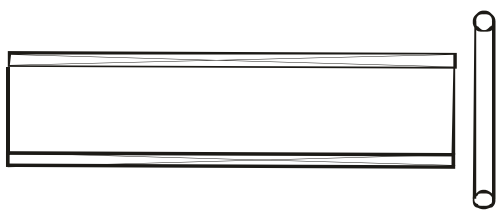

Fig. 11. Solenoid of from by the superconducting ring .

This inside the solenoid and at its ends will appear the lines of force of magnetic field..

Let us take of superconducting the ring and let us begin to dress its to the solenoid. If we look to the solenoid and the ring on top, then the magnetic fields of solenoid and currents in the solenoid and the ring will appear, as shown in Fig. 12.

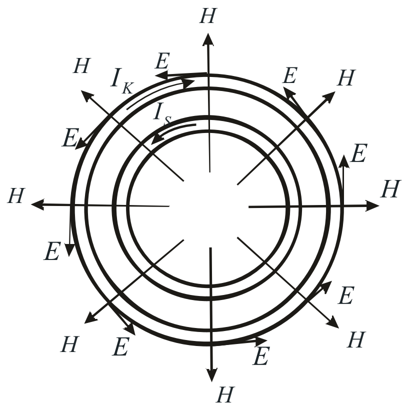

Fig. 12. Solenoid of of from of by the superconducting of ring of.

In the figure by radial vectors are designated the radial components of magnetic field near the upper edge of solenoid. If we lower ring some with the speed of $\vec{v}$, then to the charges in the ring will act electric field (15.4), which will accelerate charges in the Ger. It is clear that it is possible to attain this effect not only by dressing ring to the solenoid, but also sliding solenoid into the ring. With the reverse process electrical induction fields will be opposite sign, they will extinguish current in the ring, when it is completely taken from the solenoid.

Such to the procedure along the outline the ring will be induced the circulation the electrical the field

$$\oint \vec{E}d\vec{l} = \oint \left[\vec{v} \times \mu_0 \vec{H} \right] d\vec{l} \ .$$

If we ring open, and to connect to its ends voltmeter, thus will fix EMF, which is the result of the mechanical displacements of the extended turn. This the principle is used into all electromechanical the generators.

In law (15.1) is used complete time derivative. This means that for obtaining the circulation of electric field is not important the method of changing the magnetic flux, i.e., magnetic flux can change both due to the motion of outline in the three-dimensional changing magnetic field and due to a local variation in the time.

In order of to pass from integral the relationships to by the local, as we already previously spoke, is introduced of vector of the potential the magnetic the field :

$$\Phi_B = \mu_0 \oint \vec{A}_H \, d\vec{l}$$

and further

$$\vec{E} = -\mu_0 \frac{\partial \vec{A}_H}{\partial t}$$

It should be noted that in some text books, for example in [1], vector potential is introduced with the aid of the relationship

$$\Phi_B = \oint \vec{A}_H \, d\vec{l} \ , \qquad (15.1)$$

then

$$\vec{E} = -\frac{\partial \vec{A}_H}{\partial t} \ , \qquad (15.2)$$

Again let us take long the solenoid and let us surround its by that extended by the turn (Fig. 13).

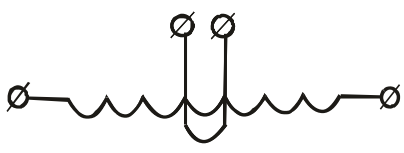

Fig. 13. Long the solenoid surrounded extended by the turn.

Since magnetic field inside the solenoid is defined by the relationship $H = nI$,where I - current in the solenoid, and n - a quantity of turns not the unit its length, magnetic flux inside the solenoid to be defined as

$$\Phi_B = \pi r_0^{\ 2} \mu_0 n I ,$$

where r_0 - radius the solenoid.

Using the relationship (15.1), we obtain

$$\oint \vec{A}_H d\vec{l} = \pi r_0^{\ 2} \mu_0 n I ,$$

from this relationship follows that at any point r out of the solenoid the absolute value of vector potential will be determined by the equality

$$A_H = \frac{\mu_0 n r_0^{\ 2} I}{2r} . \qquad (15.3)$$

This of indicates, that long the solenoid gird concentric the circle the circulation the vector of the potential. With this magnetic the field is located of only inside of the solenoid, and outside its there are no.

Using the relationships (15.2, 15.3), we obtain electrical induction the field out the solenoid:

$$E = -\frac{\mu_0 n r_0^{\ 2}}{2r} \frac{dI}{dt} . \qquad (15.4)$$

Let us look, that apropos the diagram the formation of electrical pour on inductions around the long solenoid written in the work [1]. In the fifth the volume on page 286 is given the formula (14.27) for the vector the potential out the long the solenoid. Is evident, that it coincides from by the equality (15.3). Is discovered the sixth that and on page 21 we read: "You remember that if there is a long solenoid, along which flows the electric current, then the field $\vec{B}$ exists inside it, bat no outside the field whereas the set the vectors $\vec{A}$ they circulate outside the solenoid (Fig.15.6) (end of the quotation). In the figure is drawn the long solenoid, through cross section of which the lines force of magnetic induction are passed, and the concentric circles the circulation of vector potential are drawn around the solenoid. As in this case are obtained electrical induction fields we they already showed, after obtaining relationship (15.11). And this the point the sight against to nature pour on the induction it has the place into all the existing textbooks. But of is accurate it?

If we to the solenoid connect of the source EMF U, then, as it was considered earlier, current in it will begin grow according to the linear law $I = \frac{Ut}{L}$, where L - inductance of solenoid. Differentiate current on the time and substituting it in equality (15.11), we obtain:

$$E = -\frac{\mu_0 n r_0^2}{2r}\frac{U}{L} .$$

This means that the voltage source is as soon as connected to the solenoid and the current in it beginnings grow according to the linear law, instantly around the solenoid it appears the circulation of electric field. This the fact causes the bewilderment. Moreover, with the calculation the energy, stored up in the solenoid, only magnetic fields are considered, and energy of electrical pour on, that arose thus mysterious, it is not considered. Consequently, these mysterious the field and energy not possess. Is certain, this the interpretation the appearance electrical pour on the induction around the solenoid not it is acceptable. This absurd result is connected with the fact that we they assumed that current in all turns of the solenoid, whatever it length had, it grows synchronously.

All this means that the Faradey induction law (2.1), recorded in the particular time derivatives in that version, as it is understood now, it is not accurate.

Currents cannot arise simultaneously in all turns of solenoid, but their appearance in that diagram, which is shown in the figure it begins at the beginning of solenoid, and this current wave is propagated on solenoid at a velocity, determined, including and by its linear inductance. And how was not short solenoid, this process will occur. In this consists the basic contradiction of the law of the Faraday induction.

PART II
NEW IDEAS IN THE CLASSICAL ELECTRODYNAMICS

CHAPTER 4
NEW APPROACHES AND THE DETERMINATION

§ 16. Dynamic potentials and the field of the moving charges

The method, which is demonstrated in the second chapter, that is concerned the introduction of total derivatives pour on, it is passed in the substantial part still by Hertz [17]. Hertz did not introduce the concept of vector potentials, but he operated only with fields, but this does not diminish its merits. It made mistakes only in the fact that the electrical and magnetic fields were considered the invariants of speed. But already simple example of long lines is evidence of the inaccuracy of this approach. With the propagation of wave in the long line it is filled up with two forms of energy, which can be determined through the currents and the voltages or through the electrical and magnetic fields in the line. And only after wave will fill with electromagnetic energy all space between the generator and the load on it it will begin to be separated energy. I.e. the time, by which stays this process, generator expended its power to the filling with energy of the section of line between the generator and the load. But if we begin to move away load from incoming line, then a quantity of energy being isolated on it will decrease, since. the part of the energy, expended by source, will leave to the filling with energy of the additional length of line, connected with the motion of load. If load will approach a source, then it will obtain an additional quantity of energy due to the decrease of its length. But if effective resistance is the load of line, then an increase or the decrease of the power expendable in it can be connected only with a change in the stress on this resistance. Therefore we come to the conclusion that during the motion of the observer of those of relatively already existing in the line pour on must lead to their change. The productivity of this approach with the application of conversions of Galileo will be demonstrated in this chapter.

Being located in assigned IMS, us interest those fields, which are created in it by the fixed and moving charges, and also by the electromagnetic waves, which are generated by the fixed and moving sources of such waves. The fields, which are created in this IMS by moving charges and moving sources of electromagnetic waves, we will call dynamic. Can serve as an example of dynamic field the magnetic field, which appears around the moving charges.

As already mentioned, in the classical electrodynamics be absent the rule of the conversion of electrical and magnetic pour on upon transfer of one inertial system to another. This deficiency removes STR, basis of which are the covariant of the Lorenz conversions. With the entire mathematical validity of this approach the physical essence of such conversions up to now remains unexplained [18].

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions pour on upon transfer of one IMS to another, and to also explain what dynamic potentials and fields can generate the moving charges. The first step, demonstrated in the works [10,11,19], was made in this direction a way of the introduction of the symmetrical laws of magnetoelectric and electromagnetic induction. These laws are written as follows:

$$\begin{gathered}\oint \vec{E}'dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v} \times \vec{B} \right] dl' \\ \oint \vec{H}'dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v} \times \vec{D} \right] dl' \end{gathered}, \tag{16.1}$$

or

$$\begin{gathered} rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B} \right] \\ rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D} \right] \end{gathered}. \tag{16.2}$$

For the constants pour on these relationships they take the form:

$$\begin{gathered} \vec{E}' = \left[\vec{v} \times \vec{B} \right] \\ \vec{H}' = -\left[\vec{v} \times \vec{D} \right] \end{gathered}. \tag{16.3}$$

In relationships (16.1-16.3), which assume the validity of the Galilean transformations the primed system and not primed system values present fields and elements in moving and fixed IMS respectively. It must be noted, that conversions (16.3) earlier could be obtained only from the covariant Lorentz transformations.

The relationships (16.1-16.3), which present the laws of induction, do not give information about how arose fields in initial fixed IMS. They describe only laws governing the propagation and conversion pour on in the case of motion with respect to the already existing fields.

The relationship (16.3) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e., motion in the fields $\vec{H}$ leads to the appearance pour on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [3].

Electric field beyond the limits of the long charged rod is determined from the relationship $E = \frac{g}{2\pi\varepsilon r}$, where g - charge of the unit length of rod.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IMS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IMS begin to move third frame of reference with the speed Δv, then already due to the motion in the field ΔH will appear additive to the electric field $\Delta E = \mu\varepsilon E(\Delta v)^2$. This process can be continued and further, as a result of which can be obtained the number, which gives the value of the electric field $E'_v(r)$ in moving IMS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IMS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship:

$$E'(r, v_\perp) = \frac{g ch \frac{v_\perp}{c}}{2\pi\varepsilon r} = E ch \frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship:

$$E'(r, v_\perp) = \frac{e ch \frac{v_\perp}{c}}{4\pi\varepsilon r^2},$$

where $v_\perp$ - normal component of charge rate to the vector, which connects the moving charge and observation point.

Expression for the scalar potential, created by the moving charge, for this case will be written down as follows [by 10,11,18]:

$$\varphi'(r,v_\perp) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r} = \varphi(r)ch\frac{v_\perp}{c}, \tag{16.4}$$

where $\varphi(r)$ - scalar potential of fixed charge. The potential $\varphi'(r,v_\perp)$ can be named scalar- vector since it depends not only on the absolute value of charge, but also on speed and direction of its motion with respect to the observation point. Maximum value this potential has in the direction normal to the motion of charge itself. Moreover, if charge rate changes, which is connected with its acceleration, then can be calculated the electric fields, induced by the accelerated charge.

During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp) = Hch\frac{v_\perp}{c}.$$

where $v_\perp$ - speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components pour on parallel speeds [ISO] as $E_\uparrow$ and $H_\uparrow$, and $E_\perp$ and $H_\perp$ as components normal to it, then conversions pour on they will be written down:

$$
\begin{aligned}
&\vec{E}'_{\uparrow} = \vec{E}_{\uparrow},\\
&\vec{E}'_{\perp} = \vec{E}_{\perp} ch\frac{v}{c} \;+\; \frac{Z_0}{v}\left[\vec{v}\times\vec{H}_{\perp}\right] sh\frac{v}{c},\\
&\vec{H}'_{\uparrow} = \vec{H}_{\uparrow},\\
&\vec{H}'_{\perp} = \vec{H}_{\perp} ch\frac{v}{c} \;-\; \frac{1}{vZ_0}\left[\vec{v}\times\vec{E}_{\perp}\right] sh\frac{v}{c},
\end{aligned}
\qquad (16.5)
$$

where $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ - impedance of free space, $c = \sqrt{\frac{1}{\mu_0\varepsilon_0}}$ - speed of light.

Conversions pour on (16.5) they were for the first time obtained in the work [3].

§ 17. Phase aberration and the Doppler transverse effect

Of the assistance of relationships (16.5) it is possible to explain the phenomenon of phase aberration, which did not have within the framework existing classical electrodynamics of explanations. We will consider that there are components of the plane wave H_z and E_x, which is extended in the direction y, and primed system moves in the direction of the axis x with the speed v_x. Then components pour on in the primed system in accordance with relationships (16.5) they will be written down:

$$
\begin{aligned}
&E'_x = E_x,\\
&E'_y = H_z sh\frac{v_x}{c},\\
&H'_z = H_z ch\frac{v_x}{c}.
\end{aligned}
$$

Thus, is a heterogeneous wave, which has in the direction of propagation the component E'_v.

Let us write down the summary field E' in moving IMS:

$$E' = \left[\left(E'_x\right)^2 + \left(E'_y\right)^2 \right]^{\frac{1}{2}} = E_x ch \frac{v_x}{c}. \qquad (17.1)$$

If the vector $\vec{H}'$ is as before orthogonal the axis y, then the vector $\vec{E}'$ is now inclined toward it to the angle α, determined by the relationship:

$$\alpha \cong sh \frac{v}{c} \cong \frac{v}{c}. \qquad (17.2)$$

This is phase aberration. Specifically, to this angle to be necessary to incline telescope in the direction of the motion of the Earth around the sun in order to observe stars, which are located in the zenith.

The vector Poynting vector is now also directed no longer along the axis y, but being located in the plane xy, it is inclined toward the axis y to the angle, determined by relationships (17.2). However, the relation of the absolute values of the vectors $\vec{E}'$ and $\vec{H}'$ in both systems they remained identical. However, the absolute value of the Poynting vector increased. Thus, even transverse motion of inertial system with respect to the direction of propagation of wave increases its energy in the moving system. This phenomenon is understandable from a physical point of view. It is possible to give an example with the rain drops. When they fall vertically, then is energy in them one. But in the inertial system, which is moved normal to the vector of their of speed, to this speed the velocity vector of inertial system is added. In this case the absolute value of the speed of drops in the inertial system will be equal to square root of the sum of the squares of the speeds indicated. The same result gives to us relationship

(17.1). The transformations with respect to the vectors $\vec{E}$ and $\vec{H}$ is completely symmetrical.

Such waves have in the direction of its propagation additional of the vector of electrical or magnetic field, and in this they are similar to E and H of the waves, which are extended in the waveguides. In this case appears the uncommon wave, whose phase front is inclined toward the Poyntnng vector to the angle, determined by relationship (17.2). In fact obtained wave is the superposition of plane wave with the phase speed $c = \sqrt{\frac{1}{\mu\varepsilon}}$ and additional wave of plane wave with the infinite phase speed orthogonal to the direction of propagation.

The transverse Doppler effect, who long ago is discussed sufficiently, until now, did not find its confident experimental confirmation. For observing the star from moving ISM it is necessary to incline telescope on the motion of motion to the angle, determined by relationship (17.2). But in this case the star, observed with the aid of the telescope in the zenith, will be in actuality located several behind the visible position with respect to the direction of motion. Its angular displacement from the visible position in this case will be determined by relationship (17.2). but this means that this star with respect to the observer has radial spid, determined by the relationship

$$v_r = v \sin \alpha .$$

Since for the low values of the angles $\sin\alpha \cong \alpha$, and $\alpha = \frac{v}{c}$, the Doppler frequency shift will compose

$$\omega_{d\perp} = \omega_0 \frac{v^2}{c^2} . \qquad (17.3)$$

This result numerically coincides with results STR, but it is principally characterized by rel.un. of results. It is considered in STR that the transverse Doppler effect, determined by relationship (17.3), there is in reality, while in this case this only apparent effect. If we compare the results of conversions pour on (17.5) with conversions STR, then it is not difficult to see that they coincide with an accuracy to the quadratic members of the ratio of the velocity of the motion of charge to the speed of light.

The STR conversion although they were based on the postulates, could correctly explain sufficiently accurately many physical phenomena, which before this explanation did not have. With this circumstance is connected this great success of this theory. Conversions (17.4) and (17.5) are obtained on the physical basis without the use of postulates and they with the high accuracy coincided with STR. Difference is the fact that in conversions (17.5) there are no limitations on the speed for the material particles, and also the fact that the charge is not the invariant of speed. The experimental confirmation of the fact indicated can serve as the confirmation of correctness of the proposed conversions.

§ 18. Power interaction of the current systems, homopolar induction and the ponderomotive forces

The Maxwell equationsdo not contain of information about power interaction of the current carrying systems. In the classical electrodynamics for calculating such an interaction it is necessary to calculate magnetic field in the assigned region of space, and then, using a Lorentz force, to find the forces, which act on the moving charges. Obscure a question about that remains with this approach, to what are applied the reacting forces with respect to those forces, which act on the moving charges.

The concept of magnetic field arose to a considerable degree because of the observations of power interaction of the current carrying and magnetized systems. Experience with the iron shavings, which are erected near the magnet poles or around the annular turn with the current into the clear geometric figures, is especially significant. These figures served as occasion for the introduction of this concept as the lines of force of magnetic field. In accordance with third Newton's law with any power interaction there is always a equality of effective forces and opposition, and also always there are those elements of the system, to which these forces are applied. A large drawback in the concept of magnetic field is the fact that it does not give answer to that, counteracting forces are concretely applied to what, since. magnetic field comes out as the independent substance, with which occurs interaction of the moving charges.

Is experimentally known that the forces of interaction in the current carrying systems are applied to those conductors, whose moving charges create magnetic field. However, in the existing concept of power interaction of such systems the positively charged lattice, to which are applied the forces, does not participate in the formation of the forces of interaction. That that the positively charged ions take direct part in the power processes, speaks the fact that in the process of compressing the plasma in transit through it direct current (the so-called pinch effect) it occurs the compression also of ions.

Let us examine this question on the basis of the concept of scalar- vector potential [10-12]. We will consider that the scalar- vector potential of single charge is determined by relationship (16.4), and that the electric fields, created by this potential, act on all surrounding charges, including to the charges positively charged lattices.

Let us examine from these positions power interaction between two parallel conductors (Fig. 14), along which flow the currents. We will consider that g_1^+, g_2^+ and g_1^-, g_2^- present the respectively fixed and moving charges, which fall per unit of the length of conductor.

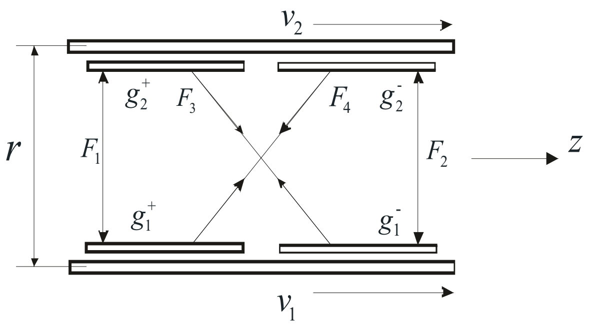

Fig. 14. Schematic of power interaction of the current carrying wires of two-wire circuit taking into account the positively charged lattice.

The charges g_1^+, g_2^+ present the positively charged lattice in the lower and upper conductors. We will also consider that both conductors prior to the start of charges are electrically neutral. This means that in the conductors are two systems of the mutually inserted opposite charges with the specific density g_1^+, g_1^- and g_2^+, g_2^-, which neutralize each other. In Fig. 14 these systems for larger convenience in the examination of the forces of interaction are moved apart along the axis z. Subsystems with the negative charge (electrons) can move with the speeds v_1 and v_2. The force of interaction between the lower and upper conductors we will search for as the sum of four forces, whose designation is understandable from the figure. The repulsive forces F_1 and F_2 we will take with the minus sign, while the attracting force F_3 and F_4 we will take with the plus sign.

For the single section of the two-wire circuit of force, acting between the separate subsystems, will be written down

$$F_1 = -\frac{g_1^+ g_2^+}{2\pi\varepsilon r},$$

$$F_2 = -\frac{g_1^- g_2^-}{2\pi\varepsilon r} ch\frac{v_1 - v_2}{c},$$

$$F_3 = +\frac{g_1^- g_2^+}{2\pi\varepsilon r} ch\frac{v_1}{c}, \qquad (18.1)$$

$$F_4 = +\frac{g_1^+ g_2^-}{2\pi\varepsilon r} ch\frac{v_2}{c}.$$

Adding all force components, we will obtain the amount of the composite force, which falls per unit of the length of conductor,

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_1}{c} + ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} - 1 \right). \qquad (18.2)$$

In this expression as g_1 and g_2 are undertaken the absolute values of charges, and the signs of forces are taken into account in the bracketed expression. Let us take only two first members of expansion in the series $ch\frac{v}{c}$, i.e., we will consider that $ch\frac{v}{c} \cong 1 + \frac{1}{2}\frac{v^2}{c^2}$. From relationship (18.2) we obtain

$$F_{\Sigma 1} = \frac{g_1 v_1 g_2 v_2}{2\pi\varepsilon c^2 r} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r}, \qquad (18,3)$$

where g_1 and g_2 are undertaken the absolute values of specific charges, and v_1 and v_2 take with its signs.

Since the magnetic field of straight wire, along which flows the current I, we determine by the relationship

$$H = \frac{I}{2\pi r},$$

From relationship (18.2) we obtain

$$F_{\Sigma 1} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r} = \frac{H_1 I_2}{\varepsilon c^2} = I_2 \mu H_1,$$

where H_1 - the magnetic field, created by lower conductor in the location of upper conductor.

It is analogous

$$F_{\Sigma 1} = I_1 \mu H_2,$$

where H_2 - the magnetic field, created by upper conductor in the region of the arrangement of lower conductor.

These relationships completely coincide with the results, obtained on the basis of the concept of magnetic field.

Relationship (18.3) represents the known rule of power interaction of the current carrying systems, but it is obtained not on the basis the introduction of phenomenological magnetic field, but on the basis of completely intelligible physical procedures. In the formation of the forces of interaction in this case the lattice takes direct part, which is not in the model of magnetic field. In the model examined are well visible the places of application of force. The obtained relationships coincide with the results, obtained on the basis of the concept of magnetic field and by the axiomatically introduced Lorentz force. In this case is undertaken only first member of expansion in the series $ch\frac{v}{c}$. For the speeds $v \sim c$ should be taken all terms of expansion. If we consider this circumstance, then the connection between the forces of interaction and the charge rates proves to be nonlinear. This, in particular it leads to the fact that the law of power interaction of the current carrying systems is asymmetric. With the identical values of currents, but with their different directions, the attracting forces and repulsion become unequal. Repulsive forces prove to be greater than attracting force. This difference is small and is determined by the expression

$$\Delta F = \frac{v^2}{2c^2} \frac{I_1 I_2}{2\pi \varepsilon c^2 \varepsilon},$$

but with the speeds of the charge carriers of close ones to the speed of light it can prove to be completely perceptible.

Let us remove the lattice of upper conductor (Fig. 14), after leaving only free electronic flux. In this case will disappear the forces F_1 and F_3, and this will indicate interaction of lower conductor with the flow of the free electrons, which move with the speed v_2 on the spot of the arrangement of upper conductor. In this case the value of the force of interaction is defined as:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} \right). \qquad (18.4)$$

The Lorentz force assumes linear dependence between the force, which acts on the charge, which moves in the magnetic field, and his speed. However, in the obtained relationship the dependence of the amount of force from the speed of electronic flux will be nonlinear. From relationship (18.4) it is not difficult to see that with an increase in v_2 the deviation from the linear law increases, and in the case, when $v_2 >> v_1$, the force of interaction are approached zero. This is very meaningful result. Specifically, this phenomenon observed in their known experiments Thompson and Kaufmann, when they noted that with an increase in the velocity of electron beam it is more badly slanted by magnetic field. They connected the results of their observations with an increase in the mass of electron. As we see reason here another.

Let us note still one interesting result. From relationship (18.3), with an accuracy to quadratic terms, the force of interaction of electronic flux with the rectilinear conductor to determine according to the following dependence:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(\frac{v_1 v_2}{c^2} - \frac{1}{2}\frac{v_1^2}{c^2}\right). \qquad (18.5)$$

From expression (18.5) follows that with the unidirectional electron motion in the conductor and in the electronic flux the force of interaction with the fulfillment of conditions $v_1 = \frac{1}{2}v_2$ is absent.

Since the speed of the electronic flux usually much higher than speed of current carriers in the conductor, the second term in the brackets in relationship (18.5) can be disregarded. Then, since

$$H_1 = \frac{g_1 v_1}{2\pi\varepsilon c^2 r}$$

we will obtain the magnetic field, created by lower conductor in the place of the motion of electronic flux:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\frac{v_1 v_2}{c^2} = g_2 \mu v_2 H .$$

In this case, the obtained value of force exactly coincides with the value of Lorentz force.

Taking into account that

$$F_\Sigma = g_2 E = g_2 \mu v_2 H ,$$

it is possible to consider that on the charge, which moves in the magnetic field, acts the electric field E, directed normal to the direction of the motion of charge. This result also with an accuracy to of the quadratic terms $\frac{v^2}{c^2}$ completely coincides with the results of the concept of magnetic field and is determined Lorentz force.

As was already said, one of the important contradictions to the concept of magnetic field is the fact that two parallel beams of the like charges, which are moved with the identical speed in one direction, must be attracted. In this model there is no this contradiction already. If we consider that the charge rates in the upper and lower wire will be equal, and lattice is absent, i.e., to leave only electronic fluxes, then will remain only the repulsive force F_2.

Thus, the moving electronic flux interacts simultaneously both with the moving electrons in the lower wire and with its lattice, and the sum of these forces of interaction it is called Lorentz force.

Regularly does appear a question, and does create magnetic field most moving electron stream of in the absence compensating charges of lattice or positive ions in the plasma? The diagram examined shows that the effect of power interaction between the current carrying systems requires in the required order of the presence of the positively charged lattice. Therefore most moving electronic flux cannot create that effect, which is created during its motion in the positively charged lattice.

Let us demonstrate still one approach to the problem of power interaction of the current carrying systems. The statement of facts of the presence of forces between the current carrying systems indicates that there is some field of the scalar potential, whose gradient ensures the force indicated. But that this for the field? Relationship (18.3) gives only the value of force, but he does not speak about that, the gradient of what scalar potential ensures these forces. We will support with constants the currents I_1 and I_2, and let us begin to draw together or to move away conductors. The work, which in this case will be spent, and is that potential, whose gradient gives force. After integrating relationship (18.3) on r, we obtain the value of the energy:

$$W = \frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2}.$$

This energy, depending on that to move away conductors from each other, or to draw together, can be positive or negative. When conductors move away, then energy is positive, and this means that, supporting current in the conductors with constant, generator returns energy. This phenomenon is the basis the work of all electric motors. If conductors converge, then work accomplish external forces, on the source, which supports in them the constancy of currents. This phenomenon is the basis the work of the mechanical generators of EMP.

Relationship for the energy can be rewritten and thus:

$$W = \frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2} = I_2 A_{z1} = I_1 A_{z2},$$

where

$$A_{z1} = \frac{I_1 \ln r}{2\pi\varepsilon c^2}$$

is z- component of vector potential, created by lower conductor in the location of upper conductor, and

$$A_{z2} = \frac{I_2 \ln r}{2\pi\varepsilon c^2}$$

is z- component of vector potential, created by upper conductor in the location of lower conductor.

The approach examined demonstrates that large role, which the vector potential in questions of power interaction of the current carrying systems and conversion of electrical energy into the mechanical plays. This approach also clearly indicates that the Lorentz force is a consequence of interaction of the current carrying systems with the field of the vector potential, created by other current carrying systems. Important circumstance is the fact that the formation of vector potential is obliged to the dependence of scalar potential on the speed. This is clear from a physical point of view. The moving charges, in connection with the presence of the dependence of their scalar potential on the speed, create the scalar field, whose gradient gives force. But the creation of any force field requires expenditures of energy. These expenditures accomplishes generator, creating currents in the conductors. In this case in the surrounding space is created the special field, which interacts with other moving charges according to the special vector rules. In this case only scalar product of the charge rate and vector potential gives the potential, whose gradient gives the force, which acts on the moving charge. Thisis a Lorentz force.

In spite of simplicity and the obviousness of this approach, this simple mechanism up to now was not finally realized. For this reason the Lorentz force, until now, was introduced in the classical electrodynamics by axiomatic way.

Let us examine the still one case, when the single negative charge e moves with the speed v_2 in parallel to the conductor, along which with the speed v_1 move the electrons, whose specific density, that falls per unit of the length of wire, composes q_1^- (Fig.15). We will consider that the conductor prior to the beginning of electron motion was electrically neutral and the specific density of positive ions and electrons they were equal. The grain, which falls in the section dz of conductor with the current, in this case will compose $q_1^- dz$. The element of the effective force of the moving charge e on the element $q_1^- dz$ will be determined by the relationship:

$$dF = \frac{eg_1 dz}{4\pi\varepsilon r^2}\left(\frac{v_{1n}v_{2n}}{c^2} - \frac{1}{2}\frac{{v_{1n}}^2}{c^2}\right),$$

where v_{1n} and v_{2n} - components of the corresponding speeds, normal to the radius, which connects the moving charge with the grain $q_1^- dz$. The speed of the electron motion v_{2n} is considerably more than the speed of the motion of charges in the conductor v_{2n}; therefore last term in the brackets in this relationship can be disregarded.

Since $v_{1n}=v_1\sin\alpha$ and $v_{2n}=v_2\sin\alpha$, and also, taking into account that $r_0=r\ \sin\alpha$ and $dz=\dfrac{r_0 d\alpha}{\sin^2\alpha}$,

we obtain

$$dF=\frac{q_1 v_1 e v_2}{4\pi\varepsilon c^2 r_0}d\alpha .$$

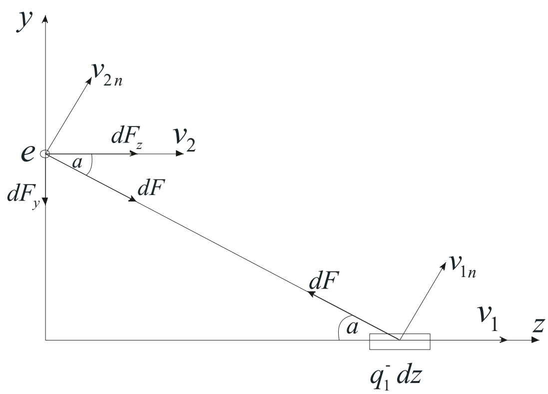

Fig. 15. The diagram of interaction of the moving point charge with the conductor, along which flows the current.

The obtained force corresponds to attraction. The element of this force, parallel r_0, will be written down as:

$$dF_y=\frac{q_1 v_1 e v_2}{4\pi\varepsilon c^2 r_0}\sin\alpha\ d\alpha \qquad (18.6)$$

and the element of the force, normal to r_0 will be equal:

$$dF_x=\frac{q_1 v_1 e v_2}{4\pi\varepsilon c^2 r_0}\cos\alpha\ d\alpha . \qquad (18.7)$$

After integrating relationship (18.6) and taking into account that the current, which flows by the lower conductor it is determined by the relationship $I = q_1 v_1$, let us write down the force, which acts on the single moving charge e from the side of the right side of the wire:

$$F = \int_0^{\frac{\pi}{2}} \frac{Iev_2}{4\pi\varepsilon c^2 r_0} \sin\alpha \, d\alpha = \frac{Iev_2}{4\pi\varepsilon c^2 r_0}. \qquad (18.8)$$

If we consider interaction, also, with her left side of the wire, then the force, which acts in parallel r_0 will be doubled, and the forces, which act normal to r_0, they are compensated. Thus, the composite force, which acts on the charge, which moves in parallel to wire, will be written down:

$$F_\Sigma = \frac{Iev_2}{2\pi\varepsilon c^2 r_0}. \qquad (18.9)$$

Since the magnetic field, created by lower conductor with the current at the point of the presence of the moving charge, is determined by the relationship

$$H = \frac{I}{2\pi r_0},$$

and magnetic permeability $\mu = \frac{1}{\varepsilon c^2}$, then from relationship (18.8) we obtain

$$F_\Sigma = ev_2 \mu H$$

This force is exactly equal to the Lorentz force.

Now let us examine the case, when the charge moves between two limitless parallel plates, along which flows the specific current I, (Fig. 16). This current flows along the normal to the plane of figure. In this case the charge moves in parallel to the current, which flows in the plates.

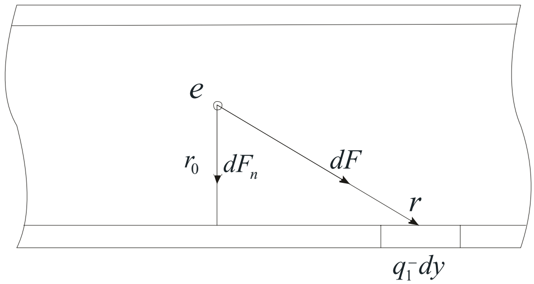

Fig.16. Diagram of interaction of the moving point charge with the currents, which flow along the parallel conducting plates.

Taking into account relationship (18.9), let us write down the element of the force, which acts on the moving charge from the side of the current element, which flows normal to the element, dy

$$dF = \frac{dz\ dy\ nv_1 q_2 v_2}{2\pi\varepsilon c^2 r}. \tag{18.10}$$

In this relationship dz is this thickness of the layer, along which the current flows, and n - electron density.

Let us rewrite relationship (18.10), taking into account that $dy = \frac{r_0 d\alpha}{\sin^2\alpha}$, $r = \frac{r_0}{\sin\alpha}$, and also that that $\frac{dF_n}{dF} = \sin\alpha$, where dF - element of force, directed in parallel r, and dF_n - element of force, directed normal to r_0:

$$dF_n = \frac{dz\ nv_1 g_2 v_2 d\alpha}{2\pi\varepsilon_0 c^2}.$$

After integrating this expression, we will obtain the total force, which acts on the moving charge from the side of one half-plane:

$$F = \int_0^{\frac{\pi}{2}} \frac{dz\ nv_1 g_2 v_2 d\alpha}{2\pi\varepsilon_0 c^2} = \frac{dz\ nv_1 g_2 v_2}{4\varepsilon_0 c^2}.$$

Taking into account that the fact that on the charge act the forces from the side of four half-planes (two from the side of lower plate two from the side of upper), finally we obtain:

$$F_{\Sigma} = \frac{g_2 v_2 H}{\varepsilon_0 c^2} = \mu g_2 v_2 H .$$

And again eventual result exactly coincided with the results of the concept of magnetic field.

Thus, the results, obtained taking into account the introduction of scalar-vector potential and concept of magnetic field, completely coincide, if we consider only quadratic members of the expansion of hyperbolic cosine in series. In the case of the calculation of the terms of the expansion of the higher orders, when the speeds of the motion of charges are great, this agreement it will not be and the connection between the force and the speed becomes nonlinear, and the concept of magnetic field will no longer give correct results.

By the merit of this method of examining interaction between the current carrying systems and the charges appears the fact that he indicates the concrete places of application of force, which act between their elements and moving charges, which is not in the concept of magnetic field.

now it is possible to verify does work the mechanism of interaction of the current carrying systems in the case of the long line (Fig.2) examined, along which is propagated electriccurent wave. The tension of the electric field between the planes of line is determined by the relationship:

$$E = \frac{g_{\square}}{\varepsilon_0}, \qquad (18.11)$$

where $g_{\square}$ - the charge, which falls to the single square of the surface of long line.

The specific current, which falls per unit of the width of line, magnetic and electric field in it are connected with the relationship

$$I = g_{\square} v = H = \frac{E}{Z_0}. \qquad (18.12)$$

From this relationship we obtain

$$v = \frac{E}{g_{\square} Z_0}. \qquad (18.13)$$

Since the currents in the planes of line are directed in opposite directions, taking into account relationships (18.11 - 18.13), value of the repulsive force, falling to the single square surface, let us write down:

$$F_{\square} = \frac{{g_{\square}}^2 v^2}{2\varepsilon_0 c^2} = \frac{1}{2}\mu_0 H^2.$$

Thus, the concept of scalar- vector potential and in this case gives correct answer.

Let us examine the still one interesting consequence, which escapes from the given examination. If we as the planes of long line use an superconductor, then the magnetic field on its surface, equal to specific current, can be determined from the relationship:

$$H = nev\lambda, \qquad (18.14)$$

where $\lambda = \sqrt{\frac{m}{ne^2\mu}}$ - depth of penetration of magnetic field into the superconductor.

If we substitute the value of depth of penetration into relationship (18.14), then we will obtain the unexpected result:

$$H = v\sqrt{\frac{nm}{\mu}}.$$

Occurs that the magnetic field strength completely does not depend on the magnitude of the charge of current carriers, but it depends on their mass. Thus, the specific energy of magnetic pour on

$$W_H = \frac{1}{2}\mu H^2 = \frac{nmv^2}{2} \qquad (18.15)$$

is equal to specific kinetic the kinetic energy of charges. But magnetic field exists not only on its surface, also, in the skin-layer. Volume, occupied by magnetic fields, incommensurably larger than the volume of this layer. If we designate the length of the line, depicted in Fig. 2 as l, then the volume of skin-layer in the superconductive planes of line will compose $2lb\lambda$. Energy of magnetic pour on in this volume we determine from the relationship:

$$W_{H,\lambda} = nmv^2 lb\lambda,$$

however, energy of magnetic pour on, accumulated between the planes of line, it will comprise:

$$W_{H,a} = \frac{nmv^2 lba}{2} = \frac{1}{2} lba\mu_0 H. \qquad (18.16)$$

If one considers that the depth of penetration of magnetic field in the superconductors composes several hundred angstroms, then with the macroscopic dimensions of line it is possible to consider that the total energy of magnetic pour on in it they determine by relationship (18.16). Therefore, the formation of magnetic pour on H between the planes of line, which appear in connection with the motion of charges in the skin-layer, it requires the same expenditures of energy, as if entire volume of line was filled with the particles, which move with the speed v, whose density and mass compose respectively n and m.

Is obvious that the effective mass of electron in comparison with the mass of free electron grows in this case into $\frac{a}{2\lambda}$ of times. This is the consequence of the fact that the mechanical electron motion leads not only to the accumulation of their kinetic energy in the skin-layer, but in the line also occurs accumulation and potential energies, whose gradient gives the force, which acts on the conducting planes of line. Thus, becomes clear nature of such parameters as inductance and the effective mass of electron, which in this case depend, in essence, not from the mass of free electrons, but from the configuration of conductors, on which the electrons move.

homopolar induction was discovered by Farady more than 200 years ago, but also up to now the physical principles of the operation of some constructions of unipolar generators remain obscure. There were the attempts to explain the work of such generators by action on the moving charges of Lorentz force, but it turned out that there are such constructions, in which to explain their operating principle thus is impossible.

Beginning the study of the problem about the homopolar induction, it is necessary to clearly demarcate the concepts of a potential difference and electromotive force (EMF). The scalar potential of fixed charge is determined by the relationship

$$\varphi_0(r) = \frac{Q}{4\pi\varepsilon r},$$

where Q - magnitude of the charge, and ε - dielectric constant of medium.

Electric field is the gradient of the scalar potential

$$\vec{E} = -grad\ \varphi_0(r).$$

This field is potential, while this means that the work is not accomplished with the transfer of trial charge in this field along any locked trajectory, i.e. the condition is satisfied

$$\oint \vec{E}d\vec{l} = 0.$$

The electromotive force (EMF) is the scalar quantity, which characterizes the work of strange nonpotential forces in the locked conducting outline and is determined the work of these forces on the displacement of unit charge along the outline. In this case

$$\oint \vec{E}d\vec{l} = U ,$$

where U is EMF, generated in this outline.

The EMF can be determined also in any section of the locked outline, in this case the work is determined by work EMF in this section and magnitude of the charge, moved in this section. Both potential difference and EMF are measured in volts.

In the usual electric generators EMF is generated in the locked fixed or moving outline, partly which appears the load, in which is separated the energy. A difference in the unipolar generator from such generators is the fact that in it the locked outline is composite: one part of this outline is fixed, and the second moves relative to the first. Galvanic contact between these parts is ensured with the aid of the feeder brushes. Both parts of the locked outline of unipolar generator their potential differences, which in the sum give complete EMF, are excited. If the discussion deals with the direct current, then EMF can be generated only in the locked outline.

The concept of scalar-vector potential, developed in the works [3,11,12,19], the dependence of the scalar potential of charge on its relative speed is assumed.

$$\varphi(v) = \varphi_0 ch\frac{v_\perp}{c} , \qquad (18.17)$$

where $v_\perp$ - normal component of charge rate to the vector, which connects the moving charge and observation point. Use of this concept gives the possibility not only to explain the work of all existing types of unipolar generators, but also to answer a question about the polarization of the moving magnet. We will consider that magnet it is possible to present in the form the framework, along which flows the current (Fig. 17).

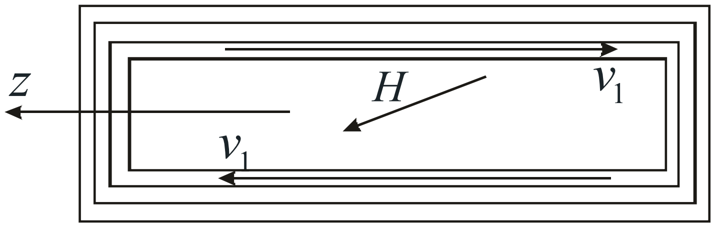

Fig. 17. Framework with the current.

In the conductor is located two subsystems of the mutually inserted charges: the ions of the positively charged lattice and electrons. These two subsystems neutralize each other, making conductor with neutral. When current flows along the conductor and conductor itself is fixed, then relative to fixed observer move only electrons.

In Fig. 17 the subsystems indicated are moved apart. Outer duct presents the positively charged rigid lattice, and internal outline presents the current of the moving electrons, which generate magnetic field.

If the framework with the current moves in the direction z, the like to relation to the fixed observer the electron velocity in the lower and upper section of the framework it changes differently: in the upper section it increases, while in the lower - it decreases. While the speed of lattice is identical and in the upper, and in the lower section and equal to the speed of the motion of the framework.

Let us examine the case, when there is a section of the conductor, along which flows the current (Fig.18). We will also consider that in the conductor are two subsystems of the mutually inserted charges of the positive lattice g^+ and free electrons g^-. For convenience in the examination in the figure these two subsystems are moved apart along the coordinate r.

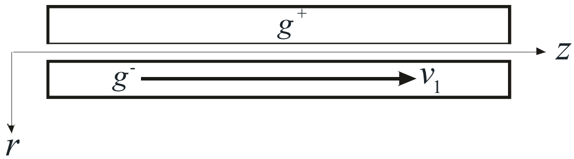

Fig. 18. Section is the conductor, along which flows the current.

The electric field, created by rigid lattice depending on the coordinate r, takes the form:

$$E^+ = \frac{g}{2\pi\varepsilon r}\ , \qquad (18.18)$$

where g - positive charge, which falls per unit of the length of conductor.

as in relationship (18.18) with the further consideration we will introduce only absolute values of the densities both of positive and negative charges, counting the absolute values of electrical pour on, which coincide in the direction for r by positive, and opposite to this direction - negative.

Using relationship (18.17), we obtain the values of electrical pour on, created by the electrons, which move in the conductor with the speed v_1

$$E^- = -\frac{g}{2\pi\varepsilon r} ch\frac{v_1}{c} \cong -\frac{g}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v_1^{\,2}}{c^2}\right). \qquad (18.19)$$

In this relationship only two first members of expansion in the series of hyperbolic cosine are undertaken.

Adding (2) and (3), we obtain the summary value of the electric field at a distance r from the axis of the conductor:

$$E = -\frac{g v_1^{\,2}}{2\pi\varepsilon c^2 r}.$$

This relationship indicates that around the conductor, along which move the electrons, is created the electric field, which corresponds to the negative charge of conductor. However, this field with those current densities, which can be provide ford in the normal conductors, has insignificant value, and discovered be it cannot with the aid of the existing measuring means. It can be discovered only with the use of the superconductors, where the current density can on many orders exceed currents in the normal metals [12].

Let us examine the case, when very section of the conductor, on which with the speed v_1 flow the electrons, moves in the opposite direction with speed v (Fig. 19).

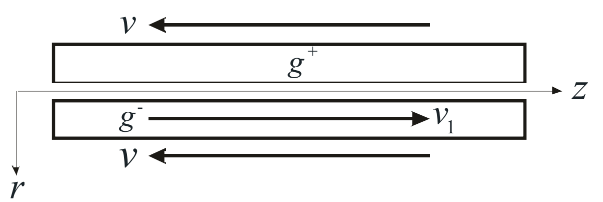

Fig. 19. Section of conductor with the current, which moves with the speed v.

In this case relationships (2) and (3) will take the form

$$E^{+} = \frac{g}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right) \tag{18.20}$$

$$E^{-} = -\frac{g}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{(v_1 - v)^2}{c^2}\right) \tag{18.21}$$

Adding (18.20) and (18.21), we obtain the summary field

$$E_{\Sigma} = \frac{g}{2\pi\varepsilon r}\left(\frac{v_1 v}{c^2} - \frac{1}{2}\frac{v_1^2}{c^2}\right) \tag{18.22}$$

We will consider that the speed of the mechanical motion of conductor is considerably more than the drift velocity of electrons. Then in relationship (18.22) the second term in the brackets can be disregarded, and finally we obtain:

$$E \cong \frac{gv_1 v}{2\pi\varepsilon c^2 r}. \tag{18.23}$$

The obtained result means that around the moving conductor, along which flows the current, with respect to the fixed observer also is formed the electric field, but it is considerably greater than in the case of fixed conductor with the current. This field is equivalent to appearance on this conductor of the specific positive charge of the equal

$$g^+ = \frac{gv_1 v}{c^2}. \tag{18.24}$$

If in parallel with the conductor with the same speed moves the plate (it is shown in the lower part of figure 20), whose width is equal $r_2 - r_1$, then between its edges will be observed a potential difference

$$U_1 = -\int_{r_1}^{r_2} \frac{gv_1^2 dr}{2\pi\varepsilon c^2 r} = -\frac{gv_1^2}{2\pi\varepsilon c^2} \ln\frac{r_2}{r_1} \tag{18.25}$$

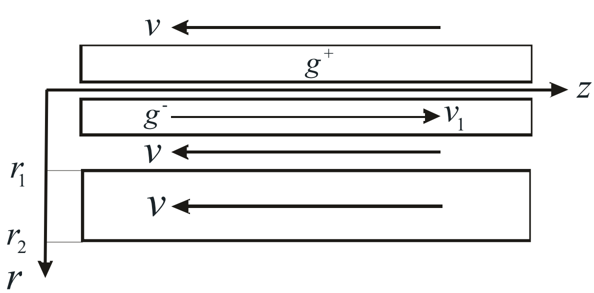

Fig. 20. The conducting plate moves with the same speed, as conductor.

However, a potential difference in the relation to the fixed observer between the points r_1 and r_2 we will obtain, after integrating equality (18.23)

$$U_2 = \frac{g v_1 v}{2\pi\varepsilon c^2} \ln\frac{r_2}{r_1}, \tag{18.26}$$

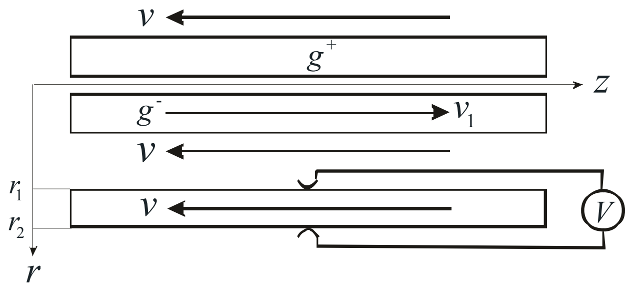

Fig. 21. To the conducting plate, which is moved together with the conductor, with the aid of the brushes the voltmeter is connected.

This potential difference will be observed between fixed contacts, which slide along the edges of plate and on the cross connection by their of that connecting (Fig. 21). In this case such cross connection is the circuit of voltmeter. The conducting plate, which is moved together with the conductor, presents together with the circuit of voltmeter the composite locked outline, in which will act EMF, which is been the sum of potential differences, which is located on the component parts of the outline. This potential difference will fix voltmeter. We will obtain its value, summing up expressions (18.25) and (18.26):

$$U_\Sigma = U_2 + U_1 = \left(\frac{g v_1 v}{2\pi\varepsilon c^2} - \frac{g v_1^2}{2\pi\varepsilon c^2} \right) \ln\frac{r_1}{r_2}. \tag{18.27}$$

but since $v \quad v_1$, finally we considerably more than obtain

$$U_\Sigma \cong \frac{g v_1 v}{2\pi\varepsilon c^2} \ln\frac{r_1}{r_2} \tag{18.28}$$

Is possible the conductor, along which flows the current, to roll up into the ring, after making from it a turn with the current, and to revolve this turn so that its speed would be equal v. In this case around this turn the electric field, which corresponds to the presence on the conductor of the ring of the specific charge, determined by relationship will appear (18.24). Let us roll up into the ring the conducting plate, after making from it a disk with the opening, and let us join to its generatrix feeder brushes, as shown in Fig. 22. If we with the identical speed revolve ring and disk, then on the condition that that the diameter of ring is considerably more than its width, on the brushes we will obtain EMF, determined by relationship (18.28).

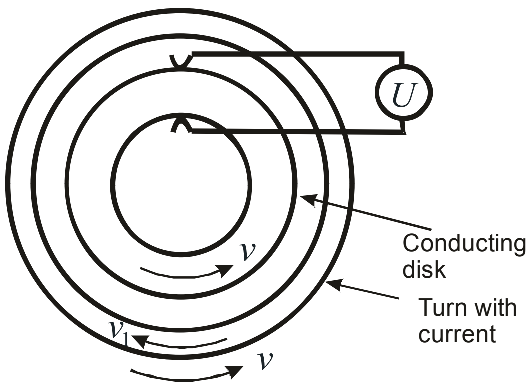

Fig. 22. Schematic of unipolar generator with the revolving turn with the current and the revolving conducting dick.

Is examined the most contradictory version of the unipolar generator, the explanation of the operating principle of which in the literary sources previously was absent. With its examination it is not possible to use a concept of the Lorentz force, since and magnet and conducting ring revolve together with the identical speed.

The conducting dick and the revolving together with it magnet it is possible to combine in the united construction. For this should be carried out ring from the magnetic material and magnetized it in the axial direction. The continuous magnetized disk is the limiting case of this construction. With this EMF it is removed with the aid of the feeder brushes between the generatrix of disk and its axis. This construction presents the unipolar generator, which was proposed still by Faraday.

Different combinations of the revolving and fixed magnets and disks are possible.

The case with the fixed magnet and the revolving conducting disk is characterized by the diagram, depicted in Fig. 23.

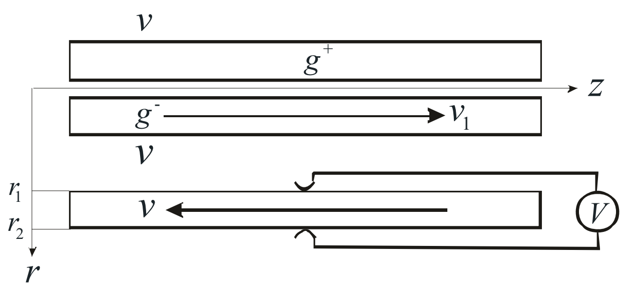

Fig. 23. The case, when the section of conductor with the current is fixed, and moves only the conducting plate.

In this case the following relationships are fulfilled:

The electric field, which acts on the electrons in the plate from the side of electrons, that move in the fixed annular turn, is determined by the relationship

$$E_1^- = -\frac{g}{2\pi\varepsilon r}ch\frac{v_1 - v}{c} = -\frac{g}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{(v_1 - v)^2}{c^2}\right),$$

and the electric field, which acts on the electrons in the disk, from the side of ions in the ring

$$E_2^+ = \frac{g}{2\pi\varepsilon r} ch\frac{v}{c} = \frac{g}{2\pi\varepsilon r}\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right).$$

Therefore a potential difference between the edges of the revolving disk will comprise

$$U_1 = \frac{g}{2\pi\varepsilon}\left(\frac{v_1 v}{c^2} - \frac{1}{2}\frac{v_1^{\ 2}}{c^2}\right)\ln\frac{r_2}{r_1}.$$

At the same time a potential difference between the brushes, which are fixed with respect to the reference system, will be determined by the relationship

$$U_2 = -\int_{r_1}^{r_2} \frac{g v_1^2 dr}{2\pi\varepsilon c^2 r} = -\frac{g v_1^2}{2\pi\varepsilon c^2}\ln\frac{r_2}{r_1} .$$

summarizing U_1 and U_2, we obtain value EMF in the composite outline of

$$U_\Sigma = \frac{g}{2\pi\varepsilon}\left(\frac{v_1 v}{c^2} - \frac{v_1^{\ 2}}{c^2}\right)\ln\frac{r_2}{r_1} \cong \frac{g v_1 v}{2\pi\varepsilon c^2}\ln\frac{r_2}{r_1} .$$

It is evident that this relationship coincides with relationship (18.28).

If we for the case examined roll up into the ring wire, and plate into the disk with the opening, then we will obtain the case, depicted in Fig. 24. Therefore there is no difference whatever between the case of the magnet, which revolves together with the disk and the magnet, which in the reference system of counting rests, and disk revolves is no. Specifically, this phenomenon did not find, until now, of explanation.

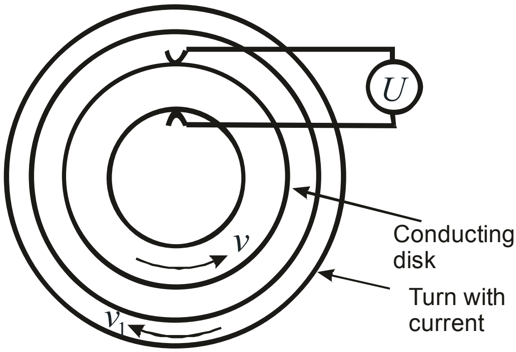

Fig. 24. Case of fixed magnet and revolving disk.

Now let us examine a question about what fields in the surrounding space it will direct the moving magnet, represented in Fig. 1 in the form the framework with the current. We will consider that the width of magnet is considerably lower than its length, and we will examine those fields, which will be generated near its average part without taking into account edge effects.

Let us at first examine a question about what electric fields the fixed framework with the current generates. We already said that the appearance of external static pour on around the conductors, along which flows the current, it is equivalent to appearance on these conductors of static charge. Therefore the it should be noted that indicated fields can be observed only when current into the framework is introduced by induction noncontact method. Otherwise electrical contact with the surrounding conductive bodies can lead to the overflow of the charges between the framework and these bodies, which will distort the results of experiment.

Let us examine a question about what electric fields must appear in the environment of the framework with the current, current into which is introduced by induction method. The middle part of the framework is represented in Fig. 25. Here electrons move with the speed v_1. At the point A the electric field will be they will be determined by the relationship

$$E_\Sigma = -\frac{g{v_1}^2}{2\pi\varepsilon c^2}\left(\frac{1}{r_1}+\frac{1}{r_2}\right). \qquad (18.29)$$

The same field will be observed, also, at the symmetrical point B.

If the framework moves in the direction of the axis z with the speed v, then upper conductor at the point A will create the electric field

$$E \cong \frac{g v_1 v}{2\pi\varepsilon c^2 r_1},$$

and lower conductor at the same point will create the will

$$E \cong -\frac{g v_1 v}{2\pi\varepsilon c^2 r_2}.$$

We will obtain summary field, after accumulating these two expressions

$$E_\Sigma \cong \frac{g v_1 v}{2\pi\varepsilon c^2}\left(\frac{1}{r_1}-\frac{1}{r_2}\right) \qquad (18.30)$$

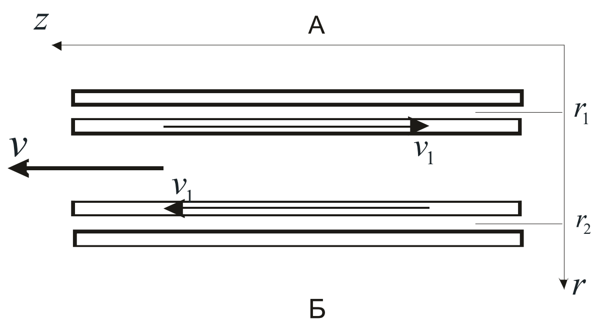

Fig. 25. Section of the moving framework with the current.

However, at the point B will be observed the same field only with the opposite sign.

Relationship (18.30) shows that with respect to the fixed observer the moving framework with the current creates electric field, in this case the impression of its polarization is created. However, observer, who moves together with the framework, will observe only the insignificant fields, determined by relationship (18.29).

Let us examine the new type of the unipolar generator, in which are used the magnetized rollers. In Fig. 26 is shown the magnetized conducting roller, which is rolled between two planes. We will consider that the lower conducting plane is fixed, and upper moves with the speed of v, making it necessary a roller to achieve simultaneously and progressive and rotary motion. Moreover, since the roller is magnetized, we will compare it, as before, with the turn, on which the electrons move with the speed v_1.

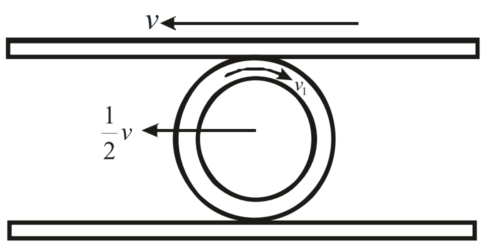

Fig. 26. Magnetized roller, which is rolled between two parallel planes.

In this case the center of turn moves with the speed $\frac{1}{2}v$. The instantaneous speed of turn at the point of its contact with the lower plane is equal to zero, and at upper point it is equal v. Let us isolate in the upper part of the turn the small section dl. The speed of the positive charges of lattice in this section relative to fixed observer will be equal v, while the electron velocity will be equal $v - v_1$. This situation corresponds to the case, depicted in Fig. 18. The section indicated, flying near the fixed observer, who is located near the upper plate, will create the tension of electric field equal

$$E \cong \frac{g v_1 v}{2\pi\varepsilon c^2 r}.$$

The duration of the pulse of electric field will compose vdl.

For registering this single-pole pulse it is possible to use the diagram, represented in Fig. 26. This examination demonstrates only the principle of obtaining the pulse of electric field with the aid of the rolling turn. In actuality situation is more complex. All parts of the rolling turn as the components of charge rates, have different composing the speeds parallel to plates in the dependence from the distance to the upper plate. Therefore for finding the field at the assigned fixed point out of the roller necessary to integrate the components of all electrical pour on, created by both the moving charges and by moving lattice of all parts of the turn.

The diagram, given in Fig. 27 it is not unipolar generator, since the galvanic contact between the lower terminal of voltmeter and the upper point of the rolling roller is absent. This contact must be created for transforming this diagram into the unipolar generator.

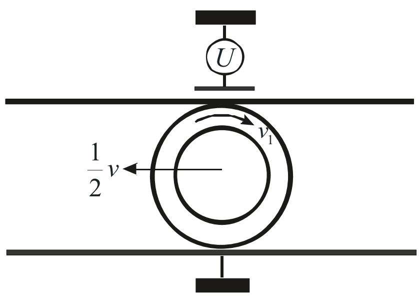

Fig. 27. Pulse-registering circuit of homopolar induction.

One of the possible diagrams of the creation of this contact simultaneously with all rollers, which are located in the bearing races, it is shown in Fig. 28.

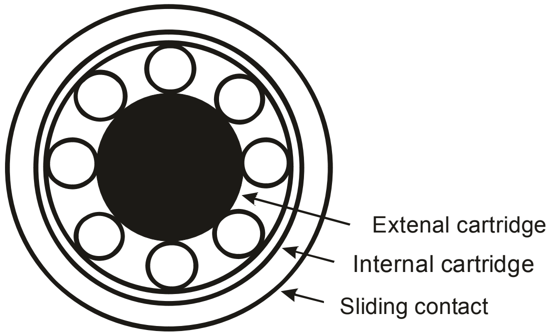

Fig. 28. Bearing with the magnetized rollers.

Bearing consists of the internal fixed conducting cartridge clip, external cartridge clip and sliding annular fixed contact. Internal cartridge clip can be both the continuous, as shown in figure and annular as in the usual bearing. External cartridge clip can be executed both of the conductor and from the dielectric. The fixed sliding contact, executed in the form of disk with the opening, must be prepared so that its internal annuli would not roll along the edge, but they slid immediately all rollers. If external cartridge clip was set into rotation, then each roller, presenting unitary unipolar generator, will generate in the fixed sliding contact a potential difference relative to internal cartridge clip. Longitudinal form of one of the possible constructions of this generator is shown in Fig. 29.

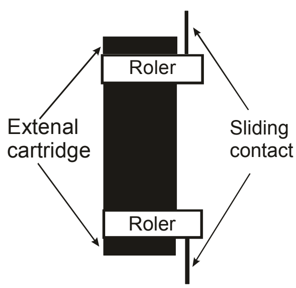

Fig. 29. The longitudinal section of unipolar generator with the magnetized rollers.

This model has only demonstration value, since. it is very difficult to reach this manufacturing precision in order to ensure the reliable sliding contact between the fixed slit ring terminal and all with that sliding on it by rollers.

More rational are the constructions, given in Fig. 30.

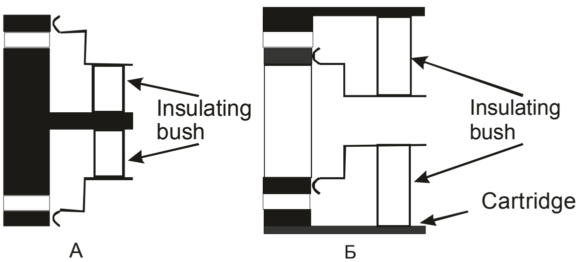

Fig. 30. Constructions of unipolar generator with the feeder brushes.

In both constructions are used roller bearings with the metallic cartridge clips and the magnetized rollers, EMF in which is removed with the aid of the brushes, which slide along the edge of cartridge clips. Then each roller, occurring opposite the sliding contact, will generate single-pole pulse EMF between the contact and the stationary part of the generator. In the construction A internal cartridge clip and the brushes, fastened to it on the insulating bushes, they are fixed, and external cartridge clip revolves. Constant stress EMF in this case appears between the central cartridge clip and the brushes. In the construction B internal cartridge clip, on the contrary, revolves, and spring cartridge clip with the brushes fastened to it, remains fixed. EMF in this case appears between the metallic cartridge clip, into which is pressed the bearing and by brushes. For an increase in the current, which they can ensure such generators should be increased a quantity of rollers and sliding contacts, after arranging them equidistantly on the perimeter of cartridge clip.

§ 19. Laws of the electric-electrical induction

Since pour on any process of the propagation of electrical and potentials it is always connected with the delay, let us introduce the being late scalar-vector potential, by considering that the field of this potential is extended in this medium with a speed of light [19]:

$$\varphi(r,t) = \frac{g\ ch\dfrac{v_{\perp}\left(t-\dfrac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r}, \tag{19.1}$$

where $v_{\perp}\left(t-\dfrac{r}{c}\right)$ - component of the charge rate g, normal to

to the vector $\vec{r}$ at the moment of the time $t' = t - \dfrac{r}{c}$, r - distance between the charge and the point, at which is determined the field, at the moment of the time t.

But does appear a question, on what bases, if we do not use the Maksvell equation, from whom does follow wave equation, is introduced the being late scalar- vector potential? This question was examined in the thirteenth paragraph, when the velocity of propagation of the front of the wave of the tension of magnetic and electric field in the long line was determined. There, without resorting to the Maxwell's equations, it was shown that electrical and magnetic field they are extended with the final speed, which in the vacuum line is equal to the speed of light. Consequently, such fields be late to the period $\dfrac{r}{c}$ (see relationship (13.2)). The same delay we introduce in this case and for the scalar- vector potential, which is the carrier of electrical pour on.

Using relationship $\vec{E} = -grad\ \varphi(r,t)$, let us find field at point 1 (Fig. 31) . The gradient of the numerical value of a radius of the vector $\vec{r}$ is a scalar function of two points: the initial point of a radius of vector and its end point (in this case this point 1 on the axis of x and point 0 at the origin of coordinates). Point 1 is the point of source, while point 0 - by observation point. With the determination of gradient from the function, which contains a radius depending on the conditions of task it is necessary to distinguish two cases: 1) the point of source is fixed and $\vec{r}$ is considered as the function of the position of observation point; and 2) observation point is fixed and $\vec{r}$ is considered as the function of the position of the point of source.

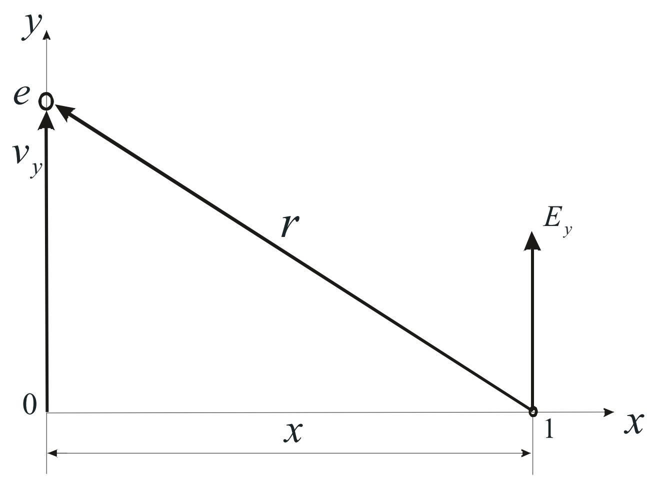

Fig. 31. Diagram of shaping of the induced electric field.

We will consider that the charge e accomplishes fluctuating motion along the axis y, in the environment of point 0, which is observation point, and fixed point 1 is the point of source and $\vec{r}$ is considered as the function of the position of charge. Then we write down the value of electric field at point 1:

$$E_y(1) = -\frac{\partial \varphi_\perp(r,t)}{\partial y} = -\frac{\partial}{\partial y}\frac{e}{4\pi\varepsilon_0 r(y,t)}\ ch\frac{v_y\left(t - \frac{r(y,t)}{c}\right)}{c}$$

When the amplitude of the fluctuations of charge is considerably less than distance to the observation point, it is possible to consider a radius vector constant. We obtain with this condition:

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 cx}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} sh\frac{v_y\left(t-\frac{x}{c}\right)}{c} \qquad (19.2)$$

where x - some fixed point on the axis x.

Taking into account that

$$\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{\partial t}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{1}{v_y\left(t-\frac{x}{c}\right)}$$

we obtain from (19.2):

$$E_y(x,t) = \frac{e}{4\pi\varepsilon_0 cx}\frac{1}{v_y\left(t-\frac{x}{c}\right)}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}. \qquad (19.3)$$

This is a complete emission law of the moving charge.

If we take only first term of the expansion $sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}$, then we will obtain from (19.3):

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} = -\frac{ea_y\left(t-\frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x}, \qquad (19.4)$$

where $a_y\left(t-\frac{x}{c}\right)$ - being late acceleration of charge. This relationship is wave equation and defines both the amplitude and phase responses of the wave of the electric field, radiated by the moving charge.

If we as the direction of emission take the vector, which lies at the plane xy, and which constitutes with the axis of y the angle α, then relationship (19.4) takes the form:

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}. \qquad (19.5)$$

Relationship (2.5) determines the radiation pattern. Since in this case there is axial symmetry relative to the axis y, it is possible to calculate the complete radiation pattern of this emission. This diagram corresponds to the radiation pattern of dipole emission.

since $\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x} = A_H\left(t-\frac{x}{c}\right)$ - being late vector potential, relationship (19.5) it is possible to rewrite

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} =$$

$$= -\frac{1}{\varepsilon_0 c^2}\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t} = -\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}$$

Is again obtained complete agreement with the equations of the being late vector potential, but vector potential is introduced here not by phenomenological method, but with the use of a concept of the being late scalar- vector potential. It is necessary to note one important circumstance: in the Maxwell equations the electric fields, which present wave, vortex. In this case the electric fields bear gradient nature.

Let us demonstrate the still one possibility, which opens relationship (19.5). Is known that in the electrodynamics there is this concept, as the electric dipole and the dipole emission, when the charges, which are varied in the electric dipole, emit electromagnetic waves. Two charges with the opposite signs have the dipole moment:

$$\vec{p} = e\vec{d}\,, \tag{19.6}$$

where the vector $\vec{d}$ is directed from the negative charge toward the positive charge. Therefore current can be expressed through the derivative of dipole moment on the time of

$$e\vec{v} = e\frac{\partial \vec{d}}{\partial t} = \frac{\partial \vec{p}}{\partial t}\ .$$

Consequently

$$\vec{v} = \frac{1}{e}\frac{\partial \vec{p}}{\partial t},$$

and

$$\vec{a} = \frac{\partial \vec{v}}{\partial t} = \frac{1}{e}\frac{\partial^2 \vec{p}}{\partial t^2}\ .$$

Substituting this relationship into expression (19.5), we obtain the emission law of the being varied dipole

$$\vec{E} = -\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2}. \qquad (19.7)$$

This is also very well known relationship [1].

In the process of fluctuating the electric dipole are created the electric fields of two forms. First, these are the electrical induction fields of emission, represented by equations (2.4), (2.5) and (2.6), connected with the acceleration of charge. In addition to this, around the being varied dipole are formed the electric fields of static dipole, which change in the time in connection with the fact that the distance between the charges it depends on time. Specifically, energy of these pour on the freely being varied dipole and it is expended on the emission. However, the summary value of field around this dipole at any moment of time defines as superposition pour on static dipole pour on emissions.

Laws (2.4), (2.5), (2.7) are the laws of the direct action, in which already there is neither magnetic pour on nor vector potentials. I.e. those structures, by which there were the magnetic field and magnetic vector potential, are already taken and they no longer were necessary to us.

Using relationship (2.5) it is possible to obtain the laws of reflection and scattering both for the single charges and, for any quantity of them. If any charge or group of charges undergo the action of external (strange) electric field, then such charges begin to accomplish a forced motion, and each of them emits electric fields in accordance with relationship (19.5). The superposition of electrical pour on, radiated by all charges, it is electrical wave.

If on the charge acts the electric field of , then the acceleration of charge is determined by the equation $E'_y = E'_{y0}\sin\omega t$

$$a = -\frac{e}{m} E'_{y0} \sin \omega t .$$

Taking into account this relationship (18.5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2 \ \sin\alpha}{4\pi\varepsilon_0 c^2 mx} E'_{y0} \sin\omega(t - \frac{x}{c}) = \frac{K}{x} E'_{y0} \sin\omega(t - \frac{x}{c}), \quad (19.8)$$

where the coefficient $K = \frac{e^2 \ \sin\alpha}{4\pi\varepsilon_0 c^2 m}$ can be named the coefficient of scattering (re-emission) single charge in the assigned direction, since it determines the ability of charge to re-emit the acting on it external electric field.

The current wave of the displacement accompanies the wave of electric field:

$$j_y(x,t) = \varepsilon_0 \frac{\partial E_y}{\partial t} = -\frac{e \sin\alpha}{4\pi c^2 x} \frac{\partial^2 v_y\left(t - \frac{x}{c}\right)}{\partial t^2} .$$

If charge accomplishes its motion under the action of the electric field, then bias current in the distant zone will be written down as $E' = E'_0 \sin\omega t$

$$j_y(x,t) = -\frac{e^2 \omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right). \quad (19.9)$$

The sum wave, which presents the propagation of electrical pour on (2.8) and bias currents (2.9), can be named the electric-current wave. In this current wave of displacement lags behind the wave of electric field to the angle equal $\frac{\pi}{2}$.

For the first time this term and definition of this wave was used in the works [8, 10].

In parallel with the electrical waves it is possible to introduce magnetic waves, if we assume that

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H}\,, \qquad (19.10)$$

$$div\vec{H} = 0$$

Introduced thus magnetic field is vortex. Comparing (19.9) and (19.10) we obtain:

$$\frac{\partial H_z(x,t)}{\partial x} = \frac{e^2\omega \sin\alpha}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right).$$

Integrating this relationship on the coordinate, we find the value of the magnetic field

$$H_z(x,t) = \frac{e^2 \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t - \frac{x}{c}\right). \qquad (19.11)$$

Thus, relationship (2.8), (2.9) and (2.11) can be named the laws of electrical induction, since they give the direct coupling between the electric fields, applied to the charge, and by fields and by currents induced by this charge in its environment. Charge itself comes out [v] in the role of the transformer, which ensures this reradiation. The magnetic field, which can be calculated with the aid of relationship (2.11), is directed normally both toward the electric field and toward the direction of propagation, and their relation at each point of the space is equal

$$\frac{E_y(x,t)}{H_z(x,t)} = \frac{1}{\varepsilon_0 c} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z\,,$$

where Z - wave impedance of free space.

The wave impedance determines the active power of losses on the single area, located normal to the direction of propagation of the wave:

$$P = \frac{1}{2} Z E^2{}_{y0}.$$

Therefore electric-curent wave, crossing this area, transfers through it the power, determined by the data by relationship, which is located in accordance with by the Poynting theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electric-curent wave and knowledge of the wave drag of space. In this case it is in no way compulsory to introduce this concept as magnetic field and its vector potential, although there is nothing illegal in this. In this setting of the relationships, obtained for the electrical and magnetic field, they completely satisfy Helmholtz's theorem. This theorem says, that any single-valued and continuous vector field, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function and rotor of a certain vector function, whose divergence is equal to zero:

$$\vec{F} = grad\varphi + rot\vec{C},$$

$$div\vec{C} = 0.$$

Consequently, must exist clear separation pour on to the gradient and the vortex. It is evident that in the expressions, obtained for those induced pour on, this separation is located. Electric fields bear gradient nature, and magnetic bear vortex nature.

Thus, the construction of electrodynamics should have been begun from the acknowledgement of the dependence of scalar potential on the speed. But nature very deeply hides its secrets, and in order to come to this simple conclusion, it was necessary to pass way by length almost into two centuries. The grit, which so harmoniously were erected around the magnet poles, in a straight manner indicated the presence of some power pour on potential nature, but to this they did not turn attention; therefore it turned out that all examined only tip of the iceberg, whose substantial part remained invisible of almost two hundred years.

Taking into account entire aforesaid one should assume that at the basis of the overwhelming majority of static and dynamic phenomena at the electrodynamics only one formula (2.1), which assumes the dependence of the scalar potential of charge on the speed, lies. From this formula it follows and static interaction of charges, and laws of power interaction in the case of their mutual motion, and emission laws and scattering. This approach made it possible to explain from the positions of classical electrodynamics such phenomena as phase aberration and the transverse the Doppler effect, which within the framework the classical electrodynamics of explanation did not find. After entire aforesaid it is possible to remove construction forests, such as magnetic field and magnetic vector potential, which do not allow here already almost two hundred years to see the building of electrodynamics in entire its sublimity and beauty.

Let us point out that one of the fundamental equations of induction (2.4) could be obtained directly from the Ampere law, still long before appeared the Maksvell equations. The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z

$$\vec{H} = \frac{1}{4\pi} \int \frac{I d\vec{l} \times \vec{r}}{r^3}$$

where I - current in the element $d\vec{l}$, $\vec{r}$ - vector, directed from $d\vec{l}$ to the point x, y, z.

It is possible to show that

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right) \times d\vec{l}$$

and, besides the fact that

$$grad\left(\frac{1}{r}\right)\times d\vec{l} = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r} rot\ d\vec{l}\ .$$

But the rotor $d\vec{l}$ is equal to zero and therefore is final

$$\vec{H} = rot\int I\left(\frac{d\vec{l}}{4\pi r}\right) = rot\ \vec{A}_H,$$

where

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right). \qquad (19.12)$$

Remarkable property of this expression is that that the vector potential depends from the distance to the observation point as $\frac{1}{r}$. Specifically, this property makes it possible to obtain emission laws.

Since $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, from (2.12) we obtain:

$$\vec{A}_H = \int \frac{gv\ d\vec{l}}{4\pi r}.$$

For the single charge e this relationship takes the form:

$$\vec{A}_H = \frac{e\vec{v}}{4\pi r},$$

and since

$$\vec{E} = -\mu\frac{\partial\vec{A}}{\partial t},$$

that

$$\vec{E} = -\mu\int\frac{g\frac{\partial v}{\partial t}\ d\vec{l}}{4\pi r} = -\mu\int\frac{ga\ d\vec{l}}{4\pi r}, \qquad (19.13)$$

where a - acceleration of charge.

This relationship appears as follows for the single charge:

$$\vec{E} = -\frac{\mu e \vec{a}}{4\pi r}. \tag{19.14}$$

If we in relationships (19.13) and (19.14) consider that the potentials are extended with the final speed and to consider the delay $\left(t - \frac{r}{c}\right)$, and assuming $\mu = \frac{1}{\varepsilon_0 c^2}$, these relationships will take the form:

$$\vec{E} = -\mu \int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi r} = -\int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi \varepsilon_0 c^2 r}, \tag{19.15}$$

$$\vec{E} = -\frac{e\vec{a}(t - \frac{r}{c})}{4\pi \varepsilon_0 c^2 r}. \tag{19.16}$$

Of relationship (19.15) and (19.16) represent, it is as shown higher (see (19.4)), wave equations. Let us note that these equations - this solution of the Maxwell equations, but in this case they are obtained directly from the Ampere law, not at all coming running to the Maxwell equations. To there remains only present the question, why electrodynamics in its time is not banal by this method?

Given examples show, as electrodynamics in the time of its existence little moved. The phenomenon of electromagnetic induction Faraday opened into 1831 years and already almost 200 years its study underwent practically no changes, and the physical causes for the most elementary electrodynamic phenomena, until now, were misunderstood. Certainly, for his time Faraday was genius, but that they did make physics after it? There were still such brilliant figures as Maxwell and Hertz, but even they did not understand that the dependence of the scalar potential of charge on its relative speed is the basis of entire classical electrodynamics, and that this is that basic law, from which follow the fundamental laws of electrodynamics.

§ 20. As are formed electrical induction fields and the magnetic vector potential

Earlier has already been indicated that solution of problems interactions of the moving charges in the classical electrodynamics are solved by the introduction of the magnetic field or vector potential, which are fields by mediators. To the moving or fixed charge action of force can render only electric field. Therefore natural question arises, and it is not possible whether to establish the laws of direct action, passing fields the mediators, who would give answer about the direct interaction of the moving and fixed charges. This approach would immediately give answer, also, about sources and places of the application of force of action and reaction. Let us show that application of scalar- vector potential gives the possibility to establish the straight laws of the induction, when directly the properties of the moving charge without the participation of any auxiliary pour on they give the possibility to calculate the electrical induction fields, generated by the moving charge [19].

Let us examine the diagram of the propagation of current and voltage in the section of the long line, represented in Fig. 6 . In this figure the wave front occupies the section of the line of the long z_2, therefore, the time of this transient process equally $t = \frac{z_2}{c}$. This are thing time, for which the voltage on incoming line grows from zero to its nominal value. The duration of this transient process is adjustable, and it depends on that, in which law we increase voltage on incoming line, now we will attempt to understand, from where is taken that field strength, which forces charges in the conductors, located near the current carrying elements of line, to move in the direction opposite to the direction of the motion of charges in the primary line. This exactly are that question, to which, until now, there is no physical answer. Let us assume that voltage on incoming line grows according to the linear law also during the time Δt it reaches its maximum value U, after which its increase ceases. Then in line itself transient process engages the section $z_1 = c\Delta t$. Let us depict this section separately, as shown in Fig. 32. In the section z_1 proceeds the acceleration of charges from their zero speed (more to the right the section z_1) to the value of speed, determined by the relationship

$$v = \sqrt{\frac{2eU}{m}} \ ,$$

where e and m - charge and the mass of current carriers, and U - voltage drop across the section z_1. Then the dependence of the speed of current carriers on the coordinate will take the form:

$$v^2(z) = \frac{2e}{m}\ \frac{\partial U}{\partial z} z\,. \qquad (20.1)$$

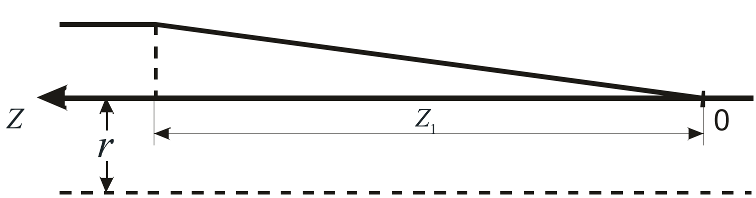

Fig. 32. Current wavefront, which is extended in the long line.

Since we accepted the linear dependence of stress from the time on incoming line, the equality occurs

$$\frac{\partial U}{\partial z} = \frac{U}{z_2} = E_z,$$

where E_z - field strength, which accelerates charges in the section z_1. Consequently, relationship (20.1) it is possible to rewrite

$$v^2(z) = \frac{2e}{m} E_z z .$$

Using for the value of scalar-vector potential relationship (16.4), let us calculate it as the function z on a certain distance r from the line of

$$\varphi(z) = \frac{e}{4\pi\ \varepsilon_0 r}\left(1 + \frac{1}{2}\ \frac{v^2(z)}{c^2}\right) = \frac{e}{4\pi\ \varepsilon_0 r}\left(1 + \frac{eE_z z}{mc^2}\right). \qquad (20.2)$$

For the record of relationship (20.2) are used only first two members of the expansion of hyperbolic cosine in series.

Using the formula $E = -grad\ \varphi$, and differentiating relationship (20.2) on z, we obtain

$$E_z' = -\frac{e^2 E_z}{4\pi\ \varepsilon_0 rmc^2}, \qquad (20.3)$$

where E_z' - the electric field, induced at a distance r from the conductor of line. Near E we placed prime in connection with the fact that calculated field it moves along the conductor of line with the speed of light, inducing in the conductors surrounding line the induction currents, opposite to those, which flow in the basic line. The acceleration of charge is determined by the relationship $a_z = \frac{eE_z}{m}$. Taking this into account from (20.3) we obtain

$$E_z' = -\frac{ea_z}{4\pi\ \varepsilon_0 rc^2}\ . \qquad (20.4)$$

Thus, the charges, accelerated in the section of the line z_1, induce at a distance r from this section the electric field, determined by relationship (20.4). Direction of this field conversely to field, applied to the accelerated charges. Thus, is obtained the law of direct action, which indicates what electric fields generate around themselves the charges, accelerated in the conductor. This law can be called the law of electro-electrical induction, since it, passing fields mediators (magnetic field or vector potential), gives straight answer to what electric fields the moving electric charge generates around itself. This law gives also answer about the place of the application of force of interaction between the charges. Specifically, this relationship, but not the Faraday law, we must consider as the fundamental law of induction, since specifically, it establishes the reason for the appearance of induction electrical pour on around the moving charge. In what the difference between the proposed approach and that previously existing consists. Earlier we said that the moving charge generates vector potential, and the already changing vector potential generates electric field. Relationship (20.4) gives the possibility to exclude this intermediate operation and to pass directly from the properties of the moving charge to the induction fields. Let us show that relationship it follows from this and the introduced earlier phenomenologically vector potential, and, therefore, also magnetic field. Since the connection between the vector potential and the electric field is determined by relationship (2.3), equality (20.4) it is possible to rewrite

$$E_z{}' = -\frac{e}{4\pi\ \varepsilon_0 rc^2}\frac{\partial v_z}{\partial t} = -\mu\frac{\partial A_H}{\partial t},$$

and further, integrating by the time, we obtain

$$A_H = \frac{ev_z}{4\pi r}.$$

This relationship corresponds to the determination of vector potential. It is now evident that the vector potential is the direct consequence of the dependence of the scalar potential of charge on the speed. The introduction also of vector potential and of magnetic field this is the useful mathematical device, which makes it possible to simplify the solution of number of electrodynamic problems, however, one should remember that by fundamentals the introduction of these pour on it appears scalar- vector potential.

§ 21. Experimental confirmation of the dependence of the scalar potential of charge on its relative speed

If we in relationship (18.1) place $g_2^+ = 0$ and $V_2 = 0$, i.e. to examine the case of interaction of the lower conductor, along which flows the current, with the fixed charge of the upper conductor $g_2^- = 0$ in the absence of lattice, then for the force of interaction we will obtain:

$$F_{\Sigma 2} = -\frac{1}{2}\ \frac{g_1\ g_2 v_1^2}{2\pi\ \varepsilon\ c^2 r}.$$

This means that the current when flows along the conductor, it ceases to be electrically neutral, and around it must be formed the radial static electric field

$$E_{\perp} = -\frac{g_1 \, v_1^2}{4\pi \, \varepsilon \, c^2 r}, \qquad (21.1)$$

which is equivalent to appearance on the lower conductor of additional negative potential, which is, in turn, equivalent to appearance on this conductor of the additional specific static charge

$$g = -2g_1 \, \frac{v_1^2}{c^2}. \qquad (21.2)$$

This fact attests to the fact that the adoption of the concept of scalar- vector potential indicates the acknowledgement of the dependence of charge on the speed. However, up to now no one obtained experimental confirmation the validity of relationships (21.1) and (21.2).

When by Farady and Maksvell were formulated the fundamental laws of electrodynamics, to experimentally confirm relationship (21.1) it was impossible, since. the current densities, accessible in the usual conductors, are too small for the experimental detection of the effect in question. Thus, position about the independence of scalar potential and charge from the speed and the subsequent introduction of magnetic field they were made volitional way on the phenomenological basis.

Of current density, which can be achieved in the superconductors, make it possible to experimentally detect the electric fields, determined by relationship (21.1) [10-12, 19]. If such fields will be discovered, then this means that the scalar potential of charge depends on its relative speed.

let us examine setting the experiment, which must give answer to the presented questions. The diagram of experiment is depicted in Fig. 33.

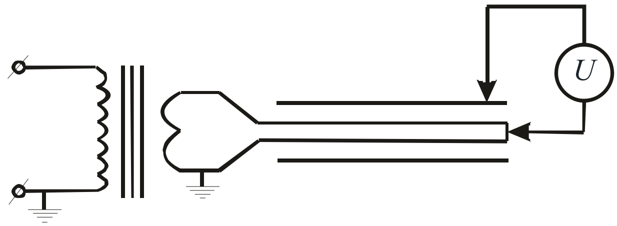

Fig. 33. Experimental confirmation of the dependence of the scalar potential of charge on its relative speed.

If the folded in half superconductive wire (we will call its bifilar) to surround by the conducting cylinder and to introduce into it current in an induction manner, then in the case the dependence of charge on the speed the electrometer with the high internal resistance, connected between the cylinder and the wire, must show the presence of a potential difference. The noncontact induction introduction of current adapts with that purpose in order to exclude the presence of contact potential differences with the contact introduction of current. The difficulty of conducting this experiment consists in the fact that the input capacitance of the electrometer (usually several ten picofarad) it will be considerably more than the capacity between the bifilar loop and the cylinder. Since we measure not EMP, but a potential difference, with the connection to this device of the input capacitance of electrometer the charge, induced on the cylinder to redistribute between both capacities. If we consider that an initial potential difference between the loop and the cylinder was U_1, and the capacity between them composed C_1, then with the connection between loop and cylinder of the additional tank of the electrometer C_2 a potential difference U_2 to be determined by the relationship:

$$U_2 = \frac{C_1 U_1}{C_1 + C_2} = k_1 U_1 . \qquad (21.3)$$

is obvious that if $C_1 \ll C_2$ then $U_2 \ll U_1$. In the final analysis it turns out that in order to obtain a maximum voltage drop across electrometer itself should be increased the capacity between the loop and the cylinder, increasing the length of entire construction.

Let us begin from the determination of the expected effect the calculation of the parameters of the measuring system, intended for detecting the expected effect.

If is located the plane layer of charges with the density n and the thickness λ, the like both sides from this layer it is created the electric field:

$$E_{\perp} = \frac{1}{2}\ \frac{ne\lambda}{\varepsilon_0}.$$

Thus far this layer of charges does not move its electric field is completely compensated by the positive charges of lattice. But, when layer begins to move, is created additional electric field equal:

$$\Delta E \cong \frac{1}{2}\ E_{\perp}\frac{v^2}{c^2}. \qquad (21.4)$$

The speed of the motion of charges is connected with the magnetic field with the relationship:

$$H = nev\lambda.$$

If the speed, obtained from this relationship was substituted in (21.4), then we will obtain:

$$\Delta E_{\perp} = \frac{1}{2}\ \frac{H^2}{\varepsilon_0 ne\lambda c^2} = \frac{1}{2}\ \frac{\mu_0 H^2}{ne\lambda}.$$

For enumerating a maximally expected magnitude of effect as H should be taken the value of critical field for this type of superconductor.

Let us calculate the maximum magnitude of this effect for the case of superconductive niobium, after assuming: $H_c = 1{,}5 \cdot 10^5 \frac{A}{м}$, $\lambda \cong 10^{-7}$ m,

$n \cong 3 \cdot 10^{28} \frac{1}{м^3}$. With such values of the parameters indicated we obtain $\Delta E_{\perp} \cong 3\frac{B}{м}$. We will consider that the diameter d of bifilar loop composes the doubled value of the diameter of the utilized superconductive wire with a diameter 0,25 mm. If we take the diameter of the cylinder of D equal 10 mm, then a potential difference between the loop and the cylinder will comprise: $U = \Delta E_{\perp} \frac{d}{2} \ln\frac{D}{d} \cong 3mB$. The linear capacity of coaxial there will be $C_0 \cong 15\frac{n\Phi}{м}$.

In conducting the experiments at our disposal was located vibrating reed electrometer with a input capacitance o ~ 60 pF and the sensitivity ~ 1 mV. In order to ensure at least the same capacity of the coaxial (in this case a voltage drop across the capacity of electrometer after its connection to the coaxial it will be 1.5 mV) it is necessary to take the length of the coaxial 4 meters. Certainly, for the technical reasons it is difficult to cool this coaxial to helium temperatures and furthermore and effect itself proves to be insufficient for its reliable measurement. Therefore the magnitude of effect must be increased at least 100 times. This can be carried out, after increasing a quantity of central cores of coaxial, after bringing it to two hundred, for which to be required 400 meters of wire. Certainly, in this case it is necessary to increase the diameter of its cylindrical part. It is possible to again produce calculation, but use of an experimental model with the coaxial of this size nevertheless unacceptably in view of its unwieldiness, although the possibility of the precise calculation of the expected effect is the great advantage of this solution.

In this case us even does not so much interest the precise agreement of calculated and experimental data, as reliable detection of effect itself. Therefore experimental model was created according to another diagram.

For purposes the introduction of current into the superconductive winding with the small inductance was used the cooled to helium temperatures transformer with the iron core. Using as the secondary winding of transformer the superconductive winding, connected with the solenoid, it is possible without the presence of galvanic contacts to introduce current into it. In the transformer was used ring-shaped core made of transformer steel. The primary and secondary windings of transformer were wound by niobium-titanium wire with the copper coating and contained 150 and 10 turns respectively. Thus, transformer has a transformation ratio 15. The wire diameter composed 0.25 mm. The secondary winding of transformer is connected in series with the solenoid with the small inductance, which is wound bifilar and contains 2448 turns of the same wire. The overall length of coil composes 910 m of. The ends of solenoid and secondary winding of transformer are welded with the aid of the laser welding. Solenoid is wound on the body from polyfluoroethylene resin. Inside and outside diameter of the winding of solenoid 35 and 90 mm of respectively, the width of the coil of 30 mm. To the midpoint of solenoid is connected internal wiring of the coaxial, which emerges outside cryostat, the same coaxial is connected also to the screen of solenoid. The construction of solenoid is shown in Fig. 34.

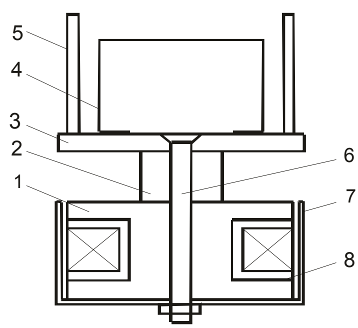

Fig. 34. Construction of the superconductive solenoid.

By numbers in the figure are designated the following elements: 1- aluminum bobbin, 2- teflon bushing, 3- teflon disk, 4- cramp, 5- column, 6- bolt, 7- copper screen, 8- teflon bobbin. Solenoid is wound on teflon bobbin 8, which is concluded in aluminum bobbin 1. Outside solenoid is surrounded by copper screen 7, which together with bobbin 1 is the screen of solenoid. To bobbin 1 by means of bolt 6 and teflon bushing 2 is fastened teflon disk 3, on which is installed clamp 4. The turns of the secondary winding of transformer cover clamp 4, through which, without concerning it, is passed the magnetic circuit of transformer. Entire construction is attached to the transformer by means of counters 5. Transformer together with the solenoid is placed in the tank of helium cryostat. The diagram of the connection of coaxials to the solenoid is shown in Fig. 35.

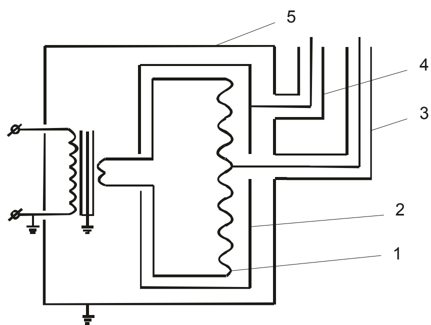

Fig. 35. Diagram of connection of solenoid.

By the figure are accepted the following designations: 1- solenoid, 2- the screen of solenoid, 3,4 - coaxials, 5- the common screen, which the helium tank is. Resistance between the grounded elements, the screen of solenoid and solenoid itself composes not less than 10^{14} Ohm. The elements, utilized in the construction, had the following capacities relative to the earth- the coaxial - 3- 44 pF, coaxial 4- 27 pF, capacity screen - the earth it comprises - 34 pF, capacity screen- solenoid compose - 45 pF, as the electrometer was used by capacitive vibrating reed electrometer with a input capacitance 60 pF and a input resistance 10^{14} Ohm.

During this construction of the superconductive solenoid and its surrounding screen it cannot be produced the precise calculation of electrostatic pour on, that appear around the solenoid to, however, establish the presence of effect itself, this construction allows.

With the measurements electrometer was connected directly to the screen by means of coaxial 4, and the midpoint of the superconductive solenoid by means of coaxial 3 was grounded. Current into the primary winding of transformer was introduced from the source of direct current, indication of electrometer in this case they did not depend on direction of flow. With the strengths of introduced current ~ 9 A occurred the spontaneous discharge of the indications of electrometer. This means that the current in the winding of solenoid reached its critical value, and the winding by jump converted to normal state. Iron core in this case seized magnetic flux, also, with the decrease of the current introduced into the solenoid, the curve of the dependence of the measured potential on the current was repeated, and potential reached its maximum value with current zero.

The dependence of the measured potential difference is given in Fig. 36.

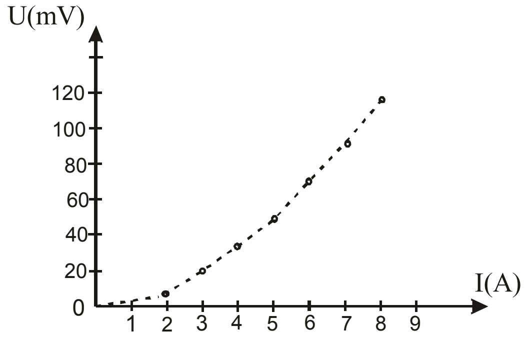

Fig. 36. Dependence of the given potential difference between the screen and the low-inductive solenoid on the current in its winding.

Thus, experimental results indicate that the value of scalar potential, and, therefore, also charge depends on speed.

However in this diagram of experiment occurs the direct galvanic connection of electrometer to the superconductive solenoid. This can cause questions, but are not the reason for the appearance of a potential difference between the solenoid and the screen some contact phenomena in the place of the contact of wire, which connects electrometer with the solenoid? The experiments with the superconductive niobium torus were carried out for the answer to this question.

The diagram of experiment is shown in Fig. 37. Inside the torus-shaped conducting screen is placed the superconductive torus, made from niobium. When charge will appear inside the screen, a potential difference will appear between the internal and external screen. In the experiment, as external screen 1, the yoke of transformer, made from transformer steel, was used. On the central rod of this yoke was located primary winding with 2, wound by niobium-titanium wire, which contains 1860 turns. Torus-shaped metal screen 3, made from copper, was located on the same rod. Torus 4, made from niobium, is located inside this screen. The outer diameter of niobium torus composed 76 mm, and internal 49 mm. Transformer was placed in the tank of helium cryostat and was cooled to the helium temperature, in this case the yoke of transformer and helium tank were grounded. The current was induced during the introduction of direct current into the primary winding of transformer in the superconductive torus, and electrometer fixed the appearance between screen 3 and yoke of transformer a potential difference U. This means that the niobium torus, located inside screen 3 during the introduction into it of direct current ceases to be electrically neutral. The constant value current in the superconductive torus 1860 times exceeded the current, introduced into the primary winding of transformer.

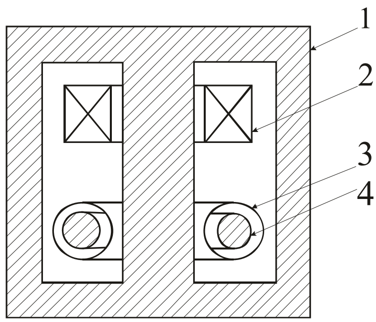

Fig. 37. Diagram of experiment with the superconductive torus.

The dependence of a potential difference U on the current I, introduced into the primary winding of transformer, it is shown in Fig. 38.

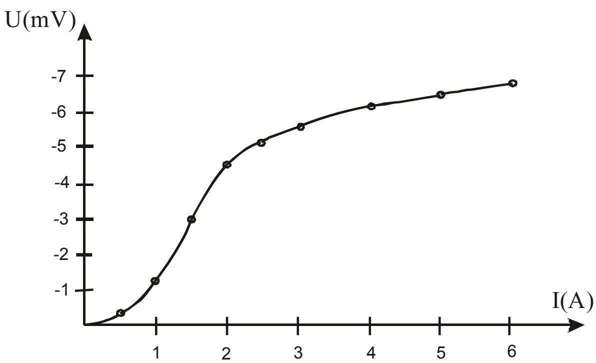

Fig. 38. Dependence of a potential difference boundary by screen 3 by the yoke of transformer on the current, introduced into the primary winding of transformer.

The obtained values of a potential difference, in comparison with the case of the superconductive wire winding, proved to be considerably smaller, this is connected with the considerably smaller surface of torus, in comparison with the surface of wire winding. The form of the dependence of a potential difference on the introduced current also strongly differs.

Quadratic section is observed only in the very small initial section up to the values of currents into 2 amperes, introduced into the primary winding. Further this dependence becomes almost rectilinear with small angle of inclination. It was not observed moreover of stalling the indications of electrometer in this case.

With which are connected such differences in the behavior of a potential difference in comparison with the wire version? In the case of wire solenoid the superconductive current is evenly distributed over the surface of wire and reaches its critical value in all its sections of surface simultaneously, with which and is connected the simultaneous passage of the entire winding of solenoid into the normal state, with the reaching in the wire of the critical value of current.

In the case of torus the process of establishing the superconductive current on its surface occurs differently. That introduced into the direct current superconducting torus is very unevenly distributed over its surface. Maximum current densities occur on the internal surface of torus, and they are considerably less on the periphery. With this is connected the fact that the internal surfaces of torus begin to convert to normal state earlier than external. The process of passing the torus into the normal state occurs in such a way that with an increase of the current in the torus into the normal state pass the first interior and normal phase begins to be moved from the interior to the external. Process lasts until entire torus passes into the normal state. But why in this case up to the moment of passing the torus into the normal state does not occur the discharge of current, as it takes place in the case of wire solenoid? This niobium is connected with the fact that the superconductor of the second kind, and it does not convert abruptly to normal state. It has the sufficiently significant region of current densities, with which it is in the mixed state, when the Abrikosov vortices penetrate inside the massive conductor. The circumstance that the indications of electrometer do not have a discharge of indications, he indicates that the superconductive torus is in the mixed state, but the presence of the vortex of the structures in it, which also present the superconductive currents, they lead to the fact that the torus ceases to be electrically neutral. From this it is possible to draw the conclusion that the vortices bear on themselves not only magnetic-flux quanta, but still electric charges.

If we change direction of flow in the primary winding, then the dependence, similar to that depicted in Fig. 38, is repeated, however, it is observed strong hysteresis. This is connected with the fact that the vortices, which penetrated into the depths of the superconductor, they are attached on the stacking faults, falling into potential wells, that also leads to hysteresis.

Thus, the results of the carried out experiments unambiguously indicate the dependence of scalar potential and magnitude of the charge from their speed, which was predicted still in the work [3] and it is experimentally confirmed in the works [11,19].

§ 22. Electric pulse of space thermonuclear explosion

According to the program "*Starfish*" USA exploded in space above Pacific Ocean H-bomb. This event placed before the scientific community many questions [20,21]. It is earlier into 1957 year future Nobel laureate doctor Hans Albrecht Bethe (Hans A. Bethe), being based on the theory of dipole emission, predicted that with a similar explosion will be observed the electromagnetic pulse (EMI), the strength of field of which on the earth's surface will comprise not more than 100 V/m. Therefore entire measuring equipment, which had to record electromagnetic radiation, was disposed for registering such tensions pour on. But with the explosion of bomb discomfiture occurred, pour on the tension of electrical, beginning from the epicentre of explosion, and further for the elongation of more than 1000 km of it reached several ten thousand volt per meters. Electric pulse had not only very large amplitude, but also very short duration on the order of 50 ns. Since doctor Bethe forecast did not justify, it was subsequently advanced a number of the theories, intended to explain experimental data.

The greatest reputation obtained the theory, in which it is assumed that the pulse shaping is obliged to the relativistic Compton electrons, which the rigid X-radiation knocks out from the molecules of air. Such electrons simultaneously with gamma-radiation move with the relativistic speeds in the direction of propagation of electromagnetic wave. It assumes this model that the process of the pulse shaping is not the property of explosion itself, but is the second effect, connected X-radiation it with the fact that knocks out from the molecules of air Compton electrons. It follows that the pulse is extended from the ionosphere into the lower layers of the atmosphere, and its field higher than ionosphere, directly in space itself, they be absent from it. But, if we with the aid of the theories examined even somehow possible explain the presence of electrical pour on in the visibility range of explosion, then the fact of strong ionospheric disturbances at large distances from the explosion, which it accompanied, to explain difficultly. Thus, after explosion in the course of several ten minutes there is no radio communication with Japan and Australia, and even at a distance into 3200 km of from the epicentre of explosion were fixed ionospheric disturbances, which several times exceeded those, which are caused by the most powerful solar flares. Explosion influenced also the automatic spacecraft. Three satellites were immediately disabled. The charged particles, which were appeared as a result explosion, were seized by the magnetosphere of the Earth, as a result of which their concentration in the artificial Earth radiation belt it increased by 2-3 orders. The action of radiation belts led to the very rapid degradation of solar batteries and electronics in seven more satellites, including in the first commercial telecommunication satellite Tele-Star. On the whole explosion derived from system third of the automatic spacecraft, which were being found in low orbits at the moment of explosion.

With the explosion of nuclear charge according to the program "*Program K",* which was realized into the USSR, the radio communication and the radar installations were also blocked at a distance to 1000 km of. As a result these tests it was established that the high-altitude nuclear explosions are accompanied by the emission of the powerful pulse, which considerably exceeds in the amplitude the value of the pulse, which occurs with the surface explosions of the same power. It was discovered, that the registration of the consequences of space nuclear explosion was possible at the large (to 10 thousand kilometers) distances from the point of impact.

From the point of view of the existing concepts of classical electrodynamics Compton models cause serious questions. For example, why all Compton electrons must move cophasal with the front of gamma-radiation with the relativistic speed. In Compton electrons the velocity vector has spatial distribution, in connection with this it is not possible to obtain such short of the pulse rise, as it takes place in actuality. In the electrodynamics such mechanisms, which give the possibility to obtain the single-pole pulse of electric field without the three-dimensional separation of charges in this place theoretically be absent. But in the pulse rise time, which is calculated by tens of nanoseconds, to obtain the three-dimensional separation of charges, which will ensure the field strength obtained during the experiment, it is impossible. Compton ionization itself leaves entire system as a whole of electrically neutral. In addition to this, the ionosphere does not have sharp boundary; therefore its ionization by X-radiation will pass gradually in proportion to the advance of the wave of emission, which will lead to an increase in the duration of terminal impulse up to several milliseconds.

Is known that the problem of this phenomenon attempted together with his students to solve and academician Zeldovich [22]. However, in the existing sources there is no information about the fact that it solved this problem. Consequently, the everything indicates that within the framework existing classical electrodynamics the results, obtained with the tests according to the program "*Starfish" of* and "*Program K"* cannot be explained thus far.

In what does consist the danger of the forecasts, which does give the model of Compton electrons? Problem in the fact that this model excludes the possibility of the presence pour on pulse in space. The let us assume that indicated model is accurate, and, relying on it as in the past for the predictions of doctor Bethe, will be produced sequential nuclear explosion in space, which will put out of action a large quantity of satellites. Moreover this explosion can be both the planned and realized for terrorist purposes. Then be justified already is late.

Let us undertake the attempt, using a concept of scalar- vector potential, to explain obtained experimental data, and let us also show that with the explosion of nuclear charge in space, there there are not fields of electromagnetic pulse (EMI), but pulse electric fields (IEF), in which the magnetic field is absent. The fields IEF in space having much more significant magnitudes, than in the atmosphere and on the earth's surface.

according to the estimations at the initial moment of thermonuclear explosion the temperature of plasmoid can reach several hundred million degrees. At such temperatures the electron gas of plasma is subordinated to the distribution of Boltzmann. Let us assume that the temperature of the plasmoid at the initial moment formed with the explosion composes ~ 10^8 K, and the total weight of bomb and head part of the rocket, made from metal with the average electron density ~5× of 10^{22} of 1/sm^3, composes 1000 kg. General a quantity of free electrons in the formed plasma, on the assumption that all atoms will be singly ionized with the specific weight of the metal ~ of 8 g/cm^3 , will comprise ~ 5×10^{27} . The most probable electron velocity at the temperature indicated let us determine from the relationship:

$$v = \sqrt{\frac{2k_Б T}{m}},$$

where $k_Б$ - Boltzmann constant, and m - mass of electron.

Now, using relationship (16.4) for enumerating the increase scalar - vector potential and taking into account only terms of the expansion ~ $\frac{v^2}{c^2}$, we obtain

$$\Delta\varphi \cong \frac{Nek_Б T}{4\pi\varepsilon_0 rmc^2}\ , \qquad (22.1)$$

where e - electron charge, and r - distance from the burst center to the observation point. We determine from the formula the tension of radial electric field, which corresponds to this increase in the potential:

$$E = \frac{Nek_Б T}{4\pi\varepsilon_0 r^2 mc^2} = \frac{\Delta q}{4\pi\varepsilon_0 r^2}, \qquad (22.2)$$

where

$$\Delta q = \frac{Nek_Б T}{mc^2} \qquad (22.3)$$

is an equivalent charge of explosion. By this value it is necessary to understand exceeding the charge of electron gas in comparison with its equilibrium value in the metal.

One should say that with the warming-up of plasma the ions also acquire additional speed, however, since their mass considerably more than the mass of electrons, increase in their charges can be disregarded.

In accordance with formula (22.2) the tension of radial electric field in the epicentre of explosion with the assigned above parameters will compose ~ 7×10^5 V/m. Certainly, are unknown neither the precise initial of the temperature of plasmoid nor mass of bomb and launch vehicle, in which it undermine nor materials, from which are prepared these elements. Correcting these data, it is possible sufficiently simply to obtain values pour on those being approaching experimental values. With resolution of this question should be considered also the screening effect of the ionosphere.

Let us first examine the case, when the ionosphere is absent (Fig. 39). For simplification in the task we will consider that the ideally conducting limitless plane represents by the earth's surface. The solution of allocation problem pour on for the charge, which is been located above this plane, well known [1].

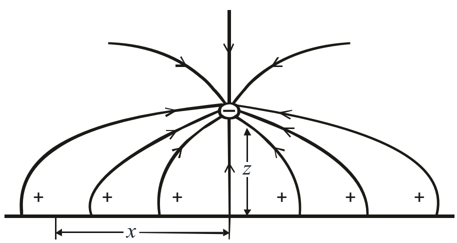

Fig. 39. Negative charge above the limitless conducting plane.

The horizontal component of electric field on the surface of this plane is equal to zero, and normal component is equal:

$$E_{\perp} = \frac{1}{2\pi\varepsilon_0} \frac{zq}{\left(z^2 + x^2\right)^{\frac{3}{2}}},$$

where q - magnitude of the charge, z - shortest distance from the charge to the plane, x - distance against the observation points to the point of intersection of vertical line, lowered from the point, where is located charge, to plane itself.

Lower than conducting plane electric fields be absent. This configuration pour on connected with the fact that charge, which is been located above the conducting plane, it induces in it such surface density of charges, which completely compensates horizontal and vertical component of the electric field of charge in the conducting plane and lower than it. The dependence of the area charge from the coordinate x can be determined from the relationship:

$$\sigma(x) = \varepsilon_0 E_{\perp} = \frac{1}{2\pi}\frac{zq}{\left(z^2 + x^2\right)^{\frac{3}{2}}}. \qquad (22.4)$$

if we integrate $\sigma(x)$ with respect to the coordinate x, then we will obtain magnitude of the charge, which is been located above the conducting plane. In such a way as not to pass the electric fields of the charge q through the conducting plane, in it must be contained a quantity of free charges, which give summary charge not less than the charge q. Let us examine from these positions the screening effect of the ionosphere (Fig. 40).

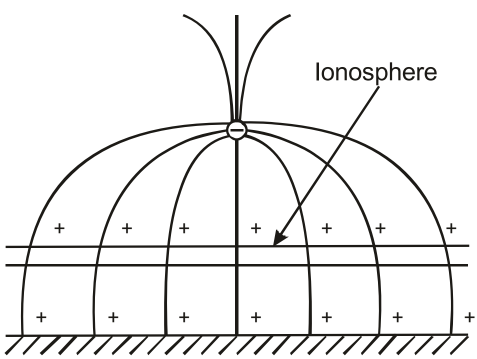

Fig. 40. Negative charge above the earth's surface with the presence of the ionosphere.

If charge will appear at the indicated in the figure point, thus it will gather under itself the existing in the ionosphere free charges of opposite sign for compensating those pour on, which it creates in it. However, if a quantity of free positive charges in the ionosphere will be less than first, which is necessary for the complete compensation for the equivalent charge of explosion, then its fields will penetrate through the ionosphere. In this case the penetrated fields, in view of the screening effect of the ionosphere, can be less than the field above it. Entire this picture can be described only qualitatively, because are accurately known neither thickness of the ionosphere nor degree of its ionization on the height.

The sphericity of the ionosphere also superimposes its special features on the process of the appearance of the compensating surface charges. This process is depicted in Fig. 41.

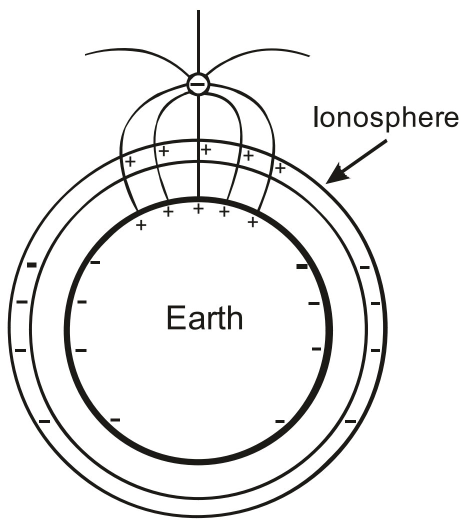

Fig. 41. Negative charge above the earth's surface with the presence of the ionosphere.

The tendency of the emergent charge to gather under itself the compensating charges will lead to the longitudinal polarization of the substantial part of the ionosphere. The compensating positive chargex will be located in the ionosphere directly in the straight visibility under the charge and here them it will be in the surplus, while beyond the line-of-sight ranges in the surplus they will be negative charges. And entire system charge - the ionosphere - the earth will obtain additional dipole moment. The distribution of induced charge in the ionosphere will depend on the height, at which is located the charge, and also from the position of the sun with respect to the charge, since the degree of ionization of the ionosphere depends on its position.

With the nuclear explosion is synchronous with the electrical radial fields, which are moved from the plasmoid with the speed of light, moves the front of X-radiation. This emission will ionize the atmosphere, increasing its conductivity, while this will, in turn, increase the shielding functions of the atmosphere from the penetration into it of the pulses of the subsequent explosions, if such arise. Furthermore, since the negative potential of plasmoid at the initial moment of the explosion of very large, from the cluster will be temporarily rejected some quantity of electrons, which also after a certain time will fall into the ionosphere. The partial neutralization of the electrons, which fell into the ionosphere, will occur, when the positive ions of plasmoid will also reach the ionosphere. But this will concern only those ions, the radial component of speed of which was directed to the side of the ionosphere. The same electrons and ions, whose radial component was directed to the side from it, will leave the limits of the earth's gravity and they will present the similarity of that solar wind, which is the consequence of the evaporation of the solar corona or flashes on the solar surface. Those complex processes, which accompany nuclear explosion, now are only schematically outlined, and is in prospect still extensive work, on the recreation of these processes for the actual conditions. It is obvious that to make this is possible only numerical methods.

The model examined speaks, that nuclear explosion will lead not only to the appearance IEF in the zone of straight visibility, but also to the global ionospheric disturbance. It is known that the explosions according to the program "*Starfish*" and according to the program "*Program K*" led to the presence of large interferences with radio-technical and radar systems at large distances from the epicentre of explosion. Certainly, the electric fields in space, generated by this explosion, have very high values and present the major threat for the automatic spacecraft.

Now let us return to the horizontal component of electrical pour on on the earth's surface, generated with the explosion. It is understandable that these fields represent the tangential component of radial pour on, that go from the point of explosion. Specifically, these fields cause the compensating currents, which create the compensating surface charges. It is possible to calculate the order of the summed currents, which will have radial directivity with respect to the epicentre of explosion. For this let us calculate summary compensating grain surface on the earth's surface, which must be formed with the explosion of nuclear charge. This charge is equal to the charge of plasmoid with the opposite sign of

$$q = 4\pi\varepsilon_0 r^2 E\ .$$

After conducting calculations according to this formula, on the basis of the actually measured vertical tensions of electrical pour on in the epicentre of explosion (5.2×10^{4} V/m), with the distance to the explosion of 400 km of we obtain the charge ~ 10^{6} coulomb. However, the value of charge, calculated according to formula (23.3) they will compose ~ 1.2×10^{7} coulomb. This divergence, as it is already said, can be connected with the screening effect of the ionosphere. If the building-up of electric field it is ~ 50 ns, then the summed current, directed toward the epicentre of explosion, must compose ~ 10^{12} A. Certainly, this number is somewhat overstated, because the compensating charges are attracted not to one point, which is been the epicentre of explosion, but to the sufficiently extensive region in its environment. But even if this value decreased several orders, previous the strength of compensating currents will be very large. It is now understandable, why on Oahu island, that is been located at a distance of 1300 km of from the epicentre of explosion, burnt 300 street lamps, and near Dzheskazgan in the air telephone line with the extent 570 km of arose the currents ~ 2.5 kA, which burnt in it all safety fuses. Even to the power cable by extent is more than 1000 km of, which connects Almaata and Akmola, and the having armored screen from lead, braiding from the steel tape, and located on the depth 0.8 m of, such focusings arose, that operated the automata, after opening from the cable power station. Certainly, the pulse of tangential currents, although the less significant than on the earth's surface, will be also in the ionosphere, which will lead to its disturbance on global scales.

Entire process of formation IEF with the explosion of charge in space can be described as follows. At the moment of explosion in the time of the detonation of nuclear charge, which lasts several nanoseconds, is formed dense plasmoid with the temperature in several ten and even hundreds of millions of degrees. This cluster generates the powerful gamma emission, which is extended in different directions from the cluster with the speed of light. Simultaneously is generated the radial electric field, which also is extended in the radial direction from the cluster with the speed of light. Radial electric fields IEF and gamma-radiation reach the ionosphere simultaneously. During its further motion to the side of the earth's surface, if explosive force for this it is sufficient, X-radiation begins to ionize and the layers of the atmosphere, which are been located lower than the ionosphere. The process of the ionization of upper air and the penetrations in them of radial electric field will simultaneously occur. In the ionized layers due to the presence of radial electric field will arise the radial currents, which will lead to the stratification of charges and to the vertical polarization of conducting layers. The processes of the polarization of the atmosphere will last as much time, as will exist radial field, and also conductivity of ionized air. Since the ionosphere will not be able to ensure the charge, necessary for the complete compensation for the radial field of plasmoid, these fields, although in the weakened form, they will continue to be extended in the direction of the earth's surface, and electric fields will create powerful radial currents. The process of propagation of X-radiation and radial pour on through the ionosphere it will lead to its additional ionization and polarization, and also to the appearance of a pulse of tangential currents. The pulse of tangential currents in the ionosphere will apply to distances considerably greater than the visibility range of explosion, which will lead to the global ionospheric disturbances.

Up to that moment, when the flow of rigid gamma emission and ionization of atmosphere cease, the part of the atmosphere, ionized lower than the existing boundary of the ionosphere, will cease to be conductor, and is, therefore, the three-dimensional divided charges will prove to be closed in it. The electrons closed in the atmosphere will as before create some static potential difference, which will slowly relax to the extent of the presence of the residual conductivity of the atmosphere. It should be noted that the polarity of this field will be opposite to the polarity of initial IEF, that also is observed in actuality. This means that the radial electric field, observed on the earth's surface, will be first directed from the earth toward the epicentre of explosion, but at some moment of time it will change its polarity.

Becomes clear and that, why after space nuclear explosion an even longer time is observed the residual glow of the atmosphere under the point of impact. This glow is obliged to those electrons, which during the first stage development IEF were displaced of the ionosphere into the denser layers of the atmosphere, and then, after the termination of the ionized effect of gamma emission, they remained closed in the little conducting atmosphere, continuing to ionize it.

Thus, the appearance IEF with the nuclear explosion are the properties of explosion itself, but not second phenomena. Its properties and characteristics can be explained within the framework to the concept of scalar- vector potential. Studying topology IEF on the earth's surface, it is possible to judge also the subsequent processes of polarization and depolarization of the ionosphere, atmosphere and earth's surface. With the explosion in the atmosphere very process of formation IEF and its development are connected with the presence of the atmosphere, and also by the presence of conductivity on the earth's surface and this will also superimpose its special features on shaping pour on IEF. With the explosions in immediate proximity from the earth's surface the equivalent charge of the cloud of explosion will see its mirror reflection under the earth's surface, forming the electric dipole. For this reason the region of propagation pour on IEF it will be strongly reduced, since the fields of dipole diminish according to the cubic law.

now should be made one observation apropos of term itself the electromagnetic pulse EMI, utilized in the literary sources. From this name should be excluded the word magnetic, since this process presents the propagation only of radial electrical pour on, and in this case magnetic fields be absent. It is another matter that electric fields can direct currents in the conducting environments, and these currents will generate magnetic fields, but this already second phenomenon.

Would seem, everything very well converges, however, there is one basic problem, which is not thus far examined, it concerns energy balance with the explosion. If we consider that one ton of trotyl is equivalent 4.6×10^{9} J, then with the explosion of bomb with the TNT equivalent 1,4 Mt. are separated 6.44×10^{15} J. If we consider that the time of detonation is equal to 50 ns, then explosive force composes $\sim1.3\times10^{23}$ W. Let us say for an example that the power of the radiation of the Sun of ~3.9×10^{26} W. Let us examine a question, where how, in so short a time, can be the intake, isolated with this explosion.

In accordance with Stephan equation Boltzmann the power, radiated by the heated surface, is proportional to the fourth degree of its temperature:

$$P = \sigma s T^4,$$

where $\sigma = 5.67\cdot10^{-8}\ \frac{Bm}{м^2 K^4}$ - the Stefan-Bolzman constant, and s - area of radiating surface.

If we take the initial temperature of the plasmoid ~10^8 K, then with its initial diameter 1 m (in this case the surface area of cluster it is ~3 m^2) entire explosive energy will be radiated in the time ~ 0.4 ns. But if we take the initial temperature ~10^7, then this time will be already ~ 400 ns. Thus, one should assume that the initial temperature of plasmoid to be located somewhere between the undertaken values. Wavelength, on which will be radiated a maximum quantity of energy, is determined by the Win law

$$\lambda_{макс} = \frac{0,28975}{T}\ \frac{см}{K}\ .$$

If we substitute here the value of the temperature 5×10^7 K, then we will obtain the wavelength on the order 6 Å, which corresponds to rigid X-radiation. Its temperature will begin to fall in proportion to cooling cluster and $\lambda_{макс}$ will begin to be shifted into the visible part of the spectrum.

But the mechanism of losses examined is not only. Since with the temperature of cluster are unambiguously connected its electric fields, immediately after detonation they will be maximum, and then with a temperature drop of cluster they will begin to decrease proportional to temperature. However, the energy, necessary for their creation, will fall not as rapidly as energy necessary for creating the X-radiation.

Appears one additional important question about which a quantity of electrons it will leave plasmoid. In order to answer it, let us examine the condition of the electricneutral of plasma. At that moment when metal is converted into the plasma, occurs not only the passage of substance from one state of aggregation to another, but also changes the statistics of the description of electron gas. In the solid state statistician Fermi-Dirac's this, while in the state of plasma - statistician Boltzmann's this. When electron gas was located in the steadfast conductor, then in the state of electricneutral to each ion it was fallen along one free electron. Let us determine from the point of view of the concept of scalar- vector potential, what relationship must be observed between the electrons and the ions in the plasma so that it would also remain electrically neutral. Before solid became plasma, the electron density and ions was identical and, therefore, the absolute values of their charges were equal

$$eN_e = eN_{np},$$

After the transformation of substance into the plasma general equivalent electron charge increased, to the value, determined by relationship (22.3), and in ions it remained practically before. Now already for observing the electricneutral must be observed the relationship:

$$N_{e(nл)}\left(1+\frac{k_Б T}{m_e c^2}\right) = N_{np},$$

where of $N_{e(nл)}$ - equilibrium quantity of electrons in the plasma.

Is evident that this equilibrium quantity is less than to the passage of substance into the state of plasma. Difference composes

$$\Delta N = N_{np}\left(1-\frac{1}{1+\frac{k_Б T}{m_e c^2}}\right), \qquad (22.5)$$

For example, at a temperature $\sim 10^8$ the value, which stands in the brackets, will compose approximately 0.13. This means that at the temperature indicated, for retaining of the electricneutral of plasma, 13% a total initial quantity of electrons had to it leave. We will call this effect the effect of temporarily excess electrons. Word “are temporarily " used by in the sense that temporary they appear as long as plasma is hot. In this connection clear to become that, from where, for example, on the surface of the sun appear powerful magnetic fields, especially when at it appear spots. These fields are induced by those currents, which overflow between the regions of plasma, which have a different temperature.

We in sufficient detail examined the behavior of the static charge above the conducting plane. But in actuality there is not a static charge, but a charge, which lives only several hundred nanoseconds. If in the origin of coordinates is located the charge $Q(t)$, depending on time, then the electric fields, created by it in the surrounding space, can be found from the relationship:

$$\varphi(r,t) = \frac{Q(t)\left(t - \frac{r}{c}\right)}{4\pi\varepsilon r}, \tag{22.6}$$

twhich correspond the being late longitudinal electric fields:

$$E(r,t) = \frac{Q(t)\left(t - \frac{r}{c}\right)}{4\pi\varepsilon r^2}. \tag{22.7}$$

In accordance with relationships (22.6, 22.7) the short-lived charge generates so short-term a pulse of longitudinal electrical pour on, which in the space are extended with the speed of light and is formed the spherical layer, whose thickness is equal to the lifetime of charge, multiplied by the speed of light. If we consider that for our case the time of life of charge composes the half-width of pulse IEF (somewhere about 100 ns), then the thickness of this layer will be about 30 m.

As was already said, analyzing the topology of pulse IEF, it is possible to judge about the temperature of plasma and the processes of proceeding in it. This method can be used also for diagnostics of other forms of plasma. For plasma itself there is no difference whatever in by what form of its energy they ignite, is important only quantity of free electrons, i.e., the degree of ionization, which depends on the final temperature of plasma.

Laser warming is considered as the promising method of its warming for realizing of thermonuclear fusion. In this case the samples under investigation undergo the action of powerful laser pulse. Model in short time is converted into the high-temperature plasma, i.e., there is a certain similarity of the behavior of plasma with the nuclear explosion. For these purposes it suffices to surround sample under investigation by two conducting screens and to connect between them high-speed oscillograph with the high input resistance. External screen in this case should be grounded. At the moment of the warming-up of plasma will arise IEF. Moreover a potential difference between the screens will arise much earlier than the material particles of plasma they will reach the walls of the first screen. Studying the topology of the recorded pulse, it is possible to judge the temporary energy processes of the warming-up of plasma. It is not difficult to calculate the expected potential difference between the screens depending on the temperature and quantities of free charge carriers. After using relationships (22.5) and (22.7), for the case, when $k_Б T \ll mc^2$ we obtain:

$$U = \frac{Nek_Б T}{4\pi\varepsilon_0 mc^2}\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right),$$

where r_1 and r_2 - radius of external and internal screens respectively, and N - quantity of free electrons in the heated plasma.

The fact of the presence of excess electrons should be considered, also, with realizing of controlled thermonuclear fusion, since this phenomenon must influence also the stability of plasma with its warming.

It should be noted that despite the fact that nuclear explosions are studied already sufficiently long ago, however, until now, not all components of the development of this process obtained its explanation. Such processes include the so-called cable tricks (rope of trick).

In Fig. 42 and Fig. 43 are represented the photographs of such it is special effect. These photographs removed American photographer Harold Edgerton by automatic camera, which is been located at a distance of 11.2 km of from the epicentre of explosion with the periodicity of survey 100 ms.

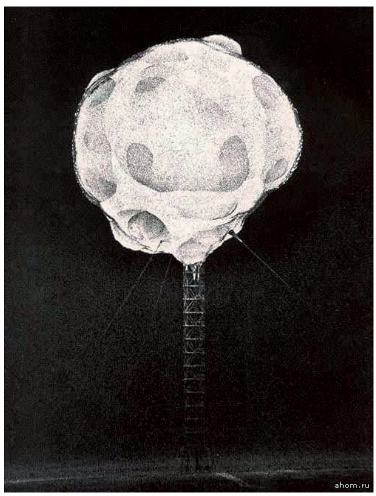

Fig. 42. Initial phase of the development of the cloud of explosion.

In Fig. to 42 is presented the initial phase of the development of the cloud of the explosion of charge, located on the metallic tower with the stretchings from the wire cables. Already it is evident on the initial phase of explosion that in the upper part of the cloud of explosion are three spinous formations.

The same shafts is especially well visible in the upper photograph (Fig. 43). Towers in this photograph already barely it remained, but it is evident that the shaft of large diameter, which exits to the earth, pierces it. Smaller two shafts are extended in the direction of the stretching ropes.

In the photographs is evident that the diameter of shaft grows with an increase in the volume of the cloud of explosion. Especially good this is evident in the lower photograph Fig. 43, when the cloud of explosion already touched the earth. The shaft, located in the lower left side of the cloud of explosion, which exits to the earth, has already considerably larger diameter, than in the upper photograph.

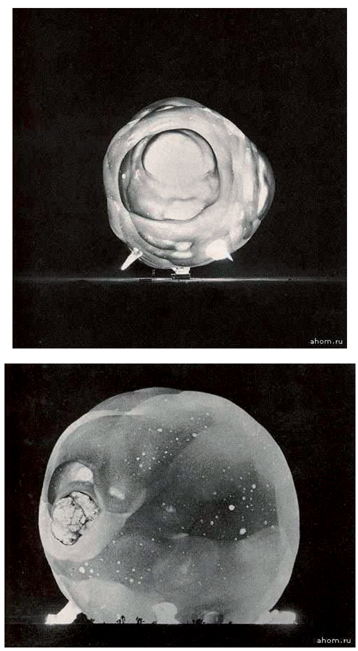

Fig. 43. Subsequent phases of the development of the cloud of explosion.

This phenomenon attempt to explain by the fact that powerful gamma-radiation of the cloud of explosion melts ropes, converting them into the plasma. But this idea is not very productive, since the ropes of stretchings go practically in parallel to light rays; therefore they cannot be heated strongly by emission.

Is certain that the ropes and tower are guiding elements for the appearance of shafts, it is clearly evident in upper Fig. 43. Moreover, this photograph finally removes version about the fact that the ropes ignite by the emission of the cloud of explosion. It is evident in the photograph that the luminosity of shafts is higher than in cloud itself, and means their temperature also higher. But, if they ignite by the emission of cloud itself, then their temperature cannot be higher than its temperature. Consequently, must be some additional sources of the warming-up of ropes.

Even the more impressive photograph of the formation of the cloud of explosion and shafts is shown in Fig. 44.

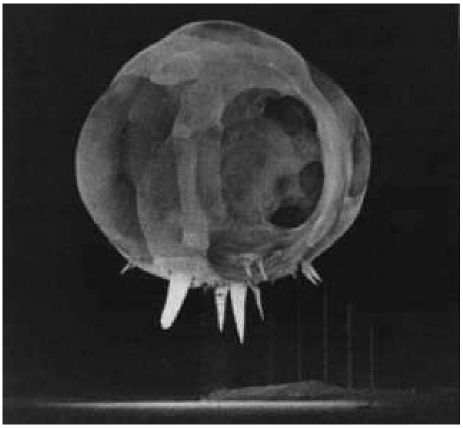

Fig. 44. Cloud species of explosion after 1 ms after the detonation of nuclear charge.

Therefore follows to assume that the warming of ropes it is connected with the advent of the equivalent charge of the explosion, which as along the lightning conductor departs through the ropes to the earth, ignite them. Since the part of the rope closest to the plasmoid is hottest, specific resistance in this part is more than in the remaining parts of the rope. Therefore a basic voltage drop will precisely fall in this section, and, therefore, and to be melted it will begin from this place. Moreover, those sections of rope and tower itself, which are converted into the plasma, also add some quantity of excess electrons, which must be somewhere rejected. Therefore this phenomenon is connected with the appearance of the equivalent charge of the explosion, which through the ropes and tower departs to the earth.

The appearance of the induced equivalent charge of explosion, and it, is as shown higher, it has very high value, it will melt not only the ropes of stretchings and tower. Very high currents will be induced on the earth's surface radial with respect to the epicentre of explosion, and also in the conducting elements of those located above the earth's surface and buried into the earth, which presents the specific danger with the ground-based or air nuclear explosion.

§ 23. Electrodynamics and the Lagrange function

By the Lagrange function or Lagrangian in the mechanics is understood the difference between the kinetic and potential energy of the system ofin question

$$L = W_k(t) - W_p(t).$$

If we integrate Lagrangian with respect to the time, then we will obtain the first Gamilton function, called action. Since in the general case kinetic energy depends on speeds, and potential - from the coordinates, action can be recorded as

$$S = \int_{t_1}^{t_2} L(x_i, v_i)dt$$

With the condition of the conservatism of this system Lagrange formalism assumes least-action principle, when system during its motion selects the way, with which the action is minimum.

In the electrodynamics Lagrangian of the charged particle, which is moved with the relativistic speed, is written as follows [1]:

$$L = -mc^2\sqrt{1-\frac{v^2}{c^2}} - e\left(\varphi + \mu_0(\vec{v}\vec{A}_H)\right), \qquad (23.1)$$

where e, m and $\vec{v}$ - charge mass and the velocity of particle, c - the speed of light, μ_0 - magnetic permeability of vacuum, φ the scalar potential of electric field, $\vec{A}_H$ - the vector potential of magnetic field, in which it moves with particle.

In the work [23] are located misunderstanding, on page 279 read: "Therefore even in the relativistic approximation Lagrange's function in the electromagnetic field cannot be represented in the form differences in the kinetic and potential energy" (end of the quotation).

In relationship (23.1), the author confuses the member, who contains the scalar product of the charge rate and vector potential, and he does not know, to what form of energy it to carry.

Among other things, this uncertainty is not over, and Landau works [7]. The introduction of the Lagrange function and moving charge in this work on paragraphs 16 and 17. With the introduction of these concepts in paragraph 16 is done the following observation: "The following below assertions it is necessary to examine to a considerable degree as the result of experimental data. The form of action for the particle in the electromagnetic field cannot be established on the basis only of general considerations, such as the requirement of relativistic invariance. (latter it would allow in action also the member of form integral of Ads, where A scalar function)" (end of the quotation).

But with the further consideration of this question of any experimental data the author does not give and it is not completely understandable, on what bases the Lagrange function introduces in the form (23.1). It is further - it is still worse. Without understanding the physical essence of Lagrangian the author immediately includes the potential part (the scalar product of speed and vector potential) in generalized momentum, and then for finding the force is differentiated on the coordinate of Lagrangian, calculating gradient from this value (see relationship after equality (18.1) [7]). But, finding gradient from the work indicated, the author thus recognizes his potential status.

Strictly speaking, the record of Lagrangian in the form (23.1) does not satisfy the condition of the conservatism of system. This is connected with the fact that the vector potential, entering this relationship, it is connected with the motion of the strange charges, with which interacts the moving charge. A change in the charge rate, for which is located Lagrangian, will involve a change in the speed of these charges, and energy of the moving charge will be spent to this. In order to ensure the conservatism of system, it is necessary to know interaction energy of the moving charge with all strange charges, including with those, on which depends vector potential. This can be made a way of using the scalar-vector potential.

The scalar potential $\varphi(r)$ at the point of the presence of charge is determined by all surrounding charges g_j and is determined by the relationship:

$$\varphi(r)=\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j}$$

The potential creates each moving charge at the observation point

$$\varphi'(r, v_\perp) = \varphi(r) ch \frac{v_\perp}{c},$$

If some quantity of moving and fixed charges surrounds this point of space, then for finding the scalar potential in the given one to point it is necessary to produce the summing up of their potentials:

$$\varphi'(r) = \sum_j \varphi(r_j) ch \frac{v_{j\perp}}{c} = \sum_j \frac{1}{4\pi\varepsilon} \frac{g_j}{r_j} ch \frac{v_{j\perp}}{c}$$

Taking into account this circumstance Lagrangian of the charge e, which is found in the environment of the fixed and moving strange charges can be written down as follows:

$$L = -e \sum_j \frac{1}{4\pi\varepsilon} \frac{g_j}{r_j} ch \frac{v_{j\perp}}{c} \quad , \qquad (23.2)$$

If the charge is moving relative to the selected ISM speed v then its Lagrangian is determined by the ratio (23.2), except that as speeds are $v_{j\perp}$ relative velocities of charges in relation to the charge and adds a member that defines the kinetic energy of the charge. Lagrangian in this case takes the form:

$$L = -mc^2 \sqrt{1 - \frac{v^2}{c^2}} - e \sum_j \frac{1}{4\pi\varepsilon} \frac{g_j}{r_j} ch \frac{v_{j\perp}}{c}$$

§ 24. Special features of the mathematical apparatus for the classical electrodynamics

Vector analysis is the basic mathematical apparatus for electrodynamics. Such vector quantities, as force, speed, acceleration, electric field and current demonstrate well the physical nature of these values. However, with the use of a vector apparatus for describing the physical processes are introduced such of vector, which do not reflect the physical essence of those processes, which they describe. We will call such vectors vector- phantoms. Let us give several examples.

If is located the disk, which revolves with the angular velocity ω, then they depict this process as the vector, which coincides with the rotational axis of disk and rests in its center. It does ask itself, is there this vector in reality and that it does represent? There is no doubt about the fact that this vector can be introduced by arrangement, but any physical sense as, for example, velocity vector, it it does not have. Thus the vector of momentum is accurately introduced. This vector also coincides with the rotational axis, it rests in the center of the plane of rotation and it is equal to the work of radial velocity to a radius. Similarly is introduced the vector of the magnetic dipole moment, which for the ring current is equal to the work of the current strength to the area of the circle streamlined with current. This vector coincides with the rotational axis of circle and rests on its plane. But any physical sense these a vector do not have.

Let us recall what is the vector is, which presents rotor. This vector is introduced as follows

$$rot\ \vec{a} = \begin{pmatrix} \vec{i} & \vec{j} & \vec{k} \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ a_x & a_y & a_z \end{pmatrix}$$

In order to explain the geometric sense of rotor let us examine solid body, which revolves with the angular velocity ω around the axis z. Then the linear speed of the body v at point (x, y, z) is numerically equal

$$v = \omega r = \omega\sqrt{x^2 + y^2}\ ,$$

and component it along the axes, for the right-handed coordinate system, will be equal

$$v_x = -\frac{vy}{\sqrt{x^2 + y^2}} = -\omega y,$$

$$v_y = -\frac{vx}{\sqrt{x^2 + y^2}} = -\omega x,$$

$$v_z = 0.$$

The vector components $rot\, v$ in this case to be determined by the relationships:

$$rot_x v = rot_y v = 0$$

$$rot_z v = \frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y} = 2\omega$$

Is again obtained the vector, directed in parallel to rotational axis and normal toward the plane of rotation. This vector also is introduced by arrangement and of any physical sense it does not have.

Thus, with the use of vector analysis for describing the physical phenomena are introduced two types of vectors. The first of them represents the real physical of vector, which characterize physical quantity itself taking into account of its value and direction (for example, the vector of force, speed, acceleration, tension of electric field and current). Another category of vectors - this those of vector, which can be presented with the aid of the operation of rotor or vector product. These vector do not represent physical quantities and they are introduced by arrangement, being vector- phantoms. Specifically, the vector of such type includes magnetic field.

Magnetic field is introduced or with the aid of the rotor of the electric field

$$\frac{\partial \vec{H}}{\partial t} = -\frac{1}{\mu} rot\vec{E},$$

or as the rotor of the vector potential

$$\vec{H} = rot\vec{A}_H .$$

This means that the magnetic field is not physical field, but represents the certain vector symbol, which is introduced by arrangement and of physical sense it does not have.

However, that does occur further? During writing of the Maxwell equations rotor from the magnetic field they make level to the full current

$$rot\vec{H} = rot\ rot\vec{A}_H = \vec{j}_\Sigma\ .$$

Is obtained so that rotor from the vector $\vec{H}$, which is introduced by arrangement, gives the real physical vector of current density. Thus, the vector of magnetic field represents typical vector-phantom.

It is possible to give another example. The Lorentz force, which acts on the moving charge, is determined by the vector product of the real velocity vector and of magnetic field:

$$\vec{F} = \mu\left[\vec{v}\times\vec{H}\right] .$$

Is again obtained so that the operation of vector product, which itself physical sense does not have, with the participation of real vector and vector of phantom it gives real physical force taking into account of its value and direction. Of this consists the sense of introduction in vector analysis of such operations as rotor and vector product. If we look to the mathematical apparatus for physics in connection with to vector analysis, then it appears that this apparatus represents the mixture of real physical vectors and vectors of the phantoms, the relation between which it is regulated with the aid of the, including and operations indicated.

Above it was convincingly shown that entire electrodynamics can be built without the use of this concept as magnetic field.

PART III
OTHER IDEAS AND THE TECHNICAL SOLUTIONS

CHAPTER 5
OTHER IDEAS AND THE TECNICAL SOLUTIONS

§ 25. Phenomenon the kinetic energy and the inertia material of the bodies

Good is known, that for the acceleration material the bodies it is necessary to spend energy, for what to by it is necessary to apply the force. Executed the work passes into kinetic energy the motion. With braking the body returns this energy to the surrounding bodies, for what they be required the forces, reverse that, which the body accelerated. This is the phenomenon the inertia.

Is clear, that the process the acceleration accumulates into the body what form of energy, which and returns then to external medium with its braking. But not one of existing into present the time the theories not gives the answer to a question, that this for energy and by what by the means it is accumulated and it returns. Charged the bodies and the charges are had electrical the field, possessing energy. It is possible it was to expect, that the dependence of these pour on from the speed it could spill the light to this a question. In the special the theory of the relativity (STR) electrical the field of the charges depend from the speed, and, it would seem, this of the theory it must was give the answer to this interesting a question. But into STR the charge is the invariant of the speed.

Into the works [10-12], is shown, that into the framework of the Galilean transformations scalar the potential of the charge depends from his the relative speed. With this electrical the field, normal to the direction its the motion, increase, into of the of the time as longitudinal the field remain constant. Similar the approach gives the possibility to explain and the phenomenon of the kinetic energy and the phenomenon the inertia.

The electron has electrical the field, energy which of easy to calculate. Specific energy electrical pour on it is written as

$$w = \frac{1}{2}\varepsilon E^2 \ .$$

The tension electrical pour on the electron it is determined by the equality

$$E = \frac{e}{4\pi\varepsilon_0 r^2} \ .$$

Using the element the volume $4\pi r^2 dr$, we obtain of energy pour on that being resting the electron:

$$W = \int_a^\infty \frac{e^2 dr}{8\pi\varepsilon_0 r^2} = \frac{e^2}{8\pi\varepsilon_0 a},$$

where e - the charge of the electron, and a - its a radius. If the electron moves from with the speed v, the its electrical the field, normal to the direction the motion according to the concept of scalar-vector potential they increase:

$$E_\perp = Ech\frac{v}{c} \approx E\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right).$$

Let us write down electrical the field, normal to the direction the motion into to the system the coordinates, that represented in Fig 45.

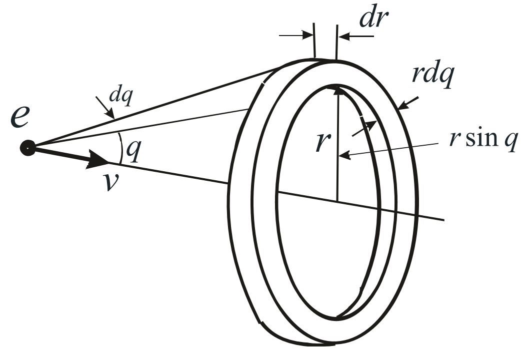

Fig. 45. The element the volume $2\pi r^2 \sin q \; dq \; dr$, utilized for the calculation energy pour on that moving the electron.

$$E_{\perp} = E\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right)\sin q$$

Then energy pour on that moving the electron it will be written down

$$W_v = \left(1 + \frac{1}{2}\frac{v^2}{c^2}\right)^2 \int \frac{e^2 \sin^3 q \; dqdr}{8\pi\varepsilon_0 r^2}$$

The integration on to the angle gives

$$\int_0^{\pi} \sin^3 q \; dq = -\int_0^{\pi} (1 - \cos^2 q) d(\cos q) = -\cos q + \frac{\cos^3 q}{3} = \frac{4}{3}$$

Therefore

$$W_v = \frac{4}{3}\left(1+\frac{1}{2}\frac{v^2}{c^2}\right)^2 \int_a^\infty \frac{e^2 dr}{8\pi\varepsilon_0 r^2} = \frac{4}{3}\left(1+\frac{v^2}{c^2}+\frac{1}{4}\frac{v^4}{c^4}\right)\frac{e^2}{8\pi\varepsilon_0 a} .$$

For the speeds is considerable smaller the speed of the light the term $\frac{1}{4}\frac{v^4}{c^4}$ can be disregarded, therefore

$$W_v = \frac{4}{3}\left(1+\frac{v^2}{c^2}\right)\frac{e^2}{8\pi\varepsilon_0 a} .$$

The connection between by energy pour on and with the mass the rest of the electron it is given by the equality [1]:

$$W = \frac{4}{3}\frac{e^2}{8\pi\varepsilon_0 a} = mc^2 .$$

Consequently additional energy the electron, connected from that, that its the field depend on the speed, to be determined by the relationship

$$W_v = mv^2 .$$

This and is kinetic energy that moving the electron. It is differed from that conventional the value by the coefficient $\frac{1}{2}$, but this indicates only the, that officially accepted the value the mass the electron it is necessary to decrease into two times.

By such by the means, we established physical the reason for the presence in moving charged the bodies the kinetic energy and consequently and their inertia the properties of. These the property are connected from with the dependence the scalar the potential charges on their relative the speed.

§ 26. Physical substantiation of the Huygens principle and the reciprocity theorem

The Gyuygens principle says, that each element of wave front can be examined as the center of the second disturbance, which generates second spherical waves, and the resulting light field at each point of space will be determined by the interference of these waves. This principle is the basic postulate of geometric optics; however, it does not reveal physical nature of this phenomenon. From geometric optics it is known that any beam of light is dispersing and that the area of its section in the process of propagation always increases. This phenomenon is subordinated to the Huygens principle. But is there any physical explanation of this principle? It occurs, there exists.

Let us examine flat monochromatic TEM the wave, passing through the slot, whose width is considerably longer more than wavelength (Fig. 46).

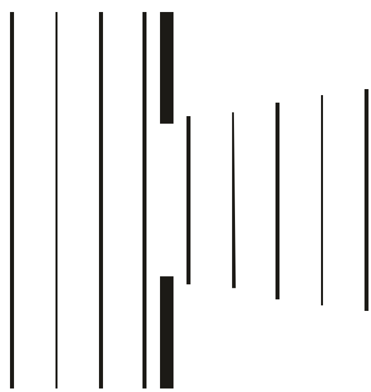

Fig. 46. Passage of the plane wave through the slot.

After passage through the slot wave begins to be enlarged in the transverse direction, and this expansion is subordinated to the Huygens principle. In this case in the expanding wave the ends of the paths of constant phase in the process of their motion move with the speed of light still, also, in the transverse direction. But since with this expansion increases beam section, begins to decrease the Poynting vector, which indicates the decrease of electrical and magnetic field on the paths of constant phase. This process of the self-expansion of electric vectors on the paths of constant phase is such to the process of the self-expansion of electric-current wave in the long line described in the thirteenth paragraph. Difference is only the fact that in the line the wave of transverse electric field is propagated, and self-expansion occurs in the direction of propagation. In this case occurs the self-expansion of the vector of electric field still, also, in the transverse direction. In the long line there is no such expansion, since wave in the transverse direction I limit the conductors of line. The transverse transformation of wave is accompanied by the fact that, beginning from the center of path of constant phase along it begins leak bias current. This process is very similar to the expansion of the compressed elastic, when all its sections begin evenly to be enlarged. In this case the energy density of electromagnetic wave begins to decrease, being evenly distributed in the increasing volume, occupied by the expanding wave.

This simple examination, he indicates the physical causes for the Huygens postulate and is in fact new physical law.

With this phenomenon is connected the so-called reciprocity theorem for the antenna systems, which does not up to now have its physical substantiation. This theorem says, that the mu-factor of the directional antennas is identical both with the emission and with the reception of signal. The strangeness of this theorem consists in the fact that the directional antenna can form the narrowly directed beam, when the radiated energy is concentrated in some direction. This means that the energy density is concentrated in the space limited from the lateral sides. This one can see well based on example of laser beam. However, receiving directional antenna is located in the fields of transmitter, which are evenly distributed in the space, and in order to increase its mu-factor to the directional receiving antenna it is necessary to know how to gather energy from the lateral space. This actually so, but as this it makes, until now, it remains riddle. A question does consist in that, is it possible to find some physical causes for this strange behavior of the directional receiving antennas.

Is known that the laws of geometric optics, when ray can be considered practically rectilinear, work when beam width considerably more than wavelength. In this case Huygens's principle works. Therefore, if we limit the width of beam with the aid of the slot, then its divergence will begin grow, and when the width of slot will become commensurate with the wavelength, after the slot we will obtain the strongly divergent ray, and when slot will become less than the wavelength, then after slot we will obtain the radially divergent waves.

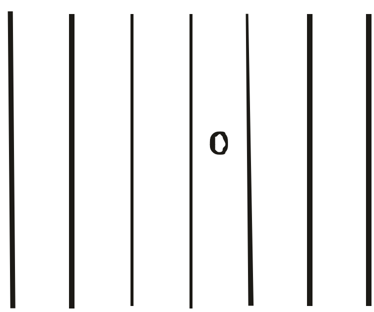

Fig. 47. Diffraction by the waves of the obstacle, whose dimensions are considerably lower than the wavelength.

However, that will be, if we on the way of transverse wave place obstacle? Let us examine two cases. In Fig. 47 is depicted the case, when the width of obstacle is considerably lower than the wavelength. Practically it they do not feel with the diffraction of this obstacle of wave.

We see other entirely picture, when obstacle is considerably more than wavelength (Fig. 48)

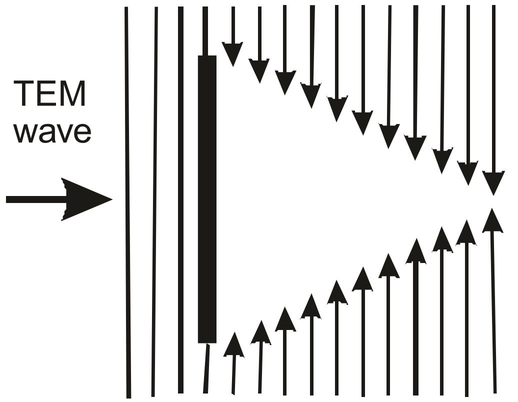

Fig. 48. The case, when on the oscillation loop is located the obstacle, whose dimensions are greater wavelength.

If obstacle on the oscillation loop is executed so that it completely absorbs energy of the incident to it waves, then the picture of wave process appears in the manner that shown in Fig. 47. It is evident that from the right side from the absorbing obstacle there is a shadow zone, where the waves be absent. But passing obstacle, the ragged ends of the waves in accordance with the Huygens principle again begin to converge, bringing additional energy into the space of shadow from the lateral space, which is located beyond the limits of the possible arrangement of the following elements of the directional antenna. This phenomenon bears the name of diffraction. And it is characteristic for any wave processes, including for the electromagnetic waves. But this process has one special feature, which is obvious. Since the absorbing obstacle absorbed the part of wave energy, the wave amplitude to the right of shadow, will be somewhat less than wave amplitude to the left of the absorbing obstacle. This being connected with the fact that the sections of the waves to the right of obstacle, enlarged, they redistribute their energy in the shady section of space after the obstacle. Direction the motions of energy in the expanding section of wave are shown by pointers. This means that in order to liquidate shadow and to restore normal wave process, wave energy begins to be pumped over from the lateral sections of those removed from the shadow zone, enlarging the sections of waves torn by obstacle. In this case summary wave amplitude after the obstacle will decrease.

Let us return to the receiving directional Yagi antenna and let us assume that the second director we arranged out of the shadow in that place, where electric fields arrived, after bringing additional energy from the lateral regions. Situation in this case will be repeated, again shadow is formed after this director. The third director we also can arrange beyond the limits of the shadow of the second director, etc. And each time each new director will occur in the fresh electric fields, taking away in them the energy assumed to him.

But situation with the real directed antenna of the type wave duct is somewhat another. First, the length of director is equal to half of wavelength, and after it practically there is no shadow and the ragged pieces of wave practically immediately are clamped after the director, but in this case energy transfer from the lateral sections into the region of the arrangement of the following director nevertheless occurs.

Let us examine, as behaves this antenna in the field by the flat TEM wave (Fig. 49). Let us assume that numbered wave consecutively occupies positions 1, 2, 3 and 4. After flying so far to the first director, it excites in it currents, making with its emitter, but in this case the part of its energy loses. In this case the first director re-emits the obtained from the wave energy into that surrounding space correspondence with his radiation pattern. Therefore wave after the passage of the first director directly in the region after it has the smaller amplitude of electric field, than to its passage.

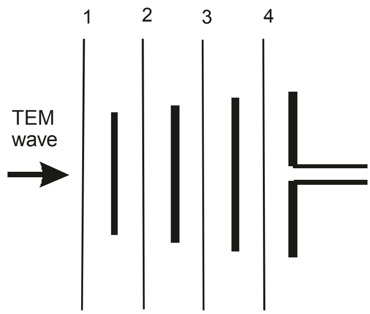

Fig. 49. Yagi antenna in the field of flat TEM of the wave of

In order to compensate for the losses indicated energy from the lateral sections, which lie beyond the limits of antenna field, will begin to be pumped over to the side of the axis of antenna. After the passage of the second director will occur the same. Thus, the phenomenon of diffraction will lead to the fact that the wave energy from the sections beyond the limits of antenna field will begin to be pumped over into the region of finding the directors. But the currents, induced in the directors, will make the active vibrators, which will increase currents in each subsequent director and after reaching the pick-up dipole, of them, these fields will considerably exceed the fields of wave itself in position 1. With this is connected the circumstance that the directional receiving antenna possesses larger effectiveness than single vibrator. Although to, of course, assert that the mu-factors, both in the regime of transfer and in the reception mode they will be identical, are cannot. Therefore reciprocity theorem although is carried out, most likely, not fully.

§ 27. Electric field thermokinetic spectroscopy

Exists a large quantity of diagnostic methods of the study of the properties of materials and models. But from the view of researchers thus far slipped off the very promising method, based on a study of the electrostatic potential of such models [24].

The majorities of the existing diagnostic methods of the control of properties and characteristics of materials and models is based on the application of various external actions, which can change the properties of such objects. The special interest present the methods of the nondestructive testing, and also those methods, whose application does not require action on models themselves. A study of the properties of materials and models into the dependence on their temperature, the pressures, the actions of different kind of irradiations, mechanical stresses and the dynamics of these processes, the kinetics of phase transitions are of great interest. In this paragraph the method, based on the measurement of the electrostatic potential of models, which gives the possibility to conduct such studies by simple method, is examined.

In the literary sources, in which is discussed a question about the possible dependence of charge on the speed, it is asserted that the dependence of magnitude of the charge from this parameter would lead with heating of conductors to an increase in their negative potential. Specifically, this assertion constantly is given as the argument of the fact that the charge cannot depend on speed.

If in any structure coexists several thermodynamic subsystems, then their chemical potential must be equal. In the conductor there are two subsystems: lattice and electron gas, electron gas in the conductors at usual temperatures is degenerate and is subordinated the statistician Fermi-Dirac, his chemical potential is determined from the relationship of

$$\mu = W_F\left(1 - \frac{\pi^2 (kT)^2}{12 W_F{}^2}\right), \qquad (27.1)$$

where

$$W_F = \frac{h^2}{2m}\left(\frac{3n}{8\pi}\right)^{\frac{2}{3}} \qquad (27.2)$$

is the Fermi energy, h - the Planck constant, n and m - electron density and their mass.

From relationships (27.1) and (27.2) is evident that chemical potential of electron gas with a temperature decrease increases, reaching its maximum value at a zero temperature. It also depends on electron density.

In general form chemical potential for any subsystem can be found from the following expressions

$$\mu = \left(\frac{\partial U}{\partial N}\right)_{S,V} = \left(\frac{\partial F}{\partial N}\right)_{T,V} = \left(\frac{\partial W}{\partial N}\right)_{S,P} = \left(\frac{\partial \Phi}{\partial N}\right)_{T,P}$$

where N- number of particles, and the thermodynamic potentials U, F, W, Φ represent internal energy, free energy, enthalpy and the Gibbs potential respectively. But, if we find chemical potential of lattice, using one of these expressions, then it will be evident that with a temperature decrease this potential decreases. Thus, it turns out that chemical potential of electrons with a temperature decrease grows, and it decreases in lattice. But as then to attain so that they would be equal? Output consists in the fact that chemical potential of electron gas depends on the density of free electrons, and so that this potential with the decrease of temperature also would decrease, must with a temperature decrease decrease a quantity of electrons. This means that for retaining the electroneutrality during cooling of conductor from it the draining of electrons must be provide ford, and with the heating their inflow is provide ford. If we this do not make, then with the heating at the model will appear positive potential, but during the cooling negative. I.e. entirely, on the contrary, in comparison with the assumptions, voiced in regard to this.

For the experimental confirmation of this behavior of conductors one should connect to the sample under investigation electrometer with the very high internal resistance and begin model to cool. In this case the electrometer must register appearance in the model of negative potential. Especially strong dependence will be observed at low temperatures, when the heat capacity of electron gas and lattice of one order. However, what must occur upon transfer of model into the superconductive state? During the passage the part of the electrons will begin to be united into the Cooper pairs and in the region of Fermi energy will begin to be formed the energy gap of the forbidden states. Moreover, for the remained normal electrons this there will also be forbidden zone; therefore for them only places of higher than the upper edge of slot will remain permitted. This will lead to the fact that it will not be sufficient vacant places for the remained electrons, therefore, in the case of the absence of the draining of electrons from the model, it will acquire negative potential.

Chemical potential of lattice depends also on stresses and number of dislocations, and conduction electrons will also track this process.

In Fig. 49 is shown the temperature dependence of the electrostatic potential of model, made from niobium-titanium alloy, with a change in its temperature within the limits of 77-4.2 K.

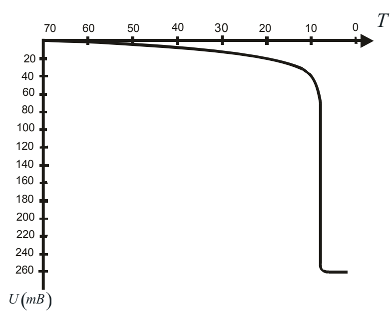

Fig. 50. Dependence of the potential of niobium-titanium model on the temperature.

It is evident that with the decrease of temperature the negative potential grows first sufficiently slowly, but in the temperature range of the passage of model into the superconductive state is observed a sharp drop in the potential.

A study of the influence of mechanical stresses and kinetics of dislocations on the electrostatic potential of models was conducted employing the following procedure. For this copper flask with the thickness of the walls ~ 3 mm and by volume ~5 liters of it was placed into vacuum chamber, from which could be pumped out air. The internal cavity of flask in conducting the experiments was found under the atmospheric pressure. Pumping out or filling into vacuum chamber air, it was possible to mechanically load its walls. Flask itself was isolated from vacuum chamber bushing from teflon resin and thus it had high resistance relative to the housing of unit. One of the typical dependences is represented in Fig. 51. It is evident that the amplitude of effect reaches 100 mV, dependence has strong hysteresis, moreover an increase in the negative potential corresponds to the tension of the walls of flask. In the figure the circuit on the hysteresis loop was accomplished clockwise. It follows from the obtained results that mechanical stresses of model lead to the appearance on it of electrostatic potential. The presence of hysteresis indicates that the formation of dislocations bears the irreversible nature.

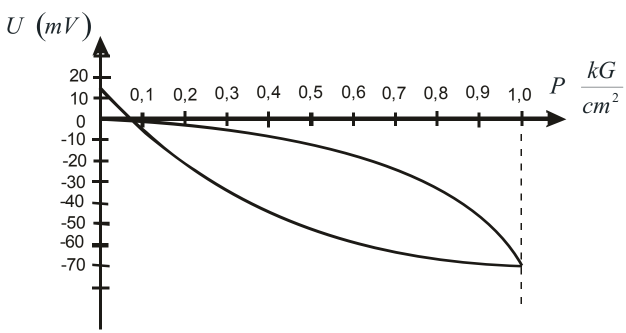

Fig. 51. Dependence of the potential of copper flask on the external pressure.

Thus, is proposed the new promising method of investigating the physical characteristics of materials and models, which gives the possibility to track different kinetic processes, and also the kinetics of phase transitions. It is promising for investigating of metals and semiconductors. With its aid it is possible to investigate the first-order transitions, connected with melting and crystallizing the objects indicated. It can be used also for study and diagnostics of plasma. This method is especially promising, since it is nondestructive, and also it does not influence model itself. It should be considered pioneer, since earlier this method was not known.

§ 28. New system of units

Is well known the word: mass, space, time. However, in the literary sources there is no precision determination of these concepts. If we speak about the mass, then to us, at least, are known its three properties, which it characterize as mass. The first property consists in the fact that any mass has linear dimensions. If it did not have this property, then it would be unobservable. The mass is had two additional fundamental properties in accordance with the law of gravity two masses they are attracted, in connection with which it is introduced the concept of force. This property is the consequence of the fact that around the mass is observed the potential field, whose gradient is critical for the appearance of this force. This also means that the system of two remote bodies possesses potential energy. The third fundamental property of mass is this its inertia properties, which indicate that for accelerating the mass, it is necessary to exert force. From this property escapes the fact that the moving mass possesses kinetic energy. Thus, mass as physical concept possesses the following fundamental properties: it has linear dimensions, and also it can possess potential and kinetic energy.

The concept of space with the concept of linear dimensions or length, space is connected three-dimensional. Coordinate systems are introduced for the formal realization of this concept. But the space has one additional characteristic, which can be named exclusion principle. This principle consists in the fact that at one and the same point of space at the given instant, cannot be located two different masses. Strictly this principle defines one of the characteristics of this concept as time, that attests to the fact that the different bodies simultaneously can be located only at the different points of space.

What is time as why it flows, scientists philosophers argue to the these rapids. It is known that time on the level with the mass and the length, enters into all systems of units as primary not on what the not depending value. However, it is known that, in order to measure the time, hours are necessary. There are many types of different hours, but all them unites one special feature. It occurs that in all conceivable hours, always occurs interaction of other primary physical quantities, after all as masses, length and force. In the pendulum hours their motion is determined by the mass of the Earth and by the length of pendulum. The same relates also to the satellites, which revolve around their stars or planets. In the hours with the mechanical springs the motion is determined by mass and dimensions of pendulum, and also by elastic properties of spring. Mechanical resonance systems can be used as the hours, but also in the required order here occurs interaction of three primary parameters: force, mass and length. Electromagnetic resonance systems also can be used as the hours, but also here their motion will depend on the dimensions of resonator, and also on the dielectric and magnetic properties of medium.

But give let us visualize that in this inertial system suddenly for some reasons changed the gravitational constant, either the inertia properties of mass changed, or the electrodynamic properties of medium finally changed - all this will involve a change in the rate of the motion of hours. Thus, asserts itself the conclusion that time is not primary physical quantity as, for example, the mass length and force, but directly it depends on the values indicated it can be through them expressed.

important is a question about side to what, and as rapidly flows the time. It is known that practically all laws of microcosm are invariant with respect to sign change of time; therefore for these laws does not have a value to what side it flows time.

If we have a frame of reference, which passes of one inertial system to another, which is unavoidably connected with the processes of retarding or accelerating this system, then in this system the process of retarding or accelerating the time must occur. Thus, it is possible to consider that the time can leak unevenly, first being accelerated, then slowing down. But if this is so, that arises question, and time can generally stop, or change its direction. Almost obvious it is the fact that, if any motion suddenly ceased, and all bodies, including atoms, suddenly they stood still at its places, then the concept of time would lose its sense. The same would occur when the universe was absolutely empty. Thus, asserts itself the conclusion that the concept of time is the consequence of existence of material objects and their properties.

Is known that time reversal, i.e., sign change of time does not change the form of equations of motion. This means that for any possible motion of system can be achieved the time-reversed motion, when system consecutively passes to the reverse order of the states, symmetrical to states, passed in the previous motion. In this posing of the question naturally to assume that, when in the system it occurs no changes, then time for this system not at all flows. When in the system some reversible changes occur, i.e., it after a certain evolution returns reversibly to its initial state, the time flows first in one, and then in other direction. Since in this case the concept of time is used to in application to this concrete system, it is possible to introduce the proper time of system, i.e., to assume that in each separately undertaken system there is its proper time. States symmetrical on the time are characterized by opposite directions of the speeds (pulses) of particles and magnetic field. Temporary invariance leads to specific ratios between the probabilities of direct and reverse reactions, to the prohibition of some states of the polarization of particles in the reactions, to the equality to zero electrical dipole moment of elementary particles.

However the existing systems of units do not assume the application of time with the different signs. Why thus it did happen? Most likely because the time as physical quantity was introduced not on the basis any deep physical principles, but on the basis the solutions of the chamber of measures and weights. Simply for measuring the time were undertaken the existing in nature periodic processes, which frequently have different nature.

As was said, the hours, with the aid of which the time is measured, compulsorily operates with other physical quantities, such, for example, as mass, length and force. And if we express time through these parameters, then their combination will prove to be under the root, and it means and time will be able to assume both positive and negative values. But, although mass, length and force exist as the primary objectively existing physical quantities, we will encounter that difficulty, that by the existing systems of units force itself is evinced after the already introduced time. Is there a way of overcoming this difficulty? Yes, this way is located.

Mass itself in accordance with the law of universal gravitation is the carrier of force, since two masses, spread in the space, are attracted. It is known from other side that there is a principle of the equivalence of heavy (gravitational) and inert mass. Moreover it is experimentally proven that this principle is observed with the very high degree of accuracy. Specifically, these two principles can be undertaken as the fundamental bases for the introduction to time as physical quantity.

If are located two identical masses m located at a distance $2r$ then in accordance with the law of universal gravitation, the force of their attraction determines the dependence:

$$F_g = \frac{mm}{4r^2} \ .$$

We will not thus far introduce any conversion factors, since it is built new system of units. It will be shown below, what it is necessary to use conversion factors in order to switch over to customary us to the units of time.

If the masses indicated revolve around the overall center of masses and acts the principle of the equivalence of gravitational and inert mass, then the equality will be carried out:

$$T = 4\pi\sqrt{\frac{r^3}{m}} \ , \qquad (28.1)$$

where T - period of revolution of masses around the overall center. relationship (28.1) includes immediately two laws: the law of universal gravitation and the principle of the equivalence of gravitational and inert mass. It also determines the dimensionality of time. Certainly, this dimensionality to us is unusual, but became accustomed we to other dimensionality in physics, into which enters incomprehensibly from where undertaken second. The advantage of this approach is the fact that the time as physical quantity is introduced on the basis of the fundamental laws of physics and it, as a consequence of this, corresponds to the principle of time reversal.

If we as the unit of length take meter, and as the unit of mass take kilogram, the unit of time in this system will be the value 4π. The dimensionality of time in this case follows from relationship (28.1) of in order to transfer this value into seconds, should be divided it into square root of gravitational constant. If we this make, then let us see, that the newly introduced unit of time is approximately five orders more than second. This, of course, is not very convenient, but in order to avoid these inconveniences, it is possible to introduce the dimensionless coefficient, equal to square root of the absolute value of gravitational constant. In this case the relationships between the values of all physical quantities will be preserved, although the dimensionality in them will be others. All mechanical values in this case will be expressed only through the length and the mass.

Since time now has its own dimensionality, passage to the electrical systems of units also does not compose labor, simply into the appropriate dimensionality of ones it is necessary to put the new dimensionality of time with the selected dimensionless conversion factor. If we for measuring the electrical units use to Gauss a system and to express in it time in the units of mass and length, then all electrical and magnetic units will be also expressed in the units of mass and length.

It should also be noted that the adoption of this innovation can lead to serious reconstruction of our views.

§ 29. Is laser quantum generator?

Lasers are considered as the quantum generators. It is known that the laser emission possesses high coherence and directivity. In radio engineering the principle of the construction of the radiating systems, which have high coherence and directivity, is well known. It consists in the use of a large quantity of elementary phased emitters, located in the determined order. Such systems are called the phased array (FA). Moreover, the greater the quantity of elementary sources it is used and the greater the dimensions of space, on which they are located, the greater the directivity and the radiated power can be obtained. For obtaining the high directivity the linear dimensions of system must be considerably more than the length of radiated wave.

In the work substance of laser also always is contained a huge quantity of elementary sources, which the atoms or the molecules of work substance are. If the discussion deals with the solid-state lasers, for example on the basis of ruby, then the radiating atoms, which are the atoms of chromium, it is also located in the crystal of work substance in the strictly defined order. Arises question, which will be, if such atoms, which are been elementary sources, are synchronously excited by any means, moreover then so that their fluctuations would be phased in a specific manner. From a radio-technical point of view this system can give the very narrowly-directed emission, since. a quantity of emitters is very great, and the length of radiated wave is much less than the linear dimensions of working element. But arises the question, how it is possible to excite atoms. The collision excitation, when the work substance of laser they irradiate by short pulse from the flashbulb, is one of such methods. Consequently, this generator works according to all laws of electrodynamics and radio engineering, and there is nothing in it quantum, although the name in it very beautiful - two-level quantum generator.

But are known and the multilevel quantum generators, in which the quanta are thrown to higher levels, and emission occurs by the way of their lowering downward by the course of several levels. And these are already accurately quantum generators. But prosaic radio engineers here say that any they not quantum, simply speech go about the nonlinear parametric systems, in which, because of the nonlinear properties of medium, occurs either parametric strengthening or parametric generation. All these processes are described well by the so-called the Menli-Rou relationships.

So that would be understandable, the discussion deals with than, let us give an example of usual mechanical resonator, for example tuning fork. If we strike tuning fork, thus for a while rings, generating acoustic waves.

Any oscillating process is characterized by this parameter as quality, the less the ohmic losses in the oscillatory system, the higher its quality. It is numerically equal to a quantity of oscillatory periods, plotted in that time interval, for which the amplitude of fluctuations decreases in e of times. This is usual classical by all intelligible approach. This process from a mathematical point of view can be examined differently, considering that this is any mechanical, but quantum oscillator. And to consider that the excited tuning fork is had two energy levels: zero and upper (excited). In quantum mechanics it is considered that when we mechanically excite tuning fork, this mechanical resonator jumps over to the upper energy level. Quantum mechanics determines the lifetime at this upper level. It is exactly equal to that interval of time, which is necessary so that the amplitude of fluctuations in the mechanical resonator would decrease in e of times.

If we take one hundred million tuning forks and it is synchronously phased to excite them, it is on top of that correct to arrange them in the space, then it is possible to obtain the coherent, narrowly directed sonic ray. Such systems successfully are used in the sonars. And this entire process as before can be considered as the phased lattice of mechanical vibrators. Quantum mechanics considers that this system is two-level quantum generator. Certainly, this approach in common with physics has nothing, but it is the result of those scholastic mathematical approaches, which are so extended in contemporary physics.

In the ruby laser in the matrix of corundum the small percentage of aluminum atoms are substituted by the atoms of chromium. These atoms have strict attitude sensing and their resonance frequency. But if we excite this resonance, then atom chromiums will emit not acoustic, but electromagnetic waves. Further entire the same histories as with the tuning forks, only atoms of chromium in one cubic centimeter of the ruby not of one hundred millions, but ten into twenty second degree.

If on ceiling hang incandescent bulb, that it emit incoherent light. Why? But because the phases of the oscillations of all atoms, which vary as a result heating tungsten, are unphased and they are spontaneous. Therefore, if you want to teach laser coherent emission, then you must not only excite in atoms or tuning forks of fluctuation, but also excite them then so that their phases would be phased according to the specific law. Then you obtain coherent (laser) emission. Therefore the problem of developing of laser consists not only the excitation of fluctuations in the separately undertaken atoms (for example the atoms of chromium in the ruby laser) but still and obtaining the correct phasing of their fluctuations with this excitation. If we this attain ourselves, then will learn the emission, which in quantum mechanics is called stimulated. External resonator for these purposes serves, where active material is placed. In this case one of the oscillating modes of external resonator must in the required order coincide with the resonance frequency of the atoms of active material. The phasing during irradiation of ruby by flashbulb occurs very simply. The light of flash excites incoherent fluctuations in the atoms of chromium, and external resonator selects from entire many excited atoms, only those, the phase of fluctuations of which coincides with the phase of fluctuations in the resonator itself. Therefore efficiency in ruby laser is low. Resonator fulfills those functions, which carry out the resonant circuit of your receiver with its tuning for the specific frequency. Therefore laser this is the usual correctly phased antenna array.

But moreover here the Menli–Rou relationship? These relationships work when in the nonlinear medium there is several resonances, let us say three resonances. In this medium such resonances are not independent and energy processes in them are connected. Moreover if we excite one of the resonances, then I will be excited and rest. If we compare the energy, stored up in each of the resonators examined, then it Budde is proportional to their resonance frequency. This quantum mechanics interprets as the presence on Wednesday of the energy levels of the proportional to frequency. But the processes of energy transfer of one resonance in another, which ensures the nonlinearity of medium, quantum mechanics interprets as the jumps from one energy level to another.

You see as all simply. But simply they do not know these elementary things of physics, simply thus they taught them, and with it drove into the head any scholastic diagrams, nothing general with physics having. Love physics any super-natural pieces. That in them electrons in a completely inconceivable manner from the orbit in orbit jump over and mysterious quanta emit. That twins in the spacecraft, which are carried with the light speeds, on millions years live. But here the engineersin no way to this they believe!

§ 30. Three-dimensional kogerentization

With the aid of the phased antenna arrays it is possible to create the pencil beams of electromagnetic waves. The process of the formation of such beams is connected with the addition in the space spatially coherent waves. Addition (interference) is accomplished in such a way that in the determinate directions the phases of waves from the separate emitters are added, and in others - they are read. This is the only way of creating the narrowly-directed beams, independent of nature of wave processes and wavelength. Is correct reverse, if we see the narrowly directed beam, for example laser beam, then it is possible to assert that it is formed with the aid of the separate emitters, which emit signals with the large length of coherence and phase of which in the space they are added in those places, where we see ray itself. But unidirectional beams of light can be obtained by simpler way and this we not one time observed. If sunlight was passed through the opening, thus almost rectilinear ray is formed. But indeed sun itself emits monochromatic and far from coherent waves. But in than here the matter? If we make a good hologram with the aid of the laser of that emitting red light and to illuminate by its sunlight, then it is possible to see holographic picture in the red light. This experiment again confirms that in the composition of sunlight is this spectral line with the large length of coherence, since only with the aid of the coherent light it is possible to see hologram. But as so, indeed the surface of the sun emits in no way coherent emission, and for some reason this noncoherent radiation from the sun suddenly at large distances becomes coherent. But give to move from the reverse, once is located the narrowly directed beam, which means, it it is formed with the aid of the addition of coherent signals. If we with the aid of the opening cut out ray from the distant star, thus will possess still smaller divergence and larger coherence than solar. The same experience can be made by the distant lamp, which is practically point-source radiator, and to obtain from it pencil beam. If we continue these experiments, then it is possible to see that the less the solid angle, at which is visible the source, the greater the coherence of signal it gives, moreover in entire range of the spectrum radiated by it. If we from this signal with the aid of the filter isolate the specific narrow spectrum band, then this ray will in no way differ from laser.

But why this strange special feature possess point luminous sources, nothing it is written about this in the existing literature. But the answer the like of the essence of the matter is very simple. If at the particular point space we observe the narrowly directed beam, then, as we already said, it can be formed only by the way of the additions of coherent components, which give separate emitters. On sun or star of the radiating atoms a huge quantity, moreover each with the radiation pattern and the frequency. But, since such atoms very much phase their emissions are chaotic, will always be located the specific quantity of atoms, the phases of emission of which will coincide into what that remote place, where we see the result of this addition in the form of rectilinear ray. Therefore any point source this is of its kind the laser, which emits spherical polychromatic ray. And already from this ray we can with the aid of the openings obtain narrow radial rays, and with the aid of the filters make with their monochromatic.

§ 31. Gravitational mass defect

Let us examine one phenomenon, which refers straight to the case of liberating the large quantities of energy. Let us take the case, when trial body with the mass m falls on the very massive body with the mass M, whose radius is equal R (subsequently the body m and the body M). Let us assume that at the initial moment of time the distance between the bodies is very great and that is fulfilled the relationship $M \gg m$. Let us also consider that the density of the massive body ρ. The rate of the fall of the body m on the body surface M in this case can be found from the relationship:

$$v = \sqrt{\frac{2\gamma M}{R}}, \qquad (31.1)$$

where γ - gravitational constant. If we switch over to substance density of massive body, then relationship (31.1) can be rewritten as follows:

$$v = 2R\sqrt{\frac{2\pi\gamma\rho}{R}}. \qquad (31.2)$$

Is obvious that kinetic energy, which possesses the falling body, it obtained from the gravitational field of the body M. This kinetic energy of the falling body with its drop on the surface of massive body to become thermal energy will be radiated into the surrounding space in the form of electromagnetic waves.

From the aforesaid it is possible to conclude that the final summary mass of two bodies will not be equal to the sum of the masses of bodies prior to the beginning of the drop:

$$M_\Sigma \neq M + m,$$

i.e. there is a gravitational mass defect. The relationship of the honey M_Σ and $M + m$ can be found, knowing that kinetic energy, which possessed the body m with the drop on the body M. This energy can be calculated from the relationship

$$E_k = m_0 c^2 \left(\left(1 - \frac{v^2}{c^2} \right)^{-\frac{1}{2}} - 1 \right).$$

During the record of this expression is taken into account the circumstance that with the fall of body in the gravitational field the acceleration of this body does not depend on its mass. Therefore relationships (31.1) and (31.2) are accurate even for the relativistic speeds. It is now not difficult to calculate gravitational mass defect.

$$\Delta m = \frac{E_k}{c^2} = m_0 \left(\left(1 - \frac{v^2}{c^2} \right)^{-\frac{1}{2}} - 1 \right). \qquad (31.3)$$

This effect comprises with the drop on the earth's surface ~ $m \times 10^{-9}$.

From relationship (31.3) is evident that the addition Δm can be both less and it is more than m. If $\Delta m < m$, then with the fall of body summary mass increases. But if $\Delta m = m$, then an increase in the summary mass ceases, and entire mass of the falling body is converted into the thermal radiation. In this case massive body is converted into the ideal anvil, which converts entire mass of the falling body into the energy of electromagnetic radiation.

as can easily be seen of relationship (31.3), the rate of the fall of the body m (let us name this speed of critical) to the body surface M will be determined by the relationship

$$v_{кр} = \frac{c\sqrt{3}}{2}\ , \tag{31.4}$$

i.e. it is considerably less than the speed of light.

If the density of massive body is known, then, using relationships (31.2) and (31.4), it is not difficult to find a critical radius of this body:

$$R_{кр} = \frac{3c}{4\sqrt{2\pi\gamma\rho}}$$

By this concept we will understand the value of the radius, with reaching of which further increase in the mass of the body of M due to the fall on it of another body becomes impossible.

Can occur the situation for the space objects examined, for example for the neutron stars. It is known that the neutron stars (pulsars), have very high density [26]. So pulsar with a mass ~ 2×10^{30} kg (mass of the sun) would have a radius a total of near 10 km. Its density in this case would compose ~5×10^{17} kg/m^3. With this density a critical radius would comprise near 15 km ; and mass would compose ~ 3.4 of masses of the sun. This means that with reaching of such sizes and this mass the neutron star no longer can increase neither its sizes nor its mass, since any falling to it objects will be completely converted into the radiant energy.

According to preliminary calculations in our galaxy is counted about 300 thousand neutron stars [26]. What to happen, if neutron star does encounter the same neutron star as it itself? It is obvious that the complete annihilation of neutron substance and its transformation into the energy will occur. Taking neutron star with a critical radius 15 km of. and with the mass ~ 3.4 of masses of the sun, we obtain the value of energy 5×10^{47} J. This value of energy is very close to that energy, which characterizes explosion in the nucleus of galaxy NGC 3034 [26]. During this explosion from the nucleus of galaxy was rejected a huge quantity of material throughout its mass equal 59×10^{6} of the masses of the sun. This of phenomenon does not find its thus far explanation and are not known those energy sources, which can lead to so immense an explosion. The process of the collision of neutron stars examined can be precisely such source.

In its essence this explosion - this is the explosion of the nuclear charge of very large power. The isolation of such significant quantities of energy will be accompanied by warming-up and transformation into the plasma of large quantities of surrounding material. This in turn will lead to the appearance of the same electrical pour on as with the explosion of nuclear bomb, only much more significant. The presence of such pour on in the surrounding space they must lead to the appearance of specific polarization effects. To them can be attributed polarization in the electric fields of atoms and molecules and the appearance of the electric dipoles, which will lead to the polarization of the electromagnetic waves of those extending in the plasma.

§ 32. Ferroelectric transformer

In connection with the fact that the law of magnetoelectric and electromagnetic induction are symmetrical, must exist the symmetrical technical solutions. Such solutions are located. For example, with the aid of the revolving magnetic field it is possible to create electric motors. For the same purposes it is possible to use the revolving electric field, and the engines, which use this principle, exist. There exists the transformers ferromagnetic heart in which with the aid of the magnetic flux they transfer energy of one winding into another. The symmetry of the laws indicated tells us that must exist the transformer, whose core will be executed not of the ferromagnetic material, but of the ferroelectric. In the technology the transformers with the ferromagnetic cores widely are used. Their incapacity to work at the high frequencies is a large drawback in such transformers. Is connected this with the large inertness of the processes of the reversal of polarity of transformer core. And in this connection question arises, and is it possible to create the transformer, in which as the core is used not the ferromagnetic material, but ferroelectric. Since the processes of electrical polarization have very small inertia, this transformer could work at the very high frequencies.

Let us examine the possible the schematics of ferroelectric transformer.

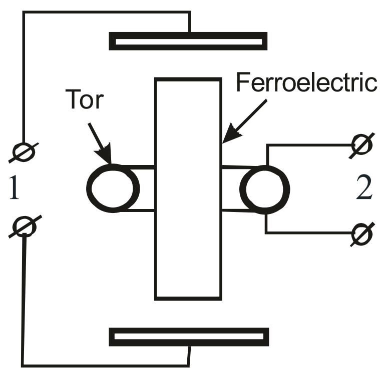

Fig. 52. Schematic of ferroelectric transformer.

Into the composition of transformer (Fig. 52) enters the parallel-plate capacitor, between plates of which is placed the cylinder from the ferroelectric with the large dielectric constant. On the cylinder is placed the winding of torus, whose ends are connected to terminals 2. During the supplying to the capacitor of alternating voltage in the cylinder there will be leak polarization currents and the time-varying circulation of magnetic field will arise around the cylinder. This circulation will excite in the torus-shaped winding currents and a variable potential difference will appear on terminals 2.

The transformer with the toroidal ferroelectric core is depicted in Fig. 53.

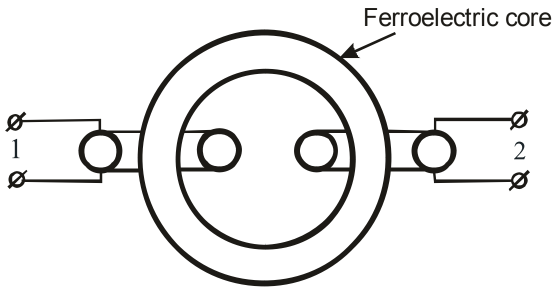

Fig. 53. Transformer with the toroidal ferroelectric core.

It consists of the torus-shaped core, made from the ferroelectric, on which are placed two torus-shaped windings. The transformation ratio of this transformer depends on the relationship of the number of turns in the windings. The merit of transformer is the fact that it can work at the very high frequencies. Furthermore, by the way of connection to the windings of the transformer of capacitors it is possible to convert into the resonance transformer.

In spite of simplicity of idea and construction, unfortunately, the transformers of this type before the appearance of works [11,12,25] is nowhere described. But indeed they open very large prospects. It is known that the magnetic amplifiers, which possess high reliability, cannot find wide application only because they work at the low frequencies. In this case there are no such limitations in practice, since the processes of electrical polarization have very small inertia, and, using the transformer examined, it is possible to create the reliable wideband amplifiers, which work at the very high frequencies.

§ 33. Multipolar unipolar alternator

Obtaining EMF with the aid of the homopolar induction is characterized by its simplicity. Moving parts of the generator windingless, the moment of the inertia of its rotor can be considerably less than in the existing constructions, which allows its rapid reverse with the use of a generator as the engine. In the existing generators of winding it is necessary to plot in the narrow grooves and to insulate them from the walls, which deprives the possibility of their effective cooling. This deficiency the unipolar generators and engines also do not have. Proposed construction of unipolar generator gives the possibility to obtain variable EMF, which allows the application of transformers, and this makes it possible to obtain any voltages from such generators.

The construction of unipolar generator, which makes it possible to obtain variable EMF is based on its transformation into the multipolar generator, as shown in Fig. 54.

Into the composition of generator enters the fixed conducting disk, along which slide the brushes, fixed at the ends of the metallic knitting needles. Disk covers magnet yoke, the pole gap of which allows the free passage of the knitting needles, fastened to the revolving drum.

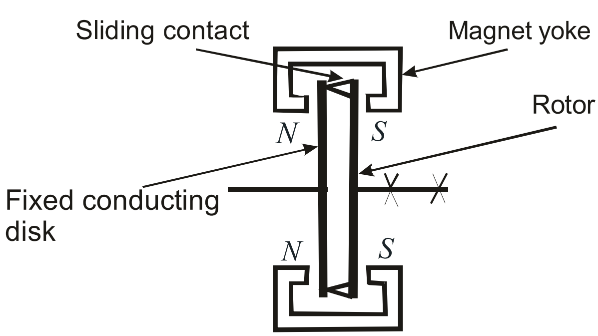

Fig. 54. Axial section of multipolar unipolar generator.

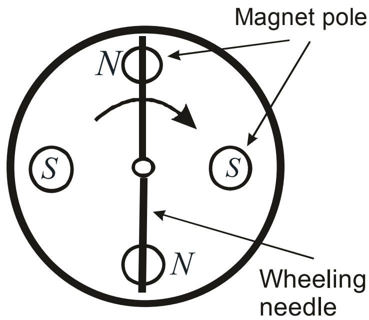

Fig. 55. The cross section of generator.

The cross section of generator is shown in Fig. 55. During the rotation of the shaft, to which are fastened the knitting needles, they consecutively are passed between pluses of magnets, in this case in them is induced EMF, whose sign depends on direction of the magnetic field. Magnet pole they are located so that direction of the magnetic field they are opposite in each with a number of the magnet confronting. A quantity of magnets is equal to the doubled number of knitting needles. This arrangement of magnet poles gives the possibility during the rotation of shaft to generate in the knitting needles ac EMF. In this case the alternating voltage appears between the fixed disk and the axis of rotor, which with the aid of the transformer, can be increased to any value. Figure shows the construction, which consists of two knitting needles and four magnets. The greater the quantity of magnets, established on the perimeter of disk, the greater the number of cycle stress alterations, which fall for one revolution of shaft. The proposed construction is very simple, and allows production in any workshop, which has machine-tool equipment. The repair of generator and the replacement of sliding contacts also labor does not represent, since. all elements of generator are easily attainable.

CONCLUSION

We passed large and difficult way on the examination of the problems of those accumulating in the contemporary electrodynamics, and, in spite of that which to this science is already more than 200 years, these problems remained still sufficiently much. For the duration entire of the period in the electrodynamics indicated primary attention was paid to the electrical and magnetic fields and this concept as magnetic vector potential remained in the shadow. The analysis, carried out in this work, showed that the magnetic vector potential is one of the most important concepts of electrodynamics. But physical nature of this potential before the appearance of works [3, 10-12, 14, 19] was not clear. Now we can draw that scenario, on which must be developed the electrodynamics, if the role of magnetic vector potential, was realized in the early stages of its development, and then if at that time was possible to understand its physical nature.

The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z

$$\vec{H} = \frac{1}{4\pi}\int \frac{Id\vec{l} \times \vec{r}}{r^3}$$

where I - current in the element $d\vec{l}$, $\vec{r}$ - vector, directed from $d\vec{l}$ to the point x, y, z.

It is possible to show that

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right)\times d\vec{l}$$

but also, that

$$grad\left(\frac{1}{r}\right)\times d\vec{l} = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r} rot\ d\vec{l}\ .$$

but the rotor $d\vec{l}$ is equal to zero and therefore is final:

$$\vec{H} = rot\int I\left(\frac{d\vec{l}}{4\pi r}\right) = rot\ \vec{A}_H,$$

where

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right). \qquad (1)$$

The remarkable property of this expression is that that the vector potential depends from the distance to the observation point as $\frac{1}{r}$. Specifically, this property makes it possible to obtain emission laws.

Since $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, from (2.12) we obtain:

$$\vec{A}_H = \int \frac{gv\ d\vec{l}}{4\pi r}.$$

For the single charge of this relationship takes the form:

$$\vec{A}_H = \frac{e\vec{v}}{4\pi r},$$

and since

$$\vec{E} = -\mu \frac{\partial \vec{A}}{\partial t},$$

the knowledge of vector potential, its time derivatives and on the coordinates makes it possible to find electrical and magnetic field.

Relationship

$$rot\ rot\vec{A}_H = \vec{j}\left(\vec{A}_H\right),$$

that obtained in the second paragraph indicates that $rot\ rot\vec{A}_H$ is the functional of current density, which for the different media is determined by the following relationships:

For the free space and the dielectrics:

$$rot\ rot\vec{A}_H = -\mu\varepsilon\frac{\partial^2\vec{A}_H}{\partial t^2}. \qquad (2)$$

For the case of fulfilling Ohm's law:

$$rot\ rot\vec{A}_H = -\sigma\mu\frac{\partial\vec{A}_H}{\partial t}. \qquad (3)$$

For the conductors, in which be absent the ohmic losses:

$$rot\ rot\vec{A}_H = -\frac{\mu}{L_k}\vec{A}_H. \qquad (4).$$

Relationships (2-4) are wave equations and make it possible to obtain the laws of the propagation of vector potential in different media.

Having relationships (2-4), it is possible to immediately obtain wave equations for the electrical and magnetic field. Differentiate on the time from both parts of these equations, we obtain:

$$rot\ rot\vec{E} = -\mu\varepsilon\frac{\partial^2\vec{E}}{\partial t^2},$$

$$rot\ rot\vec{E} = -\sigma\mu\frac{\partial\vec{E}}{\partial t},$$

$$rot\ rot\vec{E} = -\frac{\mu}{L_k}\vec{E}.$$

After taking rotor from both parts of equations (2-4), we obtain wave equations for the magnetic field for the media indicated:

$$rot\ rot\vec{H} = -\mu\varepsilon\frac{\partial^2\vec{H}}{\partial t^2}\ ,$$

$$rot\ rot\vec{H} = -\sigma\mu\frac{\partial\vec{H}}{\partial t}\ ,$$

$$rot\ rot\vec{H} = -\frac{\mu}{L_k}\vec{H}\ .$$

With this approach Maxwell's equations no longer are necessary to us, since given relationships give the possibility to examine wave processes in all media indicated.

But vector potential makes it possible to solve not only wave problems. With its aid, as shown in the second paragraph, can be solved the problems of power interaction of electriccurent systems. Which up to now were solved with the aid of the axiom about the Lorentz force.

Oreover , the use of vector potential makes it possible to write down the complete law of induction (2.7) without any withdrawals and exceptions of the type of homopolar induction. And precisely vector potential makes electrodynamics with one-piece and united science. But physical nature of this potential before the appearance of works [3, 10-12, 14, 19] was not clear.

The meaningful result of works [3, 10-12, 14, 19] is that which in them within the framework the Galilean transformations is shown that the scalar potential of charge depends on its relative speed, and this fact found its experimental confirmation. This monograph only details those ideas, which are expressed in these works. The obtained results change the ideological basis of classical electrodynamics, indicating that the substantial part of the observed in the electrodynamics dynamic phenomena, this by the consequences of this dependence. Certainly, the adoption of this concept is critical step. But this step is transparent and intelligible from a physical point of view. Indeed the main parameter of charge are those energy characteristics, which it possesses and how it influences the surrounding charges not only in the static position, but also during its motion. With the acceleration of charge its energy relative to fixed system grows, and with a relative change in the electrical connected pour on an increase in this energy. I.e. the moving charge according to its electrical characteristics corresponds to fixed charge from somewhat changed electric fields.

The dependence of scalar potential on the speed leads to the fact that in its environments are generated the electric fields, to reverse fields, that accelerate charge itself. These fields diminishing as $\frac{1}{r}$, and they be late to the period, which is equal to the distance to the point in question, divided into the speed of light. Such dynamic properties of charge allow instead of two symmetrical laws of magnetoelectric and electromagnetic induction to introduce one law of electro-electrical induction, which is the fundamental law of induction. This method gives the possibility to directly solve all problems of induction and emission, without resorting to to the application of such pour on mediators as vector potential and magnetic field. This approach makes it possible to explain the origin of the forces of interaction between the current carrying systems. The introduction of scalar- vector potential explains a number of the phenomena, such as phase aberration and the transverse the Doppler effect, which earlier in the classical electrodynamics an explanation did not have. Direct confirmation of the dependence of the scalar potential of charge on its relative speed is the appearance of the pulse of electric field with the explosion of nuclear charges.

Up to now in the classical electrodynamics existed two not connected with each other of division. From one side this the Maxwell equation, and from which follow wave equations for the electromagnetic pour on, while from other side this of the relationships, which determine power interaction of the current carrying systems. For explaining this phenomenon by axiomatic way was introduced the Lorentz force. Introduction to the dependence of the scalar potential of charge on its relative speed connects between these, up to now not connected together divisions. Thus, classical electrodynamics takes the form of the ordered united science, which has united ideological basis.

It should be noted that in the classical electrodynamics earlier was not the rules of conversion pour on upon transfer of one IMS to another. These rules are obtained by using the very intelligible physical procedures, but not by the introduction of postulates, as is done in STR . However, it occurs that with an accuracy down to the terms ~ $\frac{v^2}{c^2}$ the obtained conversions coincide with results STR. In this case one cannot fail to note that experimental check STR is at present carried out not more precisely than the orders indicated. If we continue comparisons, then the it should be pointed out that proposed theory allows possibility existence of the speeds of the material bodies greater than the speed of light, and also is assumed the dependence of magnitude of the charge from its relative speed, which contradicts STR. To the experimental confirmation of dependence of charge on the speed in the work is given significant place and it is experimentally shown that this dependence exists.

Let us be examined again how classical electrodynamics was developed, and we analyze the question of why the dependence of scalar potential on the speed was not introduced into its time. Literally in several steps from this solution there was Heinrich Hertz. He indicated that pour on upon transfer of one IMS to another necessary to use total derivatives pour on for finding the rules of conversion. However, Hertz did not note that this approach immediately gives the possibility from the equations of induction to obtain Lorentz force. The erroneous point of view of Hertz was the fact that it considered fields invariant upon transfer of one IMS to another.

In the work shows that together with the fundamental parameters $\varepsilon\varepsilon_0$ and $\mu\mu_0$, which characterize the specific forms of energy, accumulated or transferred on Wednesday, namely: electrical and magnetic energy; there are two additional fundamental material parameters: the kinetic inductance L_k and the kinetic capacity C_k. With these parameters are connected two forms of energy, namely: kinetic and potential, which can be accumulated or be transferred in the material media. If, the parameter, L_k were sometimes and used with the description of some physical phenomena, for example, in the superconductors [2], then there were no C_k, before the appearance of a work [3], known about existence. Use of all four fundamental parameters $\varepsilon\varepsilon_0$, $\mu\mu_0$, L_k and C_k gives the clear physical picture of the wave and resonance processes, which exist in the material media with the presence in them of electromagnetic pour on, and it makes it possible to solve all existing problems of electrodynamics for the linear media. Earlier it was always considered that in the material media the electromagnetic waves are propagated and only these waves transfer energy. However, this approach is insufficient to account for all forms of the energy, accumulated and transferred by fields and currents in the material media. In actuality in the material media are propagated the magnetoelectrokinetic waves or the magnetoelectropotential waves, in which the part of the energy is accumulated and is transferred purely mechanically. Resonances in the material media also bear their specific character. In contrast to the electromagnetic resonances in the locked planes, when the energy exchange occurs between the magnetic and electric fields, in the material media there are two forms of resonances. The first - electrokinetic, when electric field energy is converted into the kinetic energy of charge carriers and vice versa, but magnetic pour on no generally. The second resonance it is possible to name magnetoelectropotential, when the potential energy, accumulated in the precessional motion of magnetic moments, can return into the external space at the frequency of precession.

Should be focused attention also to the fact that the physical interpretation of some mathematical concepts, which concern electrodynamic processes, they require the specific caution. So it is mathematically very simple of two, not depending on the frequency physical quantities, to design the mathematical symbol, which will depend on frequency. Specifically, this occurred, when the concepts of the dispersion of dielectric and magnetic constant were introduced. However, it turned out that such concepts as the dispersion of these values, physically not justify, although the parameter $\varepsilon^*(\omega)$ is convenient for the mathematical description of the processes, which exist in the material media.

We are the witnesses of the phenomenon, when mathematics bore the new physical parameter, which in nature there does not exist. And, the most interesting consists in the fact that all of physics into existence of this parameter believed and many believe to the these rapids. The discussion deals with the frequency-dependent dielectric constant. This physical parameter in nature there does not exist. How did arise this error? It is known that there is a dispersion of electromagnetic waves with their passage through the material media. Here all began to think that this dispersion was generated by the dispersion of dielectric constant. Occurs everything entirely not thus. The dispersion of electromagnetic waves is the consequence not of the dispersion of dielectric constant, but the dispersion of the phase speed of electromagnetic waves. Immediately several parameters independent from the frequency form this dispersion. For the plasma the dielectric constant of vacuum and the kinetic inductance of charge carriers, which present plasma, are them. In the dielectrics this process somewhat more complex, because, together with the dielectric constant of vacuum and the kinetic inductance of bound charges, in this process participate the polarization or orientational properties of the electric dipoles, existing in the dielectric. Consequently, the dispersion of electromagnetic waves, which is observed with their propagation in the dielectrics, is connected not with the dispersion of the nonexistent parameter, which was considered the frequency-dependent dielectric constant, but with the dispersion of reactive dielectric conductance. Thus, was scattered the very beautiful myth (the same beautiful as rainbow) about the dispersion of the dielectric constant of material media, which existed almost century. Let us note that this myth began precisely from this mysterious and beautiful rainbow. The it should be noted that indicated terminological, physical and systematic error is present in all without the exception fundamental works on the electrodynamics of continuous media and physics of plasma. Naturally, it is located also in all publications, where these questions are discussed.

But if assertion about the presence of dispersion in the dielectric and magnetic constant can be to a certain degree considered systematic error, then in the electrodynamics of continuous media there are errors also of more fundamental nature. This is that case, when in conducting media at the microscopic level is introduced polarization vector similarly, as is done in dielectrics [9]. This is gross physical error, since polarization vector in the conducting structures at the microscopic level be it cannot, since in the conductors the charges are free, and the electric dipoles do not can to form. As a result such systematic and physical errors unnoticed proved to be the circumstance that in the nonmagnetized confined plasma, together with the longitudinal Langmuir resonance, it can occur and transverse plasma resonance, the frequencies in these resonances coinciding, i.e., they are degenerate. But this means that the entire scientific direction, which has great applied value, is passed, since. on its basis can be created the lasers on the collective plasma oscillations, tuned filters, the phenomenon indicated also can be used for the warming-up of plasma.

Should be focused attention still to one important circumstance. We frequently use the concept of kinetic energy of the moving bodies even we say that in this case the moving body accumulates kinetic energy STR this phenomenon is connected with an increase in the mass of the moving body. But neither one nor the other statement of this fact has a sense until are determined those physical parameters of the material body, which answer for the energy storage by the moving body. With the acceleration of body all those fields, which strictly and present mass itself and charges existing in it undergo relative changes. But if this is so, and gravitational interaction of the moving bodies must differ from their static interaction. But these questions exceed the scope of this monograph and require a separate study.

The main result of this work is that that in it the need of the conversions in the very classical electrodynamics is shown. This need became acute already long ago. Many researchers understood, and this most is clearly said in the work [1], that abnormal is that situation, when in the physical law, which is the Faraday law, there are exceptions. When into the electrodynamics it is necessary axiomatic way to introduce this concept as Lorentz force. When in fact there exists two not connected together electrodynamics. When in order to obtain the rules of conversion pour on upon transfer of one IMS to another it is necessary to use postulates. All these contradictions and need for introducing into the electrodynamics of axiom and the postulates is removed the acknowledgement of the fact that scalar of the potential of charge depends on its relative speed. United noncontradictory electrodynamics can be built on this basis.

However, that does prevent putting into practice of such productive ideas? But interferes that in its time interfere withd acknowledgement as the correct of the ideas of Galileo and Copernicus, when metaphysics of

Ptolemy for a long time was considered as the official science. In the preface we already spoke about the perniciousness of [politizatsii] of science. Specifically, it stands, until now, and it will always stand on the way of the progress in the science. Our task, the task of scientists, to breach this impenetrable wall.

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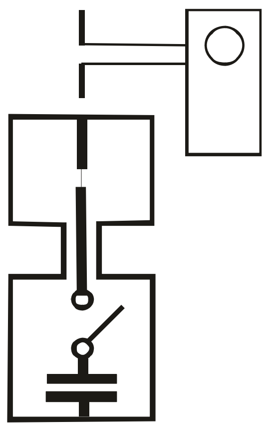
APPLICATION № 1

Installation for observing the electric pulse with the rapid warming-up of plasma

With the rapid warming-up of plasma to high temperatures must be observed electric pulse similarly, as it takes place with the explosions of nuclear charges. Installation for the realization of this experiment is shown for figure.



Installation consists of two cameras, made from metal, which are connected by metal tube. In the lower chamber to be located the capacitor, which with the aid of the key can be connected with the iron core. In the upper chamber between two iron cores the section of thin tungsten wire is located. With closing of key the energy, stored up in the capacitor, converts wire into the cloud of plasma, which emits radial electric field. In the figure the chains, with the aid of which they charge capacitor, are not shown.

Since the radial electric fields of single charge cannot be screened with the aid of the metal screen, they penetrate outside cameras. These fields are measured with the aid of the dipole antenna, which is connected to the oscillograph.

Let us carry out the tentative calculation of the expected effect.

Let us assume that the mass of tungsten wire is equal to 0. 001 g, and, after its transformation into the plasma, the temperature of plasma is 5000 degrees. Then with the density of the atoms 10^{22} 1/sm^3 and the specific weight of tungsten 19.2 g/sm^3 a quantity of atoms composes ~ 5.10^{17}. The degree of ionization at such temperatures composes several percentages. With the degree of ionization ~ 1% quantity of free electrons will compose ~ 5.10^{15}.

The jump of the electric field at a distance 1 m of the place of the formation of plasma is computed according to formula

$$\Delta E = \frac{Nek_Б T}{4\pi\varepsilon_0 r^2 mc^2},$$

it will be ~ 5 V/m. This jump of the tension of the electrical field easily yields to measurement.

CONTENT