According to the program “Starfish” of 9 July 1962 of the USA exploded in space above Pacific Ocean H-bomb. With conducting of tests it was discovered, that the explosion is accompanied by the electric pulse of very large amplitude and short duration. In spite of that which from the moment of explosion past is already more than fifty years, the up to now existing electrodynamics to explain this phenomenon does not can. Accompany nuclear explosions such phenomena as the emission of electromagnetic waves in the radio-frequency band, and also the so-called rope tricks. For explaining the phenomena indicated is used the concept of scalar - vector potential, which indicates the dependence of the scalar potential of charge on the speed. This concept was for the first time proposed and developed by the author of monograph. The long-wave radiation by which are accompanied the nuclear explosions, can be the consequence of the transverse plasma resonance in the confined plasma, which is examined in the number of the work of the author.

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Mende Fedor entire life worked in NTK FTINT AS USSR. The doctor of technical sciences. In the list of scientific works it is more than 200 designations, among which 9 monographs. It has government and departmental rewards.

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Electrodynamics of nuclear explosions

Mende

Fedor Mende

Electrodynamics and thermodynamics of nuclear explosions and TNT

The nature of the electrical pulse of nuclear explosions and TNT

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Content

Introduction

According to the program "*Starfish*" July 9, 1962 USA exploded in space above Pacific Ocean at an altitude of 400 km H-bomb. This event placed before the scientific community many questions. It is earlier into 1957 future Nobel laureate doctor Hans Albrecht Bethe, being based on the theory of dipole emission, predicted that with a similar explosion will be observed the electromagnetic pulse (EMP), the strength of field of which on the earth's surface will comprise not more than 100 V/m. But with the explosion of bomb discomfiture occurred, field 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. Actual chart area and value of tensions field on given in Fig. 1. This figure and all given, which will be given in this division, that are concerned tests according to the programs "*Starfish*" and "*Program K*", they are undertaken from the Internet. This connected with the fact that up to now in the scientific journals of publication on this question they be absent.

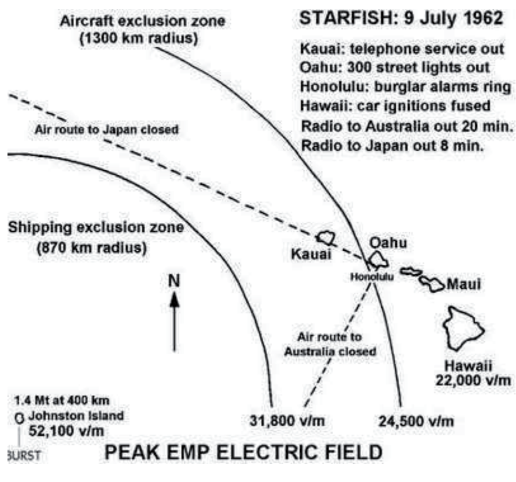

Fig. 1. Map of tests according to the program "*Starfish*".

Unfortunately, in the materials of this reference is not contained information about the polarization of these field on. Possibility to refine this question give the data, obtained in the USSR during the tests with the code name “*Program K”*, when not far from Dzhezkazgan at the height 290 km was exploded H-bomb with the TNT equivalent 300 kt. Actual chart area with the indication of the values of tensions field on, obtained with this explosion, it is shown in Fig. 2 comparing data with respect to the tensions field on, given on these two maps, it is possible to see that the values of tensions field on in Fig. 1 diminish with an increase in the distance from the epicentre of explosion, while on the map, depicted in Fig. 2, these values grow. From this it is possible to draw the conclusion that on the second map are cited the data on the measurement by the horizontal intensity of electrical field on.

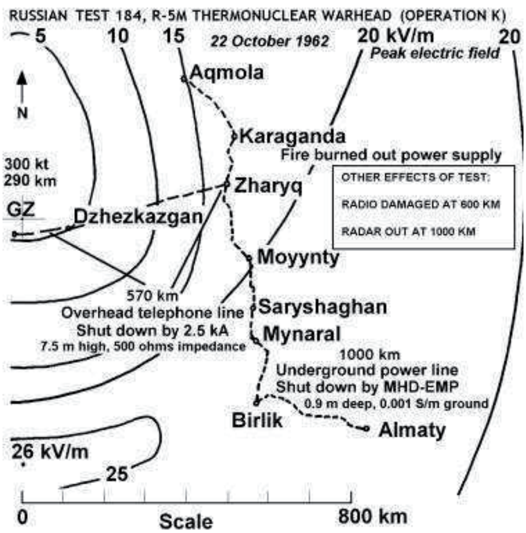

Fig. 2 Map of tests according to the program “*Program K”*.

is located the record of the shape of electrical pulse, made at a distance 1300 km from the point of impact (Fig. 3), obtained during the tests according to the program “*Starfish”*. It is evident from the given figure that EMP has not only very large amplitude, but also very short duration.

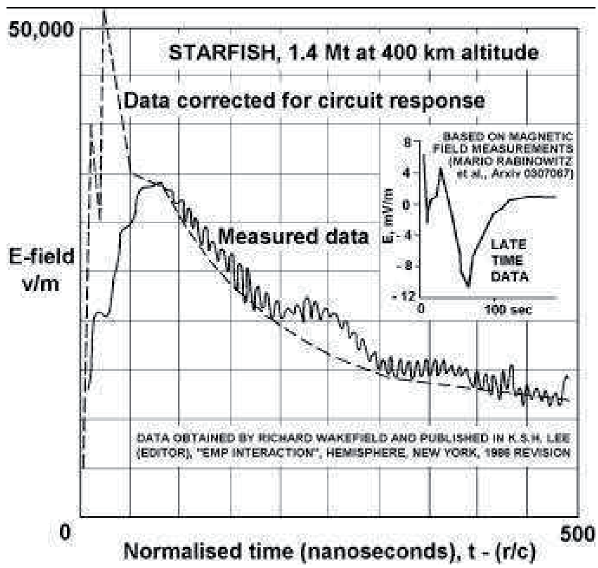

Fig. 3. Experimental dependence of amplitude EMP on the time, obtained with the tests according to the program “*Starfish”*.

Since doctor Bethe's forecast did not justify, it was subsequently advanced a number of the theories, intended to explain experimental data. The first of them was developed by doctor Conrad Longmire in 1963, which examined a question about the formation of the magnetic dipole, formed by the Compton electrons, which revolve around the lines of force of earth's magnetic field. However, this model cannot explain so short a pulse duration.

In 1975 a model was developed Louis W. Seiler, Jr, in which is assumed that the formation EMP is obliged to the relativistic Compton electrons, which the rigid X-radiation knocks out from the molecules of air and which cophasal with gamma-radiation move with the relativistic speeds in the direction of propagation of electromagnetic wave. Neither one nor the other model is reliably accepted or disproved be it cannot, since further nuclear tests in space were ended, and there is no additional experimental data, which could confirm or refute the models examined. It should be noted that neither one nor the other model up to now is published in the scientific journals. 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 field 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 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 Trlestar. 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. 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.

Consequently, the everything indicates that within the framework existing classical electrodynamics the results, obtained with the tests according to the program *"Starfish"* 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 field on pulse in space. It is known that during the tests according to the program "*Starfish"* three satellites, that are found at that time in space not far from the zone of explosion, malfunctioned. It is unknown, there are whether at present precise data apropos of the reasons for these failures. Let us assume that model advanced Louis W. Seiler, *Jr.* is incorrect, and, relying on it as in the past for the predictions Hans Albrecht Bethe, will be produced the sequential explosion of nuclear charge 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.

With the explosions of the nuclear charges, established on the metallic towers, is observed still one phenomenon, which does not find its explanation of the within the framework existing theories. It bears name rope tricks, which investigated John Malik.

In Fig. 4 and Fig. 5 are represented the photographs of rope tricks. These photographs removed American photographer Harold Edgerton by automatic camera, which is been located at a distance 11.2 km from the epicentre of explosion with the periodicity of survey 100 ms. The focal distance of camera was 3 meters, and the periodicity of survey was equal to 100 ms.

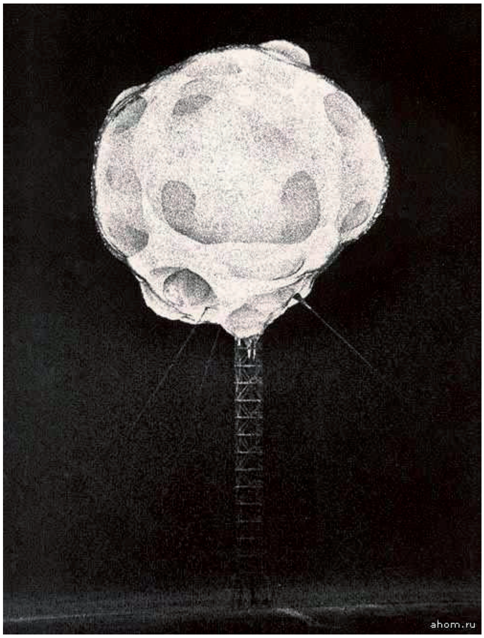

Fig. 4. Initial phase of the development of the cloud of explosion.

In Fig. 4 is presented the initial phase of the development of the cloud of the explosion, located on the metallic tower with the stretchings from the wire rope. 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. 5. 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. 5, 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.

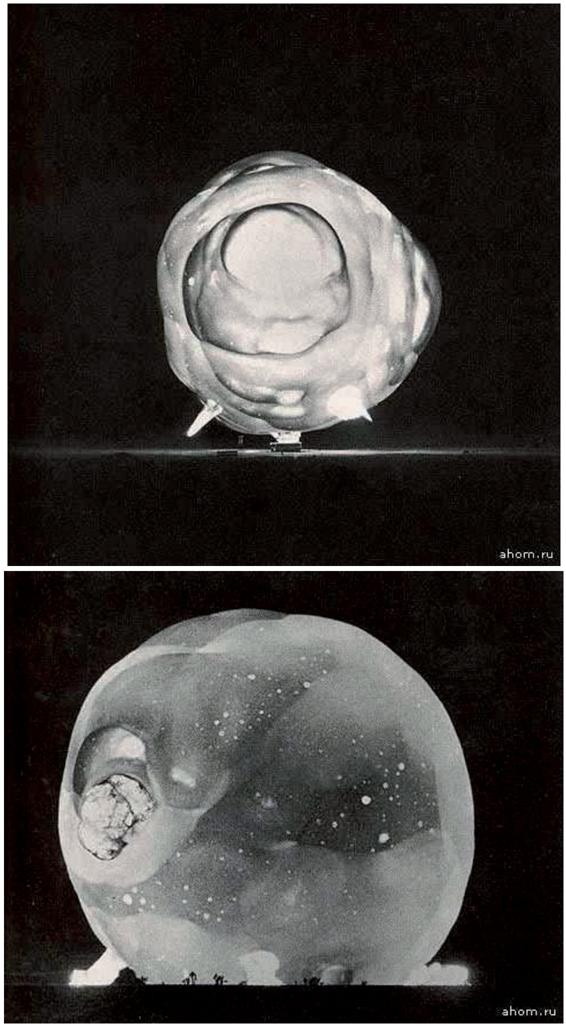

Fig. 5. Subsequent phases of the development of the cloud of explosion.

This phenomenon attempt to explain by the fact that powerful gamma-radiation of the cloud of explosion melts ropes, converting them into the plasma. There were the attempts to bring the reflecting coatings to the ropes, which decreased the phenomenon indicated. 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 that the ropes and tower are guiding elements for the appearance of shafts, it is clearly evident in upper figure 5. Moreover, this photograph finally removes version about the fact that the ropes warm up 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 warm up 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. 6 .

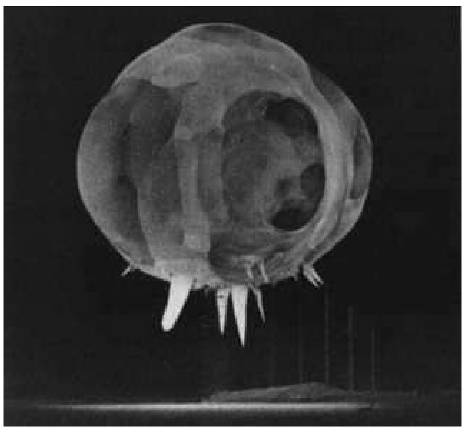

Fig. 6 . Cloud species of explosion after 1 ms after the detonation of nuclear charge, time of exposure 1 s.

Therefore possible to assume that the warming-up of ropes is connected with the advent of the additional currents of the large force, which as along the lightning conductor depart through the ropes to the earth, warm up them. Since the part of the rope closest to the plasmoid is hottest, specific resistance in its this part is more than in the remaining parts of the rope. Therefore a basic voltage drop will precisely fall in this section of rope, therefore maximally be heated it will be, beginning from this place.

With the explosions of thermonuclear charges near the earth's surface from the formed cloud of explosion to the side of the earth they beat lightning. The lightning they were photographed with the explosion of H-bomb by power into 10 Mt, which was produced in 1952 in the atoll Eniwetok. The discharges of lightning branched out upward from the surface of sea. When the expanding fireball reached that place, where before this the discharges (visible flashes by this time they disappeared), were visible, twisting channels again seemed against its background. The charge, which gave birth to lightning, judging by everything, was formed very rapidly, but the reasons for its formation remain obscure to the these rapids.

There is still one phenomenon, which associates nuclear explosions, which did not up to now also find its explanation. Nuclear explosions accompanies the emission of electromagnetic waves over a wide range up to the long-wave radiofrequency band. But the being varied electric dipole is necessary for the appearance of this emission. But very cloud of explosion, presents hot plasma, and if this cloud emits radio waves, then is necessary the mechanism, which ensures the dipole fluctuations of charges in this plasma. The existing electrodynamics and to this question answer does not give. The phenomenon, which was called name rope tricks remains also riddle.

From the times of the invention of powder and trotyl explosive technologies received wide acceptance. Were investigated the most varied forms of explosive, their explosive and thermodynamic characteristics; however, in the existing literature there are no results of investigating of electrodynamics and such explosions.

In order to understand, why up to now in the scientific journals there are no publications on the matter under discussion, and why, until now is absent the universally recognized scientifically substantiated theory of the phenomena indicated, let us examine the state of contemporary classical electrodynamics, and also those prerequisites, which can help the solution of the problems indicated.

PART I

CONTEMPORARY ELECTRODYNAMICS AND ITS MODERNIZATION

CHAPTER 1

THE BASIC CONCEPTS OF CLASSICAL ELECTRODYNAMICS AND THEIR MODERNIZATION

§ 1. Maxwell equations and Lorentz force

The laws 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 Maksvell equation. 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 $\vec{H}$ - electrical and magnetic field, $\vec{D} = \varepsilon_0 \vec{E}$ 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 on

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

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

These equations indicate that the vacuum can 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 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 $\tilde{\varepsilon}$ - relative magnetic and dielectric constants of the medium and n, e and $\vec{v}$ - density, value and charge rate.

The equation (1.1 - 1.11) are written in the assigned inertial reference frame (IRF), and in them there are no rules of passage of one IRF to another. The given equations also assume that the properties of charge do not depend on their speed, since in first term of the right side of equation (1.9) as the charge its static value is taken. The given equations also assume that the current can flow as in the electrically neutral medium, where there is an equal quantity of charges of both signs, so also to represent the self-contained flow of the charged particles, moreover both situations are considered equivalent.

In 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. This the so-called magnetic part of the Lorentz force

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

However in this axiomatics is an essential deficiency. If force acts on the moving charge, then in accordance with third Newton law the reacting force, which balances the force, which acts on the charge, must occur and to us must be known the place of the application of this force. In this case the magnetic field comes out as a certain independent substance and comes out in the role of the mediator between the moving charges, and if we want to find the force of their interaction, then we must come running to the services of this mediator. In other words, 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.

The 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.

Is certain, 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 (Ampere 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, Maxwell for the first time introduced bias current.

It should be noted 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, which with the aid of the specific mathematical procedures in large quantities of the cases give the possibility 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. This attraction is caused by the fact that the moving flow of charges creates magnetic field, and in parallel moving flow interacts with this field. Lorentz force with such an interaction is directed to the side of the flow, which creates magnetic field. 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 in the electrodynamics does not have an explanation.

The 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, with the flow of the current through the plasma its compression (the so-called pinch effect), occurs, 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.

The fundamental law of induction in the electrodynamics is considered Farrday law, consequence of whom is the first Maksvell equation. However, here are problems. It is considered until now that the unipolar generator is an exception to the rule of flow. The existing state of affairs and those contradictions, which with this are connected, perhaps, are most are clearly formulated in the sixth volume of work [1]. We read on page 52 " flow rule, according to which EMF (electromotive force) 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). Two of the possibility - "the outline of moves" or "the field of changes" - are not distinguished of 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 $\nabla\times\vec{E}=-\dfrac{\partial\vec{B}}{\partial t}$ for "changing field". "We know in physics not of one such example, if simple and precise general law required for its present understanding of analysis in the terms of two different phenomena. Usually so beautiful the generalization proves to be of outgoing from the united the deep that being basic the principle. But in this case of any separately deep principle it is not evident" (end of the quotation).

Let us give the still one exception, to which thus far no one turned attention. Farrday law indicates that the magnetic flux when through some section changes, then in the outline, which surrounds this section, vortex electric field appears. And if conductor is this outline, then in it currents are induced. Thus, in accordance with the law of the induction of Faraday the necessary condition of the appearance of currents in this outline is a change in the magnetic flux through the area, included by outline. If we insert the conducting outline into the magnetic field, then for the appearance of current in accordance with Farrday law, the lines of force of magnetic field must intersect outline itself. But it is known that the magnetic lines of force do not penetrate the superconductor and therefore they cannot intersect it. Therefore, if we take the superconductive ring, then magnetic flux through its section will be always equal to zero and as long as superconductor is superconductor, it cannot under no circumstances change.

Let us introduce the superconductive ring into the magnetic field. Naturally so that the magnetic flux through the section of ring would remain zero, it is necessary to compensate for external magnetic field in such a way that the magnetic flux through the section of ring would not change. This can be made an only method, after exciting in the ring the persistent currents, whose magnetic fields compensate for external magnetic field. But in order to excite such currents, it is necessary to the wire of the superconductive ring to apply electric field. But arises question, as these fields can arise, if summary magnetic flux through the section of ring did not change.

All these examples be evidence the fact that the law of the induction of Faraday is inaccurate or not complete and does not reflect all possible versions of the appearance of electrical field on with a change of the magnetic field or moving it.

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 field 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 field on out of the solenoid. In the work [1] even it is indicated that into 1956. 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, when with the observation of stars from moving IRF, telescope must be inclined to a certain angle in the direction of motion.

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 important task of classical electrodynamics concerns laws governing the appearance of electrical field on, and, therefore, also the forces of those acting on the charge, at the particular point spaces. This is the primary task of the laws of induction, since. only electric fields, generated other one or method or another, 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. But, making this, it is necessary to move charges in the space, and this displacement in the required order is combined with their acceleration and subsequent retarding. Acceleration or retarding of charges also can lead to the appearance in the surrounding space of induction electrical field on.

In the electrodynamics the fundamental law of induction is Farrday law. It is written as follows

$$\text{of } \oint \vec{E}\, d\vec{l} = -\frac{\partial \Phi_B}{\partial t} = -\mu \int \frac{\partial \vec{H}}{\partial t}\, d\vec{s} = -\int \frac{\partial \vec{B}}{\partial t}\, d\vec{s}\,, \tag{2.1}$$

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. It is immediately necessary to emphasize the circumstance that the law in question presents the processes of mutual induction, since for obtaining the circulation integral of the vector $\vec{E}$ we take the strange magnetic field, formed by strange source. From relationship (2.1) obtain the first Maxwell equation

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

Let us immediately point out to the terminological error. 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 field on it leads to the appearance of electrical field on, but not vice versa.

In connection with the data by examination let us give one additional exception to the rule of flow. Occurs possible such case, when the flow through the cross section of outline not at all changes, and current in the outline, and, therefore, also EMF, its exciting, it occurs. Let us place in the long solenoid the superconducting cylinder somewhat smaller diameter. If we now begin to introduce current into the solenoid, then persistent current will begin to be directed on the external surface of the superconductive cylinder, in this case, however, magnetic flux inside the superconductive cylinder will be always equal to zero.

In order to leave the difficulties examined, let us make the attempt to approach the law of magnetoelectric induction from several other side. Let us assume that in the region of the arrangement of the outline of integration there is a certain local vector $\vec{A}_H$, 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 $\vec{A}_H$ is determined in all sections of this outline, then

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

Introduced thus vector $\vec{A}_H$ assumes the local connection between the vector $\vec{A}_H$ and the electric field. It is not difficult to show that introduced thus vector $\vec{A}_H$, is connected with the magnetic field with the following relationship

$$rot \ \vec{A}_H = \vec{H} . \qquad (2.4)$$

Thus, we will consider that the vector $\vec{H}$ exists by a consequence of the presence of the vector $\vec{A}_H$, but not vice versa.

If there is a straight conductor with the current, then around it also there is a field of vector potential, the truth in this case $rot \ \vec{A}_H \neq 0$ in the environments of this conductor is, therefore, located also the magnetic field, which changes with a change of the current in the conductor. The section of wire by the length dl, over which flows the current I, generates in the distant zone (it is thought that the distance r considerably more than the length of section) the vector potential

$$d\vec{A}_H(r) = \frac{I d\vec{l}}{4\pi r} .$$

Let us note the circumstance that the vector potential in this case diminishes as $\frac{1}{r}$, and according to the same law, in accordance with relationship (2.3), diminish the induced electric fields. It is very important that the electric fields diminish no longer as $\frac{1}{r^2}$, as in the case of scalar potential, but as $\frac{1}{r}$, which is characteristic for the radiating systems.

It would seem, everything very well is obtained, but here we again encounter, first by the incorrect treatment of the concept of vector potential, then by the incorrect treatment of its appearance. Energy of electrical field on it is found from the relationship

$$W_E = \frac{1}{2}\varepsilon E^2,$$

where $\varepsilon = \tilde{\varepsilon}\varepsilon_0$ - dielectric constant of medium.

If we to the long solenoid connect the voltage source, then current, and, therefore, also flow in it will begin grow according to the linear law. Relationship (2.1) indicates that until the power source is connected to the solenoid, around the solenoid of electrical field on no. But at the moment of the connection to it of dc power supply current in its winding begins to grow according to the linear law, and around the solenoid in accordance with the concept of vector potential accepted instantly appears the circulation of electric field. Moreover, since the current in the solenoid grows according to the linear law, these electric fields are time-constant. Electric fields also instantly disappear, when a change in the current ceases. That that the electric fields, which carry on themselves energy, can instantly appear and disappear already it directs at the reflection. Appears the absurd situation, when electric fields exist, but energy in them is not stocked, since. as with the calculation of the energy, stored up in the solenoid, these fields are not considered. But once of field appear instantly and do not contain energy, then they possible to assume that and are extended with the infinite velocity. Furthermore, if solenoid is very long (in the literature sometimes even it is used expression infinitely long solenoid), then, as to explain and the fact that at all points of space inside this solenoid magnetic field grows according to the identical law. This also means that the magnetic field inside the solenoid has lengthwise infinite phase speed, and thus we can transfer information with the infinite velocity. The facts examined, to which thus far attention did not turn, are, perhaps, the most important obstacle on the way of this interpretation of the appearance of vector potential around the long solenoid, although precisely this concept of its appearance is examined in all works on electrodynamics. Below this question will be in detail examined, and will be they are given the corresponding explanations.

Until now, resolution of a question about the appearance of electrical field on in different IRF it was possible to achieve in two ways. The first consists in the calculation of the Lorentz force, which acts on the charges, which move in the magnetic field. The alternate path consisted in the measurement of a change in the magnetic flux through the outline being investigated. Both methods gave identical result. This was incomprehensible, and it was already brought in regard to this the statement of the authors of work [1]. In connection with the incomprehension of physical nature of this state of affairs they began to consider that the unipolar generator is an exception to the rule of flow [1]. Let us examine this question in more detail.

In order to answer the presented question, should be somewhat changed relationship (2.3), after replacing in it partial derivative by the complete:

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

The prime near the vector $\vec{E}$ means that this field is determined in the moving coordinate system, while the vector $\vec{A}_H$ it is determined in the fixed system. This means that the vector potential can have not only local, but also convection derivative, i.e., it can change both due to the change in the time and due to the motion in the three-dimensional changing field of this potential. 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 the marked system. Consequently, the force, which acts on the charge in the moving system, in the absence the dependence of vector potential on the time, will be written down

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

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

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

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

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

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

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

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

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 Maxwell equation, 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

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

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 the field $\vec{E}$, and the field $\vec{E}'_v$ are induction, the first is connected with a change of the vector potential with time, the second is obliged to the motion of charge in the three-dimensional changing field of this potential. In order to obtain the total force, which acts on the charge, 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 (2.7) can be rewritten as follows

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

or, after writing down the first two members of the right side of relationship (2.12) as the derivative of vector potential on the time, and also, after introducing under the sign of gradient two last terms, we will obtain

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

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 $-e\mu \frac{\partial \vec{A}_H}{\partial t}$. 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, i.e., to consider that the fields are determined only in the assigned inertial system, then we will obtain the first Maxwell equation.

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 [1].

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 of 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 IRF, 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. 7). Let us select for the coordinate axis in such a way that the axis z would be directed normal to planes, and the axis y was parallel to them. For the case, when the distance between the plates considerably less than their sizes (in this case on the picture this relationship not observed), the magnetic field H_x between them will be equal to the specific current I_y, which flows along the plates.

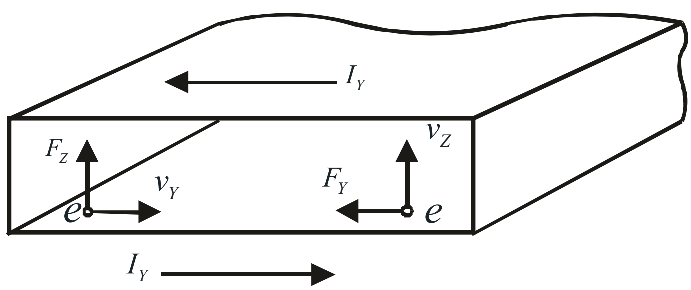

Fig. 7. Forces, which act on the charge, which moves in the field of vector potential.

If surmise 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 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 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 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 are connected first with of the local derivative of vector potential, then 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 the examination of the action of magnetic field to the moving charge has already been noted its intermediary role and absence of the law of the direct action between the moving charges. Introductions of vector potential also does not give answer to this question, this potential as before plays intermediary role and does not answer a question about the concrete place of application of force.

Now let us show that the relationships, obtained by the phenomenological introduction of magnetic vector potential, can be obtained and directly from Farrday law. With conducting of experiments Farrady 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 Farrday 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 marked 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 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 $\vec{B}$. The value of magnetic flux in relationship (2.15) is given by the expression

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

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 (2.15), we obtain from (2.16)

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

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

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

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 Galileo conversions, i.e. $d\vec{l}' = dl$ and $d\vec{s}' = d\vec{s}$. From (2.17) follows the well known result

$$\text{of } \vec{E}' = \vec{E} + \left[\vec{v} \times \vec{B}\right], \tag{2.18}$$

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 Farrday law, moreover within the framework the Galileo conversions. 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 field on relationship (2.17) for those induced it is possible to rewrite

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

and further

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

Again came out relationship (2.7), but it is obtained directly from the Farrday 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 Maxwell equation in the terms of vector potential can be written down as follows

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

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

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

For the free space relationship takes the form

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

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 $L_k = \frac{m}{ne^2}$ - kinetic inductance of charges [2]. In this relationship m , e and n - mass of charge, its value and density respectively.

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. Permittance current, either bias current, can pass through themselves free space, or dielectrics. For the free space relationship (2.20) takes the form

$$rot\ rot\vec{A}_H = -\mu\varepsilon\frac{\partial^2\vec{A}_H}{\partial t^2}. \tag{2.24}$$

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.

The use of relationships (2.21-2.24) excludes the need of using Maxwell equations, since all questions of propagation field on they can be solved by the way of using the equations indicated.

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, will be solved the very important problem both of theoretical and applied nature.

§ 3. Laws of the electromagnetic induction

Farrday law shows, how a change in the magnetic field on it leads to the appearance of electrical field on. However, does arise the question about that, it does bring a change in the electrical field on to the appearance of any others field on and, in particular, magnetic? 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 Maxwell equation 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.

From this relationship it is not difficult to switch over to the expression

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

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 Farrday 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 Farrday law, should be replaced the partial derivative by the complete. Designating by the primes of field and circuit elements in moving IRF, 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

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

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

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

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 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.

Field on from (3.4) we obtain for the case of constant electrical:

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

For the vortex electrical field on it is possible to express the electric field through the rotor of electrical vector potential, after assuming

$$\vec{E} = rot \; \vec{A}_E. \tag{3.6}$$

But the introduction of this relationship is, in fact, the acknowledgement of existence of magnetic currents. Controversy about the presence of such currents in the scientific literature has long ago been conducted. But the presence of magnetic currents is very easy to understand based on this example. Let us assume that at our disposal there is a long rod, made from magnetic material. If we to one end of the rod place solenoid and to introduce into it current, then the end of the rod will be magnetized. But the magnetization, which arose at the end of the rod, immediately not to appear at its other end. The wave of magnetization will be extended along the rod some by the speed, which depends on the kinetic properties of the very process of magnetization. Thus, magnetic bar itself, in this case, similar to the conductor of electric current, it is the conductor of the magnetic flux, which, as conduction current, can be extended with the final speed.

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 $\vec{A}_E$, but this way is specially passed traditionally, beginning from the integral law in order to show the identity of processes for two different laws, and the logical sequence of the introduction of the electrical vector of potentials.

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 field on upon transfer of one IRF to another. Of this consists the modernization of old electrodynamics.

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

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

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

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

$$rot\ rot\ \vec{A}_E = -\varepsilon\mu \frac{\partial^2 \vec{A}_E}{\partial t^2} \tag{4.5}$$

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

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

The space derivative $rot\ \vec{A}_E$ 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 field 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 space derivative of one and the same potential.

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

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

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

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

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

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

The space derivative $rot\ \vec{A}_H$ and local time derivative $\frac{\partial \vec{A}_H}{\partial t}$ are connected with wave equation (4.7).

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 field on it is possible to extend into both sides ad infinitum, introducing all new vectorial fields. Naturally in this case one should introduce and additional calibration, thus, there is an infinite set of possible writings of 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 [2].

PART II.

NEW ELECTRODYNAMICS

CHAPTER 2.

NEW IDEAS AND THE DETERMINATIONS

New ideas do not appear at the empty place, accumulation precedes their appearance and comprehension is previously the obtained results. The fact that classical electrodynamics consists in fact of several, the not connected together parts, it cannot but cause uneasiness. The fact that some electrodynamics effects cannot be explained within the framework to unified theory, also speaks, that classical electrodynamics as yet it is not possible to consider as the final physical theory. In the previous divisions it was shown, to what extent the role of magnetic vector potential in the electrodynamics was great, were examined the contradictions, which appear with the explanation of the appearance of electrical field on around the long solenoid with an attempt at the use of this parameter. But this state of affairs is brought into question and very law of the induction of Faraday, since and vector potential and magnetic field and magnetic flux in the solenoid the closely related values. In Faraday's times were still known neither Maxwell equations nor that that the electromagnetic fields are extended with the final speed, and consequently these effects, which are also tightly connected with the processes of induction also they could not be taken into account. Even Maxwell, after writing down its famous equations it could not experimentally prove existence of electromagnetic waves. Hertz made this for the first time, after creating by very simple method the first in the world high-frequency oscillator, and with the aid of this procedure were obtained the salient results, after showing that the electromagnetic waves can be extended not only in the free space, but also can with the final speed be extended along the metallic conductors. Furthermore, he the first understood that it follows to use total derivatives field on during the writing of the laws of induction. This approach showed that the Lorentz force can be introduced not as separate postulate, but it follows from the laws of induction. Hertz died very early, but there are no doubts about the fact that if this brilliant scientist lived longer, then electrodynamics, and can be and entire physics, it is banal along other entirely way. This way we will attempt to outline in this division, after building the bases of such noncontradictory electrodynamics, which will combine its odd parts and that united basis, which is its foundation, will be indicated. Development and introduction into the electrodynamics of new principles will allow us to explain the phenomena, which an explanation did not up to now have and, in particular those effects, which were connected with the explosions of nuclear charges.

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. The introduction of such concepts relates faster to metaphysics, than to physics.

§ 5. Is there a dispersion of the dielectric constant of material media.

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 J. Heaviside R. 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 [3-8].

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 [3]: “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 J. Heaviside R. 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 . During the report A. I. 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 l. D. Landau - one of the outstanding physicists of our time” (end of the quotation).

From the given quotation is incomprehensible, that precisely had in the form the author of these words. However, its subsequent publications speak, that it accepted this concept [4].

Immediately, running in forward, it must be noted, that rights there was Maxwell. However, in a number of fundamental works on electrodynamics [3-8] 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. The difficulty of understanding these questions, first of all by physicists, is connected with those errors, which are located in the works Landau. Landau's itself, as can be seen from his works, was, first of all, mathematician. Its transactions are built in such a way that their basis is not physics, for describing laws of which is used mathematics, but mathematics, on basis of which are derived physical laws. Specifically, with this method was created the metaphysical concept of the dielectric constant of plasma depending on the frequency and this concept, without understanding of physics of processes, was disseminated by also purely mathematical means to the dielectrics. There is the publications of such well-known scholars as the Drudes, Vull, Heaviside, Landau, Ginsburg, Akhiezer, Tamm [3-8], 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. Conducting 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 absence magnetic field in the media indicated equation of motion for the electrons takes the form:

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

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

In this equation is considered that the electron charge is negative. In the work [8] 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

$$\vec{j} = ne\vec{v}, \tag{6.2}$$

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 n represents electron density. After introducing the designation

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

we 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. Field on $\vec{E} = \vec{E}_0 \sin \omega t$ relationship (6.5) it will be written down for the case of harmonics:

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

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 compose [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, with the examination of the properties of such media in the rapidly changing fields, in connection with the fact that the mass of ions is considerably more than the mass of electrons, their presence usually is not considered.

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 the conductivity

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

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.

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 field 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 there will be cophased to 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, 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 field 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 field on in the plasma there exist two different currents, one of which is bias current, and it is determined by the dielectric constant of vacuum and derivative of electric field. Another current is conduction current and is determined by integral of the electric field. these two currents are antiphased. But since both currents depend on frequency, moreover one of them depends on frequency linearly, and another it is inversely proportional to frequency, between them competition occurs. 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.

Let us emphasize that from a mathematical point of view to reach in the manner that it entered to Landau, it is possible, but in this case is lost the integration constant, which is necessary to account for initial conditions during the solution of the equation, which determines current density in the material medium.

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.

Thus, 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 field on

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

and kinetic energy of charge carriers

$$W_j = \frac{1}{2} L_k j_0^2 \qquad (6.8)$$

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

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

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 field 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.

Maxwell equations for this case take the form

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

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

System of equations (6.10) completely describes all properties of nondissipative conductors. From it we obtain

$$rot\ rot\ \vec{H} + \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial\ t^2} + \frac{\mu_0}{L_k}\vec{H} = 0 . \qquad (6.11)$$

For the case field on, time-independent, equation (6.11) 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 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.

Field on wave equation in this case it appears as follows for the electrical field

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

For constant electrical field 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.

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 [4-6] 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 Maxwell equation 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. The connection between the voltage U, applied to the outline, and the summed current 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 $U = U_0 \sin \omega t$ we obtain

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

in relationship (6.12) 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 the conductivity

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

In this case relationship (6.12) 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.

Is accurate another point of view. The relationship (6.12) 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

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

But, just as $C^*(\omega)$, the value $L^*(\omega)$ cannot be called inductance, since this is the also composite parameter, which includes simultaneously capacity and inductance, which do not depend on frequency.

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

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

or

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

The 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

$$W_C = \frac{1}{2} C U_0^2, \tag{6.17}$$

$$W_L = \frac{1}{2} L I_0^2. \tag{6.18}$$

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) cannot for that reason, that these values can be both the positive and negative, and the energy, accumulated in the capacity and the inductance, is always positive. But if we for these purposes use ourselves the parameters indicated, then it is not difficult to show that the summary energy, accumulated in the outline, is determined by the expressions

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

or

$$W_{\Sigma} = \frac{1}{2}\ \frac{d\left[\omega C^{*}(\omega)\right]}{d\omega}\ U_{0}^{\ 2}, \tag{6.20}$$

or

$$W_{\Sigma} = \frac{1}{2}\ \frac{d\left(\dfrac{1}{\omega L^{*}(\omega)}\right)}{d\omega}\ U_{0}^{\ 2}. \tag{6.21}$$

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 field 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.

A now let us visualize this situation. In the audience, where are located specialists, who know radio engineering and of mathematics, comes instructor and he begins to prove, that there are in nature of no capacities and inductances, and there is only depending on the frequency capacity and that just she presents parallel resonant circuit. Or, on the contrary, that parallel resonant circuit this is the depending on the frequency inductance. View of mathematics will agree from this point. However, radio engineering they will calculate lecturer by man with the very limited knowledge. Specifically, in this position proved to be now those scientists and the specialists, who introduced into physics the frequency dispersion of dielectric constant.

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 [4-6] 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 [4] 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 OF 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

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

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 $\vec{r}$

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

where the vector $\vec{r}$ is directed from the negative charge toward the positive charge. 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 $\vec{r}$. 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

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

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 [4-8].

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, although formally this approach is permitted from a mathematical point of view, however with this approach to consider initial conditions with the calculation of integral in the relationships, which determine conduction current.

Further into §61 of work [4] 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 field on

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

of 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 field with the dispersion insufficiently for determining the difference in the internal energy per unit of volume of substance in the presence field on in their absence. After such statements is given the formula, which gives correct result for enumerating the specific energy of electrical and magnetic field on when the dispersion of is present,

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

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 field 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 field 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 specific energy as the thermodynamic parameter in this case is necessary to correctly calculate this energy, taking into account not only electric field, which accumulates potential energy, but also current of the conduction electrons, which accumulate the kinetic kinetic energy of charges (6.8). 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 [4].

Let us focus attention on the fact that with the examination of this question, which gives complete information about the electrodynamic processes, proceeding in the conductors, we used only equations of motion and did not adapt the concept of polarization vector.

One cannot fail to note and the important circumstance that with the examination of the physical properties of conductors, very important role plays the kinetic inductance of charges. It will be shown below that also the properties of dielectrics to a considerable degree depend on this parameter. 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. And, all the more it is strange since before the appearance of work [2], this parameter in the electrodynamics in practice was not used.

§ 7. 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 [11]

$$\left(\frac{\beta}{m} - \omega^2\right)\vec{r}_m = \frac{e}{m}\vec{E}, \tag{7.1}$$

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

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

we will obtain from (7.1)

$$r_m = -\frac{e\ E}{m(\omega^2 - \omega_o^2)}. \tag{7.2}$$

Is evident that in relationship (7.2) 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 relationship (7.2) we find

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{1}{L_{kd}(\omega^2 - \omega_0^{\ 2})} \frac{\partial \vec{E}}{\partial t}. \tag{7.3}$$

But 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 (7.3) it is possible to rewrite

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{1}{\varepsilon_0 L_{kd}(\omega^2 - \omega_0^{\ 2})} \right) \frac{\partial \vec{E}}{\partial t}. \tag{7.4}$$

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 (7.4) takes the form

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0^{\ 2})} \right) \frac{\partial \vec{E}}{\partial t}. \tag{7.5}$$

To appears temptation to name the value

$$\varepsilon^*(\omega)=\varepsilon_0\left(1-\frac{\omega^2{}_{pd}}{(\omega^2-\omega_0{}^2)}\right) \tag{7.6}$$

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 $\omega << \omega_0$, then from (7.5) we obtain

$$rot\vec{H}=\vec{j}_\Sigma=\varepsilon_0\left(1+\frac{\omega_{pd}{}^2}{\omega_0{}^2}\right)\frac{\partial\vec{E}}{\partial t}. \tag{7.7}$$

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 (7.7) 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 $\omega >> \omega_0$ we obtain

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

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 (7.5) 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 (7.5) 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. 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

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P}\vec{E} = \varepsilon_0 \vec{E} - \frac{ne^2}{m} \cdot \frac{1}{(\omega^2 - \omega_0^2)} \vec{E} \qquad (7.8)$$

that introduced thus electrical induction depends on frequency.

If this induction was introduced into the second equation of Maxwell, then it signs the form

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

or

$$rot\vec{H} = j_{\Sigma} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{ne^2}{m} \frac{1}{(\omega^2 - \omega_0^2)} \frac{\partial \vec{E}}{\partial t} \tag{7.9}$$

where j_{Σ} - the summed current, which flows through the model. In expression (7.9) 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 (7.9) 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 (7.3). 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, and especially in the part of the awarding to the parameter, introduced in accordance with relationship (7.8) of the designation of electrical induction, are large claims, which we 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 of 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

$$I_C = C \frac{dU_C}{dt}. \tag{7.10}$$

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

$$I = -\frac{1}{\omega \left(\omega L - \frac{1}{\omega C} \right)} \frac{\partial U_{\Sigma}}{\partial t} . \tag{7.11}$$

Taking into account that the resonance frequency of the outline

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

write down

$$I = \frac{C}{\left(1 - \frac{\omega^2}{\omega_0{}^2} \right)} \frac{\partial U_{\Sigma}}{\partial t} . \tag{7.12}$$

Comparing this expression with relationship (7.10) 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

$$C(\omega)=\frac{C}{\left(1-\frac{\omega^2}{\omega_0{}^2}\right)}. \tag{7.13}$$

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 (7.12) this altogether only the mathematical form of the record of relationship (7.11). Consequently, this is $C(\omega)$ the certain composite mathematical parameter, which is not the capacity of outline.

Relationship (7.11) 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

$$C(\omega)=-\frac{1}{L\left(\omega^2-\omega_0{}^2\right)}. \tag{7.14}$$

Is certain, the parameter $C(\omega)$, introduced in accordance with relationships (7.13) and (7.14) no to capacity refers.

Let us examine relationship (7.12) for two limiting cases:

1. When $\omega<<\omega_0$ 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.

2. For the case when $\omega >> \omega_0$ we have

$$I = -\frac{1}{\omega^2 L}\frac{\partial U_\Sigma}{\partial t}. \tag{7.15}$$

Taking into account that for the harmonic signal

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

we will obtain from (7,15)

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

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

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.

The equivalent the schematic of the dielectric, located between the planes of long line is shown in Fig. 8.

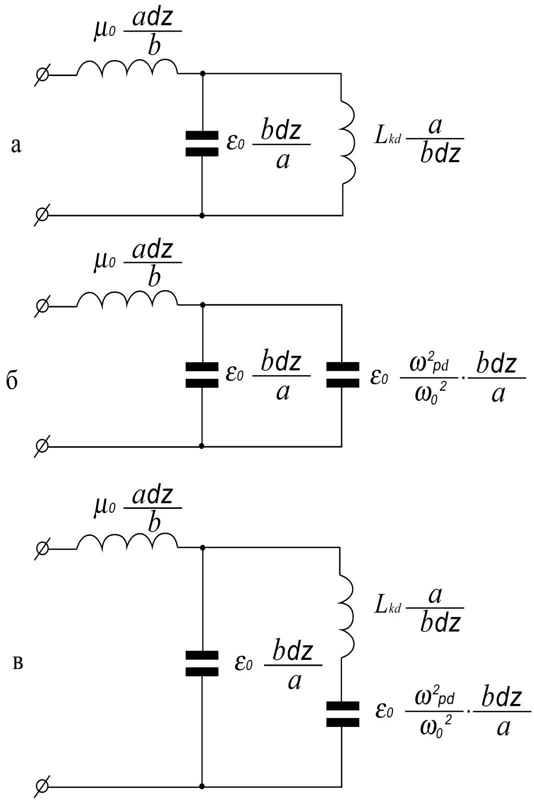

Fig. 8. a - the equivalent the schematic of the section of the line filled with dielectric for the case $\omega >> \omega_0$; б - the equivalent the schematic of the section of line for the case $\omega << \omega_0$; в - the equivalent the schematic of the section of line for entire frequency band.

In Fig. 8 (a) and 8 (б) are shown two limiting cases. In the first case, when $\omega >> \omega_0$, dielectric according to its properties corresponds to conductor, in the second case when $\omega << \omega_0$ 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. Certainly, in the dielectrics not all dipoles have different characteristics, but there are different groups with similar characteristics, and each group of bound charges with the identical characteristics will resound at its frequency. Moreover the intensity of absorption, and in the excited state and emission, at this frequency will depend on a relative quantity of pairs of this type. Therefore the partial coefficients, which consider their statistical weight in this process, can be introduced. Furthermore, these processes will influence the anisotropy of the dielectric properties of molecules themselves, which have the specific electrical orientation in crystal lattice. By these circumstances is determined the variety of resonances and their intensities, which is observed in the dielectric media. The lines of absorption or emission, when there is a electric coupling between the separate groups of emitters, acquire even more complex structure. In this case the lines can be converted into the strips. Such individual approach to each separate type of the connected pairs of charges could not be realized within the framework earlier than the existing approaches.

§ 8. Transverse plasma resonance

The poor understanding of physics of processes and role of the kinetic inductance of charges in the formation of the electrodynamic processes, which occur in the material media, led to the fact that the interesting physical phenomenon proved to be unnoticed. This phenomenon can be named transverse plasma resonance in nonmagnetized plasma [14].

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 the transverse resonance can exist, and the frequency of this resonance coincides with the frequency of plasma resonance, i.e., these resonance frequency are degenerate. Specifically, this resonance can be the reason for the emission of electromagnetic waves with the explosions of nuclear charges.

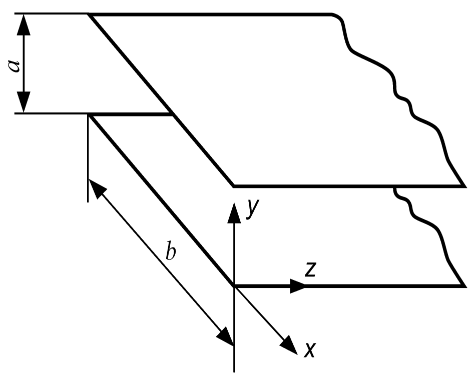

Fig. 9 The two-wire circuit, which consists of two ideally conducting planes.

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. 9.

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]

$$C_0 = \varepsilon_0 \frac{b}{a} \quad \text{и} \quad L_0 = \mu_0 \frac{a}{b}.$$

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.

Let us place into the extended line the plasma, the charge carriers of which can move without the friction, and in the transverse direction let us pass through the plasma the current I. In this case charges, in connection with the presence they have of mass, moving with the definite speed, they 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

$$W_{k\Sigma} = \frac{1}{2} \frac{m}{ne^2} abzj^2 = \frac{1}{2} \frac{m}{ne^2} \frac{a}{bz} I^2. \qquad (8.1)$$

Relationship (8.1) 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

$$L_{k\Sigma} = \frac{m}{ne^2} \cdot \frac{a}{bz}. \qquad (8.2)$$

Thus, the value

$$L_k = \frac{m}{ne^2} \qquad (8.3)$$

presents the specific kinetic inductance of charges. This value was already previously introduced by another method (see relationship (6.4)). Relationship (8.3) 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 dz can be represented in the form the equivalent diagram, shown in Fig. 10 (a).

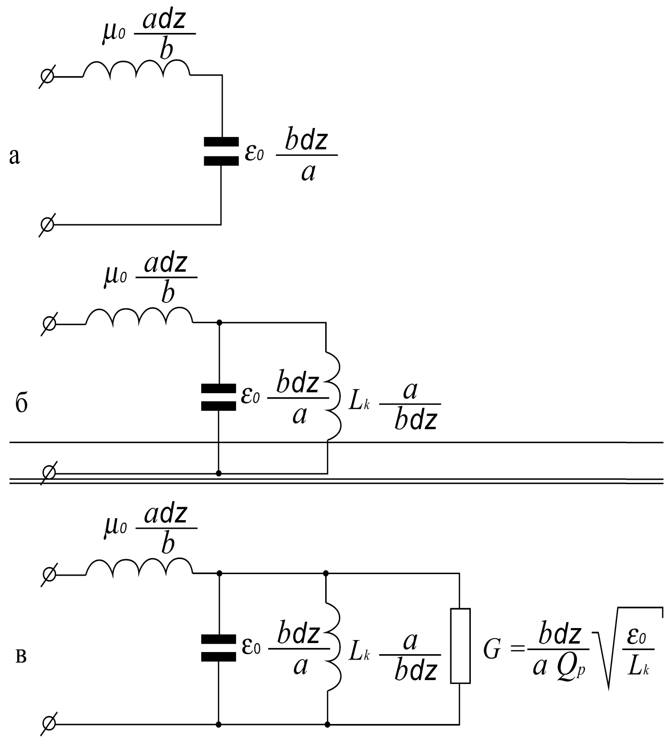

Fig. 10. a - the equivalent the schematic of the section of the two-wire circuit:
б - the equivalent the schematic of the section of the two-wire circuit, filled with nondissipative plasma;
в - the equivalent the schematic of the section of the two-wire circuit, filled with dissipative plasma.

From relationship (8.2) is evident that in contrast to C_{Σ} and L_{Σ} the value $L_{k\Sigma}$ 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. 10 (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 of 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

$$k_z^2 = \frac{\omega^2}{c^2}\left(1 - \frac{\omega_\rho^2}{\omega^2}\right), \tag{8.4}$$

and the group and phase speeds

$$v_g^2 = c^2\left(1 - \frac{\omega_\rho^2}{\omega^2}\right), \tag{8.5}$$

$$v_F^2 = \frac{c^2}{\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)}, \tag{8.6}$$

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 field on distribution and currents in this line uniform and it does not depend on the coordinate z, but current in the planes of line in the direction z 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 (8.4), (8.5) and (8.6) 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 is not described by other authors.

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.

Field 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 $Z_0 = \sqrt{\dfrac{\mu_0}{\varepsilon_0}}$ - characteristic resistance of vacuum.

The obtained value 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 field 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 $\left(1 - \dfrac{\omega_\rho^2}{\omega^2}\right)$ of 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 field 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 written

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

Thus, total specific energy 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 fields 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 elektromagnitokinetich 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 of Maxwell equation they will take the form

$$rot\ \vec{E} = -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t},$$
$$rot\ \vec{H} = \sigma_{p.ef}\ \vec{E} + \varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\, dt. \tag{8.7}$$

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

$$C = \varepsilon_0 \frac{bz_0}{a}, \tag{8.8}$$

$$L = L_k \frac{a}{bz_0}, \tag{8.9}$$

$$G = \sigma_{\rho.ef} \frac{bz_0}{a}, \tag{8.10}$$

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

Conductivity and quality in this outline enter into the relationship

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

from where, taking into account (8.8 - 8.10), we obtain

$$\sigma_{\rho.ef} = \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}. \tag{8.11}$$

Thus measuring its own quality plasma of the resonator examined, it is possible to determine $\sigma_{p.ef}$. Using (8.2) and (8.11) we will obtain

$$\begin{aligned} rot\ \vec{E} &= -\mu_0 \frac{\partial \vec{H}}{\partial t}, \\ rot\ \vec{H} &= \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k}\int \vec{E}\, dt. \end{aligned} \tag{8.12}$$

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 (8.12) 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

$$rot\ \vec{E} \cong 0,$$
$$\frac{1}{Q_p}\sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k}\int \vec{E}\,dt = \vec{j}_{CT}, \tag{8.13}$$

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

After integrating (8.13) with respect to the time and after dividing both parts to ε_0, we will obtain

$$\omega_p^2\,\vec{E} + \frac{\omega_p}{Q_p}\cdot\frac{\partial \vec{E}}{\partial t} + \frac{\partial^2 \vec{E}}{\partial t^2} = \frac{1}{\varepsilon_0}\cdot\frac{\partial \vec{j}_{CT}}{\partial t}. \tag{8.14}$$

If we relationship (8.14) integrate over the surface of normal to the vector of $\vec{E}$ and to introduce the electric flux $\Phi_E = \int \vec{E}d\vec{S}$ we will obtain

$$\omega_p^2\Phi_E + \frac{\omega_p}{Q_p}\cdot\frac{\partial \Phi_E}{\partial t} + \frac{\partial^2\Phi_E}{\partial t^2} = \frac{1}{\varepsilon_0}\cdot\frac{\partial I_{CT}}{\partial t}, \tag{8.15}$$

where I_{CT} - strange current.

Equation (8.15) 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 (8.14) 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.

The cloud of the explosion of nuclear charge presents confined plasma and in it transverse resonance oscillations are possible. The temperature of plasma in the process of the development of explosion always falls. This means that and the frequency of the plasma vibrations of the cloud of explosion varies from the highest values to the frequencies of the radio-frequency band. By this it is explained the presence of the long-wave electromagnetic radiation, which accompanies nuclear explosions.

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

The way, which is concerned introduction in the equations of the induction of total derivatives field on, it was initiated still by Hertz [16]. 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 field 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 IRF, 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 IRF 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 field on upon transfer of one inertial system to another. This deficiency removes STR, basis of which are the covariant conversions of Lorenz. With the entire mathematical validity of this approach the physical essence of such conversions up to now remains unexplained [17].

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions field on upon transfer of one IRF to another, and to also explain what dynamic potentials and fields can generate the moving charges. The first step, demonstrated in the works [11,12], was made in this direction a way of the introduction of the symmetrical laws of magnetoelectric and electromagnetic induction (2.17, 3.3). They are written as follows for the free space

$$\oint \vec{E}'dl' = -\int \frac{\partial \vec{B}}{\partial t}d\vec{s} + \oint \left[\vec{v} \times \vec{B}\right]dl'$$
$$\oint \vec{H}'dl' = \int \frac{\partial \vec{D}}{\partial t}d\vec{s} - \oint \left[\vec{v} \times \vec{D}\right]dl' \quad , \qquad (9.1)$$

or

$$rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B}\right]$$
$$rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D}\right] \quad . \qquad (9.2)$$

For the constants field on these relationships they take the form

$$\vec{E}' = \left[\vec{v} \times \vec{B}\right]$$
$$\vec{H}' = -\left[\vec{v} \times \vec{D}\right] \quad . \qquad (9.3)$$

In relationships (9.1-9.3), which assume the validity of the Galileo conversions, marked and not marked values present fields and elements in moving and fixed IRF respectively. It must be noted, that conversions (9.3) earlier could be obtained only from the Lorenz conversions.

The relationships (9.1-9.3), which present the laws of induction, do not give information about how arose fields in initial fixed [ISO]. They describe only laws governing the propagation and conversion field on in the case of motion with respect to the already existing fields.

The relationship (9.3) 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 field $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [2].

Electric field $E = \frac{g}{2\pi\varepsilon r}$, per unit length which accounts for the charge g decreases according to the law $\frac{1}{r}$, where r - the distance from the central axis of the rod to the observation point.

If we in parallel to the axis of charged rod in the field $E=\frac{g}{2\pi\varepsilon r}$ begin to move with the speed Δv another IRF, then in it will appear the additional magnetic field $\Delta H=\varepsilon E\Delta v$. If we now with respect to already moving IRF 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 $\Delta E=\mu\varepsilon E\left(\Delta v\right)^2$. 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 $E_v'\left(r\right)$ in moving IRF with reaching of the speed $v=n\Delta v$, when $\Delta v\to 0$, and $n\to\infty$. In the final analysis in moving IRF the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship

$$E'\left(r,v_\perp\right)=\frac{gch\frac{v_\perp}{c}}{2\pi\varepsilon r}=Ech\frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship

$$E'\left(r,v_\perp\right)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r^2}\quad,$$

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 [2,11,12]

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c}\qquad(9.4)$$

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 field on parallel speeds IRF as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then conversions field on they will be written down

$$\begin{aligned}
&\vec{E}'_\uparrow = \vec{E}_\uparrow, \\
&\vec{E}'_\perp = \vec{E}_\perp ch\frac{v}{c} + \frac{Z_0}{v}\left[\vec{v}\times\vec{H}_\perp\right]sh\frac{v}{c}, \\
&\vec{H}'_\uparrow = \vec{H}_\uparrow, \\
&\vec{H}'_\perp = \vec{H}_\perp ch\frac{v}{c} - \frac{1}{vZ_0}\left[\vec{v}\times\vec{E}_\perp\right]sh\frac{v}{c},
\end{aligned} \tag{9.5}$$

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 field on (9.5) they were for the first time obtained in the work [2].

§ 10. Phase aberration and the transverse Doppler effect

Using relationships (9.5) 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 field on in the marked coordinate system in accordance with relationships (16.5) they will be written down

$$E'_x = E_x,$$

$$E'_y = H_z sh\frac{v_x}{c},$$

$$H'_z = H_z ch\frac{v_x}{c}.$$

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 IRF

$$E' = \left[\left(E'_x\right)^2 + \left(E'_y\right)^2\right]^{\frac{1}{2}} = E_x ch\frac{v_x}{c}. \qquad (10.1)$$

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

$$\alpha \cong sh\frac{v}{c} \cong \frac{v}{c}. \qquad (10.2)$$

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 Pointing 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 (10.2). 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 very Pointing 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 (10.1).

Is not difficult to show that, if we the polarization of electromagnetic wave change ourselves, then result will remain before. Conversions with respect to the vectors $\vec{E}$ and $\vec{H}$ are completely symmetrical, only difference will be the fact that to now come out the wave, which has to appear addition in the direction of propagation in the component H'_v.

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 Pointing vector to the angle, determined by relationship (10.2). 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 IRF it is necessary to incline telescope on the motion of motion to the angle, determined by relationship (10.2). 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 (10.2). But this means that this star with respect to the observer has the radial speed , determined by the relationship

$$v_r = v\sin\alpha$$

Since for the low values of the angles $\sin\alpha \cong \alpha$, and $\alpha = \frac{v}{c}$, Doppler frequency shift will compose

$$\omega_{d\perp} = \omega_0 \frac{v^2}{c^2}. \qquad , (10.3)$$

This result numerically coincides with results STR, but it is principally characterized by of results fact that it is considered into STR that the transverse Doppler effect, determined by relationship (10.3), there is in actuality, while in this case this only apparent effect. If we compare the results of conversions field on (10.5) 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.

STR 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 (10.4) and (10.5) 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 (10.5) there are no limitations on the speed for the material particles, and also the fact that the charge is not the invariant of speed.

§ 11. Power interaction of the current carrying systems, homopolar induction and the ponderomotive forces

It was already said that Maxwell equations do not include 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 the current carrying systems, based on the concepts of magnetic field and Lorentz force the positively charged lattice, which is the frame of conductor and to which are applied the forces, it 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 [11-12]. We will consider that the scalar- vector potential of single charge is determined by relationship (9.4), 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. 11), over 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.

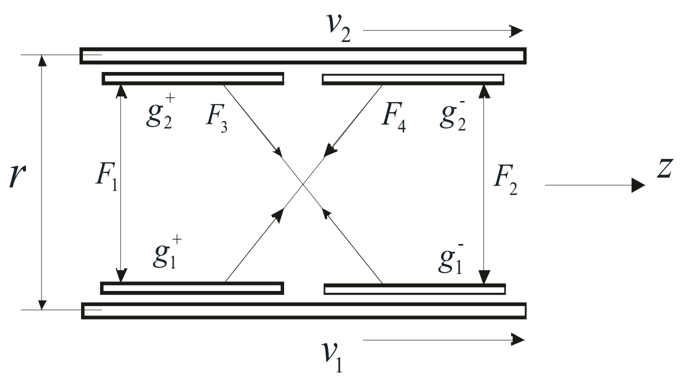

Fig. 11. Schematic of power interaction of the current carrying wires of two-wire circuit taking into account the positively charged lattice.

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, i.e. in the conductors there are two systems of the mutually inserted opposite charges with the specific density to g_1^+, g_1^- and g_2^+, g_2^-, which electrically neutralize each other. in Fig. 11 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

$$
\begin{aligned}
F_1 &= -\frac{g_1^{+} g_2^{+}}{2\pi\varepsilon r}, \\
F_2 &= -\frac{g_1^{-} g_2^{-}}{2\pi\varepsilon r} ch\frac{v_1 - v_2}{c}, \\
F_3 &= +\frac{g_1^{-} g_2^{+}}{2\pi\varepsilon r} ch\frac{v_1}{c}, \\
F_4 &= +\frac{g_1^{+} g_2^{-}}{2\pi\varepsilon r} ch\frac{v_2}{c}.
\end{aligned}
\tag{11.1}
$$

Adding all force components, we will obtain the amount of the composite force, which falls per unit of the length of conductor

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_1}{c} + ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} - 1 \right). \tag{11.2}$$

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. For the case $v << c$ 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 (11.2) we obtain

$$F_{\Sigma 1} = \frac{g_1 v_1 g_2 v_2}{2\pi\varepsilon c^2 r} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r} \tag{11.3}$$

where as 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 (17.2) 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 (11.3) represents the known rule of power interaction of the current carrying systems, but is obtained it not by the phenomenological way on the basis of the introduction of phenomenological magnetic field, but on the basis of completely intelligible physical procedures, under the assumption that that the scalar potential of charge depends on speed. 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. In terms of this the proposed method is differed from the method of calculation of power interactions by the basis of the concept of magnetic field. 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. 12), 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

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} \right). \qquad (11.4)$$

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 (11.4) of **of** 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 Kauffmann, 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 (11.3), with an accuracy to quadratic terms, the force of interaction of electronic flux with the rectilinear wire to determine according to the following dependence

$$F_{\Sigma} = \frac{g_1 g_2}{2\pi\varepsilon r}\left(\frac{v_1 v_2}{c^2} - \frac{1}{2}\frac{v_1^{\;2}}{c^2}\right). \qquad (11.5)$$

From expression (11.5) 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 (11.5) 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 the Lorentz force, which acts from the side of magnetic field to the flow of the moving electrons.

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. This force acts on the moving electron stream.

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. At the same time, if we examine two in parallel moving electron streams, then appears the extra force of interaction, which depends on the relative speed of these flows.

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 (11.3) 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 (11.3) 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 EMF.

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, with which only scalar product of the charge rate and vector potential gives the potential, whose gradient gives the force, which acts on the moving charge. This is 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.

The homopolar induction was discovered still by Farady almost 200 years ago, but in the classical electrodynamics of final answer to that as and why work some constructions of unipolar generators, there is no up to now [1]. Is separately incomprehensible the case, when there is a revolving magnetized conducting cylinder, during motion of which between the fixed contacts, connected to its axis and generatrix of cylinder, appears EMF. Is still more incomprehensible the case, when together with the cylindrical magnet revolves the conducting disk, which does not have galvanic contact with the magnet, but fixed contacts are connected to the axis of disk and its generatrix. In some sources it is indicated that the answer can be obtained within the framework STR, but there are no concrete references, as precisely STR explain the cases indicated. It will be further shown that the concrete answers to all these questions can be obtained within the framework the concept of the dependence of the scalar potential of charge on its relative speed.

Let us examine the case, when there is a single long conductor, along which flows the current. We will as before consider that in the conductor is a system of the mutually inserted charges of the positive lattice g^+ and free electrons g^-, which in the absence current neutralize each other (Fig. 12).

The electric field, created by rigid lattice depending on the distance r from the center of the conductor, that is located along the axis z it takes the form

$$E^+ = \frac{g^+}{2\pi\varepsilon r} \tag{11. 18}$$

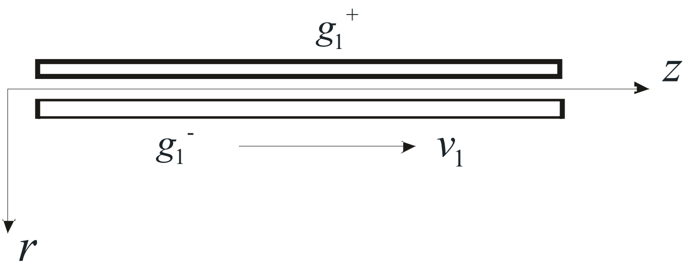

Fig. 12. Section is the conductor, along which flows the current.

We will consider that the direction of the vector of electric field coincides with the direction r. If electronic flux moves with the speed , then the electric field of this flow is determined by the equality

$$E^- = -\frac{g^-}{2\pi\varepsilon r} ch\frac{v_1}{c} \simeq -\frac{g^-}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v_1^{\ 2}}{c^2}\right). \qquad (11.19)$$

Adding (11.18) and (11.19), we obtain

$$E^- = -\frac{g^- v_1^{\ 2}}{4\pi\varepsilon c^2 r}$$

This means that around the conductor with the current is an electric field, which corresponds to the negative charge of conductor. However, this field has insignificant value, since in the real conductors $v \ll c$. This field can be discovered only with the current densities, which can be achieved in the superconductors, which is experimentally confirmed in works [11, 18].

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. 13). In this case relationships (11.18) and (11.19) will take the form

$$E^{+} = \frac{g^{+}}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v^{2}}{c^{2}}\right) \tag{11.20}$$

$$E^{-} = -\frac{g^{-}}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{(v_1 - v)^{2}}{c^{2}}\right) \tag{11.21}$$

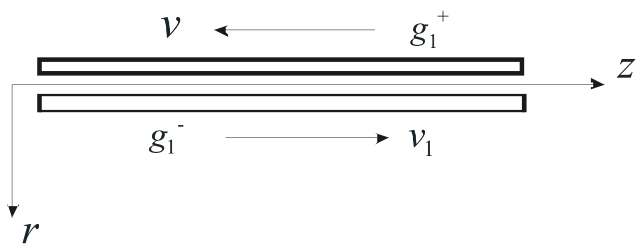

Fig. 13. Moving conductor with the current.

Adding (11.20) and (11.21) we obtain

$$E^{+} = \frac{g}{2\pi\varepsilon r}\left(\frac{v_1 v}{c^{2}} - \frac{1}{2}\frac{v_1^{\,2}}{c^{2}}\right) \tag{11.22}$$

In this relationship as the specific charge is undertaken its absolute value. since the speed of the mechanical motion of conductor is considerably more than the drift velocity of electrons, the second term in the brackets can be disregarded. In this case from (11.22) we obtain

$$E^{+} = \frac{gv_1v}{2\pi\varepsilon c^2 r} \tag{11.23}$$

The obtained result means that around the moving conductor, along which flows the current, with respect to the fixed observer is formed the electric field, determined by relationship (11.23), which is equivalent to appearance on this conductor of the specific positive charge of the equal

$$g^{+} = \frac{gv_1v}{c^2}.$$

If we conductor roll up into the ring and to revolve it then so that the linear speed of its parts would be equal v, then around this ring will appear the electric field, which corresponds to the presence on the ring of the specific charge indicated. But this means that the revolving turn, which is the revolving magnet, acquires specific electric charge on wire itself, of which it consists. During the motion of linear conductor with the current the electric field will be observed with respect to the fixed observer, but if observer will move together with the conductor, then such fields will be absent.

As is obtained the homopolar induction with which on the fixed contacts a potential difference is obtained, it is easy to understand from Fig. 14.

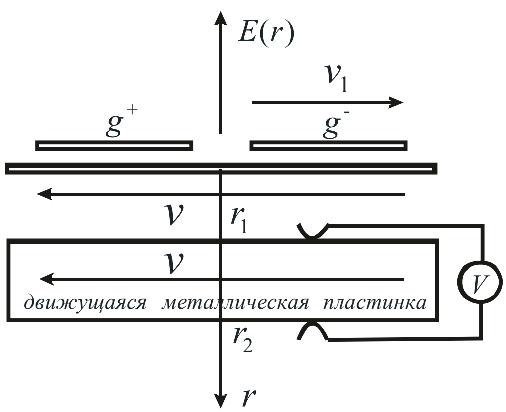

Fig. 14. Diagram of formation EMF homopolar induction.

We will consider that r_1 and r_2 is the coordinate of the points of contact of the tangency of the contacts, which slide along the edges of the metallic plate, which moves with the same speed as the conductor, along which flows the current. Contacts are connected to the voltmeter, which is also fixed. Then, it is possible to calculate a potential difference between these contacts, after integrating relationship (11.23)

$$U = \frac{g v_1 v}{2\pi\varepsilon c^2}\int_{r_1}^{r_2}\frac{dr}{r} = \frac{g v_1 v}{2\pi\varepsilon c^2}\ln\frac{r_2}{r_1}$$

But in order to the load, in this case to the voltmeter, to apply this potential difference, it is necessary sliding contacts to lock by the cross connection, on which there is no potential difference indicated. But since metallic plate moves together with the conductor, a potential difference is absent on it. It serves as that cross connection, which gives the possibility to convert this composite outline into the source EMF with respect to the voltmeter.

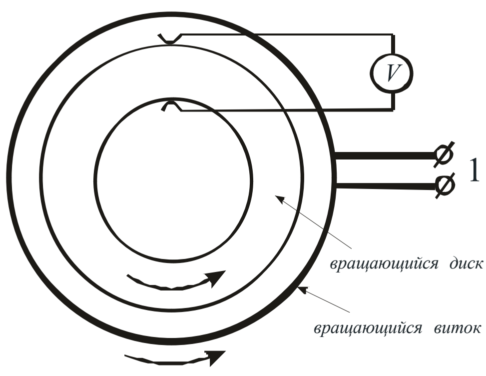

Fig. 15. Schematic of unipolar generator with the revolving turn with the current and the revolving conducting ring.

Now it is possible wire to roll up into the ring (Fig. 15) of one or several turns, and to feed it from the current source. Moreover contacts 1 should be derived on the collector rings, which are located on the rotational axis and to them joined the friction fixed brushes. Thus, it is possible to obtain the revolving magnet. In this magnet should be placed the conducting disk with the opening (Fig. 15), that revolves together with the turns of magnet, and with the aid of the fixed contacts, that slides on the generatrix of disk, tax voltage on the voltmeter. As the limiting case it is possible to take continuous metallic disk and to connect sliding contacts to the generatrix of disk and its axis. Instead of the revolving turn with the current it is possible to take the disk, magnetized in the axial direction, which is equivalent to turn with the current, in this case the same effect will be obtained.

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. 16, if the conducting plate was rolled up into the ring.

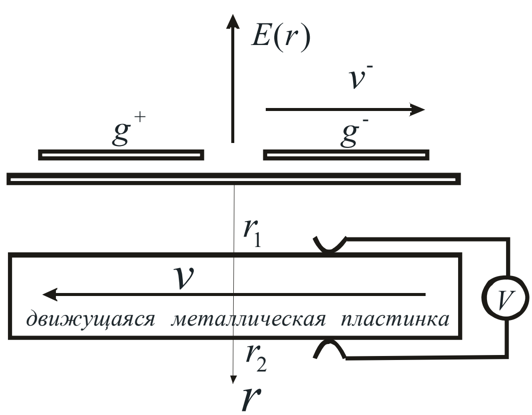

Fig. 16. The case of fixed magnet and revolving disk.

In this case the following relationships are fulfilled:

The electric field, generated in the revolving disk by the electrons, which move along the conductor, is determined by the relationship

$$E^{-}=-\frac{g^{-}}{2\pi\varepsilon r}ch\frac{v_1-v}{c}=-\frac{g^{-}}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{(v_1-v)^2}{c^2}\right),$$

and by the fixed ions

$$E^{+}=\frac{g^{+}}{2\pi\varepsilon r}ch\frac{v}{c}=\frac{g^{-}}{2\pi\varepsilon r}\left(1+\frac{1}{2}\frac{v^2}{c^2}\right).$$

The summary tension of electric field in this case will comprise

$$E_{\Sigma}=\frac{g}{2\pi\varepsilon r}\left(\frac{vv_1}{c^2}\right),$$

and a potential difference between the points r_1 and r_2 in the coordinate system, which moves together with the plate, will be equal

$$U=\frac{g(r_2-r_1)}{2\pi\varepsilon r}\left(\frac{vv_1}{c^2}\right).$$

Since in the fixed with respect to the magnet of the circuit of voltmeter the induced potential difference is absent, the potential difference indicated will be equal by EMF of the generator examined. As earlier moving conducting plate can be rolled up into the disk with the opening, and the wire, along which flows the current into the ring with the current, which is the equivalent of the magnet, magnetized in the end direction.

Thus, the concept of the dependence of the scalar potential of charge on the relative speed gives answers to all presented questions and STR here it is not necessary.

In the context of the aforesaid should be focused attention still to one physical phenomenon, which did not up to now find within the framework the classical electrodynamics of its physical substantiation and explanation. Nature of the ponderomotive action of electrical and magnetic ield on those applied to the surface of models, until now, it remains obscure. In the majority of teaching aids the authors go around this question, in the same sources, where this question is discussed, for example [19], the author rests on those experimental facts, which testify about the presence of ponderomotive forces, pronouncing the words: “As shows experience .....”. Further follows the detailed selection of the experimental facts of the action of magnetic field on to the current carrying structures without the disclosure of the physical essence of proceeding. In this case, as in all remaining teaching aids, is introduced postulate about the Lorentz force and on this “physical” explanation of ponderomotive interactions concludes. Taking into account everything said earlier now clearly, why up to now there is no physical explanation of these processes. Tamm although indicates the potential function of current in the magnetic field, he does not indicate that the gradients of this function are the consequence of the appearance of ponderomotive forces. From the relationships, obtained in work [20], follows that in the processes of ponderomotive interaction the very important role plays vector potential, but physical nature of the appearance of this potential, so it is not revealed. However, as far as the ponderomotive action of electromagnetic waves is concerned, this phenomenon from the point of view of the equations of electrodynamics not at all is examined, and mechanical impulse is assigned to electromagnetic wave and further this question is examined from the point of view of the law of momentum conservation. It occurs with this approach that nature of the ponderomotive action of constants field on and electromagnetic waves it is different.

The ponderomotronye forces appear on the border the division of two media, which can be sharp, when the electrodynamic characteristics of medium change spasmodically. But such forces appear also with a smooth change in the characteristics of medium, and as in this case to use the law of momentum conservation, in transit through this boundary electromagnetic wave it is not clear.

With incidence of wave on the interface on it the currents, which lead to the complete, or to the partial reflection of wave or a change in its direction, appear. In turn, the presence of such currents leads to the fact that on the border in a certain region appear the potential gradients energy, which lead to actions of force in the region of boundary. This approach not only from a physical point of view is clear and intelligible, but its application does not make the difference between the stationary and variable fields, which direct currents in the region of boundary. Moreover it changes ideological approach to the appearance of ponderomotive forces with the drop on the interface electromagnetic wave. This effect is considered not as the consequence of the presence in electromagnetic wave of mechanical impulse, but as the consequence of the action of those currents, which in the region of boundary wave incident to this boundary directs.

Is most easy this it is possible to understand based on the example of superconductors electromagnetic wave or presence on their surface of constant magnetic or electrical field on with the drop on them. In the superconductors the current density is unambiguously connected with the vector potential, and the work of current to the vector potential is potential energy. But since currents in the superconductor diminish exponentially, potential energy of these currents diminishes thus. But we know that the potential gradient energy gives force. Hence and appears the force, which appears to the surface and in the thickness of the superconductive layer, where currents penetrate. By here what defined by example means field " presses" to the surface of superconductor.

From these positions it is possible to examine the ponderomotive action of electrical and magnetic field on to any interface. Procedure is in all cases identical. Should be calculated currents and vector potential in the region of boundary, and then found the scalar product of these values. The gradient of this work will give the forces, which act on the surface. With this approach calculation of the dependence of the potential gradient energy on the coordinate gives information about the internal stresses, which act in the region of boundary.

§ 12. Laws of the electro-electrical induction

Since field 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 [11]

$$\varphi(r,t)=\frac{g\ ch\dfrac{v_{\perp}\left(t-\dfrac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r} \tag{12.1}$$

where $v_{\perp}\left(t-\dfrac{r}{c}\right)$ - component of the charge rate g, normal to the vector of $\vec{r}$ at the moment of the time $t'=t-\dfrac{r}{c}$, r - distance between the charge and the point at which t.

But does appear a question on what bases, if we do not use 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 Maxwell 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 field on. Using a relationship $\vec{E}=-grad\ \varphi(r,t)$ let us find field at point 1 (Fig. 17).

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 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 2) observation point is fixed and $\vec{r}$ is considered as the function of the position of the point of source.

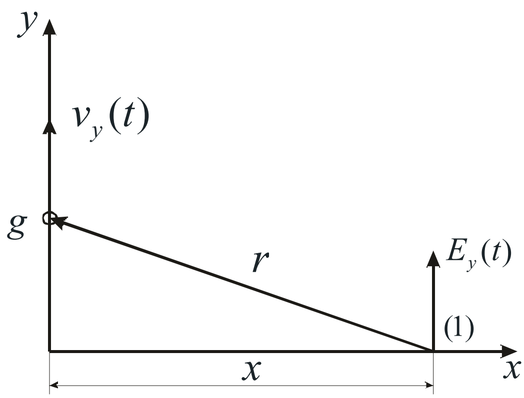

Fig. 17. Diagram of shaping of the induced electric field.

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 1 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

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 cx} \frac{\partial v_y\left(t - \frac{x}{c}\right)}{\partial y} sh \frac{v_y\left(t - \frac{x}{c}\right)}{c} \tag{12.2}$$

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 (12.2)

$$E_y(x,t) = \frac{e}{4\pi\varepsilon_0 cx} \frac{1}{v_y\left(t - \frac{x}{c}\right)} \frac{\partial v_y\left(t - \frac{x}{c}\right)}{\partial t} sh \frac{v_y\left(t - \frac{x}{c}\right)}{c}. \tag{12.3}$$

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 (12.3)

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x} \frac{\partial v_y\left(t - \frac{x}{c}\right)}{\partial t} = -\frac{ea_y\left(t - \frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x}, \tag{12.4}$$

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 y the angle α, then relationship (12.4) takes the form

$$E_y(x,t,\alpha)=-\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}. \qquad (12.5)$$

The relationship (12.5) determines the radiation pattern. Since there is a axial symmetry relative to the axis y, it is possible to calculate the complete radiation pattern of the emitter examined. 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 (12.5) it is possible to rewrite

$$E_y(x,t,\alpha)=-\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}=-\frac{1}{\varepsilon_0 c^2}\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}$$

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 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 (12.5). 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

$$\vec{p} = e\vec{d}\,, \tag{12.6}$$

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

$$e\vec{v} = e\frac{\partial \vec{d}}{\partial t} = \frac{\partial \vec{p}}{\partial t}.$$

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 (12.5), we obtain the emission law of the being varied dipole.

$$\vec{E} = -\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2}. \tag{12.7}$$

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 (12.4), (12.5) and (12.6), 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 field 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 field on static dipole field on emissions.

Laws (12.4), (12.5), (12.7) are the laws of the direct action, in which already there is neither magnetic field 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 (12.5) 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 (12.5). The superposition of electrical field on, radiated by all charges, it is electrical wave.

If on the charge acts the electric field , then the acceleration of charge is determined by the equation

$$a = -\frac{e}{m} E'_{y0} \sin \omega t .$$

Taking into account this relationship (12.5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2 \sin\alpha}{4\pi\varepsilon_0 c^2 m x} E'_{y0} \sin\omega(t - \frac{x}{c}) = \frac{K}{x} E'_{y0} \sin\omega(t - \frac{x}{c}), \quad (12.8)$$

where the coefficient $K = \dfrac{e^2 \sin\alpha}{4\pi\varepsilon_0 c^2 m}$ 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 (12.5) the displacement accompanies the wave of electric field

$$j_y(x,t) = \varepsilon_0 \frac{\partial E_y}{\partial t} = -\frac{e \sin\alpha}{4\pi c^2 x} \frac{\partial^2 v_y\left(t - \dfrac{x}{c}\right)}{\partial t^2}.$$

If charge accomplishes its motion under the action of the electric field of , then bias current in the distant zone will be written down as

$$j_y(x,t) = -\frac{e^2\omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right). \tag{12.9}$$

The sum wave, which presents the propagation of electrical field on (12.8) and bias currents (12,9), can be named elektrocurent wawe. 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 [10,11].

In parallel with the electrical waves it is possible to introduce magnetic waves, if we assume that

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H} \tag{12.10}$$

$$div\vec{H} = 0$$

Introduced thus magnetic field is vortex. Comparing (12.9) and (12.10) 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

$$H_z(x,t) = \frac{e^2 \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t - \frac{x}{c}\right). \tag{12.11}$$

Thus, relationship (12.8), (12.9) and (12.11) 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 in the role of the transformer, which ensures this reradiation. The magnetic field, which can be calculated with the aid of relationship (12.11), 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 resistance of free space.

Wave resistance 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 elektrocurent wave, crossing this area, transfers through it the power, determined by the data by relationship, which is located in accordance with by Pointing theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of elektrocurent 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 vectorial field $\vec{F}$, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function φ and rotor of a certain vector function $\vec{C}$, whose divergence is equal to zero:

$$\vec{F} = grad\,\varphi + rot\vec{C}\,,$$

$$div\vec{C} = 0\,.$$

Consequently, must exist clear separation field on to the gradient and the vortex. It is evident that in the expressions, obtained for those induced field on, this separation is located. Electric fields bear gradient nature, and magnetic - vortex.

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 field 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 (12.1), 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 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 (12.4) could be obtained directly from the Ampere law, still long before appeared Maksvell equations. The Ampere law, expressed in the vector form, determines magnetic field at the point x,y,z

$$\vec{H} = \frac{1}{4\pi}\int \frac{Id\vec{l} \times \vec{r}}{r^3}$$

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

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right)\times d\vec{l}$$

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

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right). \qquad (12.12)$$

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 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

$$\vec{E} = -\mu\int \frac{g\frac{\partial v}{\partial t}\ d\vec{l}}{4\pi r} = -\mu\int \frac{ga\ d\vec{l}}{4\pi r} \qquad (12.13)$$

where a - acceleration of charge.

This relationship appears as follows for the single charge

$$\vec{E} = -\frac{\mu e\vec{a}}{4\pi r}. \tag{12.14}$$

If we in relationships (12.13) and (12.14) 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

$$\vec{E} = -\mu \int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi r} = -\int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi\varepsilon_0 c^2 r} \tag{12.15}$$

$$\vec{E} = -\frac{e\vec{a}(t - \frac{r}{c})}{4\pi\varepsilon_0 c^2 r}. \tag{12.16}$$

Let us note that these equations - this solution of Maxwell equations, but in this case they are obtained directly from the Ampere law, not at all coming running to Maxwell equations. To there remains only present the question, why electrodynamics in its time is not banal by this method?

The meaningful result of the carried out examination is that which with the aid of the scalar - vector potential was possible not only to combine, until now, odd parts of the electrodynamics, but also to show physical nature of such phenomena as the emission of electromagnetic waves, phase aberration, the transverse Doppler effect, it was possible to also explain the work of unipolar generator. It will be shown below that by using a concept of scalar- vector potential it is possible to explain the appearance of the electric pulse of nuclear explosion and rope tricks.

Given examples show, as electrodynamics in the time of its existence little moved. The phenomenon of electromagnetic induction Faraday opened into 1831 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.

§ 13. Problem of electromagnetic pulse and rope tricks in the concept of the scalar - vector potential

It is known that problem EMI together with my students attempted to solve academician I. B. Zeldovich [18]; however, in the scientific literature there is no information about the fact that this problem was solved by it. And only in 2013 in the periodical Engineering physics appeared the first publication, in which was given an attempt at the explanation of the phenomenon of [19]. In the work it is shown that as a result nuclear explosion appears not the electromagnetic, but electric pulse, the vector of electric field of which is directed toward the point of impact. For explaining physical nature of electric pulse are used the concept of scalar- vector potential, the assuming dependence of the scalar potential of charge on its relative speed. The bases of this concept were placed in work [2], and it underwent its further development in works [10-12].

In the introduction in Fig. 2 solid line showed the dependence of the pulse amplitude on the time, recorded on the oscilloscope face, obtained with the tests according to the program *"Starfish"* and dotted line showed the shape of pulse, corrected taking into account the parameters of the input circuits of oscillograph.

With the detonation the products of explosion heat to the high temperature, and then occurs their gradual cooling, during which the explosive energy returns to environment. The dependence of the pulse amplitude on the time repeats the process indicated, and possible to assume that precisely the temperature of plasma determines its amplitude. In the time of the detonation of the charge ~ 25 ns is a sharp increase in the pulse amplitude, and then there is a slower process, with which in the time ~ 150 ns the amplitude decreases two. We will consider that the sum of these times represents the time, for which it occurs the emission of a basic quantity of energy, obtained 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. Consequently explosive force in the time interval indicated will compose ~ 3.7×10^{22} W. For the comparison let us point out that the power of the radiation of the Sun ~ 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. With the explosion in the atmosphere the energy is expended on the emission and on the creation of shock wave. In space shock wave is absent; therefore explosive energy is expended on the electromagnetic radiation.

In accordance with Stephan – Boltzmann equation the power, radiated by the heated surface, is proportional to the fourth degree of its temperature

$$P = \sigma S T^{4},$$

where σ - Stefhan – Boltsman constant, and S - area of radiating surface.

In order to calculate temperature with the known radiated power it is necessary to know the surface of radiating surface. As this surface let us select sphere with the surface ~ 3 m^2. Knowing explosive force and size of radiating surface, we find the temperature of the cloud of the explosion

$$T = \sqrt[4]{\frac{P}{\sigma S}}.$$

With the explosive force ~ 3.7×10^{22} W we obtain the value of temperature equal ~ 8.6×10^{6} K.

In the concept of scalar - vector potential, the scalar potential of charge it is determined from the relationship

$$\varphi(r) = \frac{g\ ch\frac{v_{\perp}}{c}}{4\pi\ \varepsilon_0 r}, \qquad (13.\ 1)$$

where, r - the distance between the charge and the observation point, $v_{\perp}$ - the component of the charge rate g normal to the vector $\vec{r}$, ε_0 - dielectric constant of vacuum.

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 is no longer degenerate and is subordinated to the Boltzmann distribution. The most probable electron velocity in this case is determined by the relationship

$$v = \sqrt{\frac{2k_Б T}{m}}, \qquad (13.2)$$

where T - temperature of plasma, $k_Б$ - Boltzmann constant, m - mass of electron.

Using relationships (13,1) and (13.2), and taking into account with the expansion in the series of hyperbolic cosine the terms $\sim\frac{v^2}{c^2}$, we obtain the value of increase in the scalar potential at the observation point of

$$\Delta\varphi \cong \frac{Nek_Б T}{4\pi\varepsilon_0 rmc^2}, \qquad (13.3)$$

where N - quantity of electrons in the cloud of explosion, e - electron charge. We determine from the formula the tension of radial electric field, which corresponds to this increase in the potential

$$E = \frac{Nek_Б T}{4\pi\varepsilon_0 r^2 mc^2} = \frac{\Delta q}{4\pi\varepsilon_0 r^2}, \tag{13.4}$$

where

$$\Delta q = \frac{Nek_Б T}{mc^2} \tag{13.5}$$

is an equivalent charge of explosion.

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.

For enumerating the quantity of electrons it is necessary to know a quantity of atoms, which with the warming-up formed the cloud of explosion. Let us assume that the total weight of bomb and launch vehicle, made from metal with the average density of the atoms ~ 5×10^{22} 1/sm^3 is 1000 kg. General of 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 ~ 8 g/cm^3 will comprise ~ 5×10^{27} .

In accordance with formula (4) the tension of radial electric field at a temperature of the cloud of the explosion ~ 8.6×10^6 K will comprise: in the epicentre of the explosion ~ 6.9×10^4 V/m, at a distance in 870 km from the epicentre ~1.2×10^4 V/m and at a distance 1300 km from the epicentre ~ 6×10^3 V/m. It is evident that in the epicentre the computed values of electrical field on on the earth's surface they are close to the experimental values. The ratio of rasschetnykh values to those measured they comprise: in the epicentre of explosion - 13.5, at a distance 870 km from this place - 4.5, at a distance 1300 km - 2.4. 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 field on those being approaching experimental values. But calculated three-dimensional dependence field on strongly it is differed from experimental results. Let us attempt to explain the reason for such divergences.

Let us first examine the case, when charge is located above the metallic conducting plane (Fig. 18). The distribution of electrical field on above this plane well known [1].

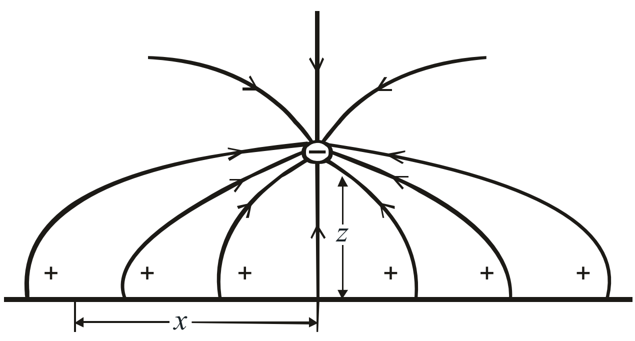

Fig. 18. Negative charge above the limitless conducting plane.

The horizontal component of electric field on the surface of this plane is equal to zero, and normal component is equal:

$$E_{\perp} = \frac{1}{2\pi\varepsilon_0} \frac{zq}{\left(z^2 + x^2\right)^{\frac{3}{2}}} \qquad (13,6)$$

where q - magnitude of the charge, z - distance from the charge to its epicentre, x - distance against the observation points to the epicentre.

Lower than conducting plane electric fields be absent, but this configuration field on equivalent to the presence under the conducting plane of the positive charge of the same value and at the same distance as initial charge. They indicate that in the conducting plane the charge sees its mirror reflection. The pair of such charges presents the electric dipole with the appropriate distribution of electrical field on. This configuration field 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 of the charge density from the coordinate of x also is well known [1]

$$\sigma(x) = \varepsilon_0 E_{\perp} = \frac{1}{2\pi} \frac{zq}{\left(z^2 + x^2\right)^{\frac{3}{2}}}. \qquad (13.7)$$

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. In this case two cases can realize. With the low charge density, which occurs in the poor conductors, it will arrive to move up to the significant distances significant quantities of charges. But in this case of charges it can and not be sufficient for the complete compensation. With the high charge density, it is possible to only insignificantly move charges in the plane. This case realizes in the metallic conductors.

If we periodically draw near and to move away charge from the plane, then in it will arise the periodic horizontal currents, which will create the compensating surface charges. The same effect will be observed, if charge at the particular point can be born and disappear. If at the assigned point above the plane charge suddenly in some time arises, then, so that the fields of charge would not penetrate through the conducting plane, in the same time on the conducting plane the compensating charges, which correspond to relationship must appear (13.7). This means that the strength of currents, which create the compensating charges, there will be the greater, the greater charge itself and the less the time of its appearance. However, with the low charge density can realize another case. With a very rapid change in the electric field the charges will not have time to occupy the places, which correspond to the complete compensation for electrical field on, and then the fields of external charge partially will penetrate through conductor, and compensation will be not complete. Specifically, this case realizes in the case of the explosion of nuclear charge in space, since between it and earth's surface is located the ionosphere, which possesses not too high a conductivity (Fig.19).

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 field on, which it creates in it. However, if a total quantity of free positive charges in the ionosphere will be less than the value of charge itself, or their displacement is insufficient in order to fall into the necessary point at the assigned moment, then their quantity will not be sufficient for the complete compensation field on the appearing charge and 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. In this case maximum compensation field on it will occur in the region, situated directly under the charge. This process will make the dependence of electrical field on from the distance by smoother, that also is observed during the experiment. 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. But even if are known these parameters, then bulky numerical calculations are necessary for the solution of problem.

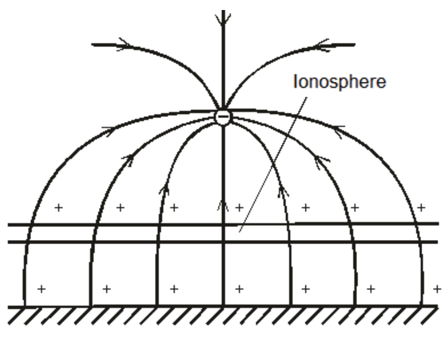

Fig. 19. Negative charge above the earth's surface with the presence of the ionosphere.

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. 20

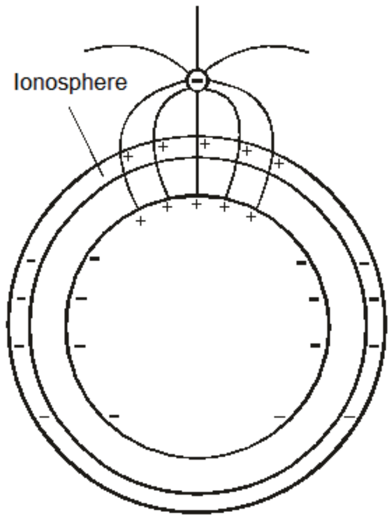

Fig. 20 Negative charge above the earth's surface with the presence of the ionosphere.

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 charges in the ionosphere will in essence appear directly in the epicentre, where they will be in the surplus, while beyond the line-of-sight ranges in the surplus will be negative charges. And entire system charge - the ionosphere - the earth will obtain additional dipole moment.

The model examined speaks, that nuclear explosion will lead not only to the appearance EP in the zone of straight visibility, but also to the global ionospheric disturbance. Certainly, electric fields in space in the environments of the explosion, where there is no screening effect of the ionosphere, have high values and present large danger to the automatic spacecraft.

In accordance with relationship (13.4) the pulse amplitude is proportional to the temperature of plasma, therefore, according to the graph, depicted in Fig. 2, it is possible to judge the knocking processes of nuclear charge and the subsequent cooling of the cloud of explosion. From the figure one can see that two peaks are visible in the initial section of the dependence of the amplitude of electric field. The first peak presents nuclear blast, which ignites thermonuclear charge, the second peak presents the knocking process of thermonuclear fuel. The rapid decrease, which characterizes the process of cooling cluster, further goes. It is evident that it occurs very rapidly. Naturally to assume that this is that period, when basic energy losses are connected with the radiant losses caused by the rigid X-radiation.

Thus, the presence of the pulse indicated they are the properties of explosion itself, but not second phenomenon.

Now should be made one observation apropos of term itself the electromagnetic pulse EMP utilized in the literary sources. From this name should be excluded the word magnetic, since. this process presents the propagation only of radial electrical field on, and in this case magnetic fields be absent. It is known that the amplitude of the electric field of pulse can reach values ~ 50000 V/m. But if pulse was actually electromagnetic, then the tension of magnetic field would compose ~ 1.3×10^{2} A/m (for obtaining this value should be the tension of electric field divided into the wave drag of free space), and its power would be ~ 5 MW, which is commensurate with the power of small power station.

It is not difficult to calculate that energy, which with the nuclear explosion is expended on obtaining of electric pulse. The pulse duration is ~ 150 ns. If we consider that the pulse is extended with the speed of light, then its extent in the free space composes d = 45 m. At a distance R = 400 km from the point of impact the tension of electric field was ~ 50000 V/m. Specific electric field energy composes

$$W = \frac{1}{2}\varepsilon_0 E^2 .$$

The total energy U of the electric field of pulse we obtain by the way of the multiplication of specific energy by the volume of the spherical layer $4\pi r^2 d$

$$U = 2\pi r^2 d \varepsilon_0 E^2 .$$

Substituting in this formula the values indicated, we obtain energy ~ 10^{12} J. If we consider that with the explosion is separated energy ~ 6.4 $\times 10^{15}$ J, then energy of electric pulse composes ~ 0.016% of the general explosive energy.

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.

Since the tension of electrical field on near the nuclear explosion it is great it can reach the values of the breakdown tension of air (300000 V/m), with the explosions, achieved in immediate proximity from the earth's surface, this can lead to the formation of lightning, that also is observed in practice.

The concept of scalar - vector potential can serve and for explaining the cable is special effect. Actually, if in the process of the appearance of the cloud of explosion in it excess charge is formed, then this charge on the ropes must flow into the earth, and this in turn will lead to their additional warming-up.

§ 14. Electrical pulse trotyl and other explosions

If the principle of the formation of electric pulse examined is accurate then the usual explosions, with which is formed cold plasma, they must be accompanied by the appearance of electric pulse, although less intensive than with the nuclear explosion.

The disintegration of the molecule of trotyl with its detonation occurs according to the following diagram

$$C_7H_5O_6N_3 = 2H_2O + 3.5CO + 1.5N_2 .$$

If each of the molecules, that was released during explosion will be singly ionized, then upon decay the molecule of trotyl will be isolated 7 free electrons. Consequently, with the detonation of one mole of trotyl will be isolated $7N_A = 4.2\times10^{24}$ of the electrons, where N_A - Avagadro number. With the explosion of trotyl the temperature of the cloud of explosion reaches 3500K. If all molecules of disintegration obtain single ionization, then the maximum strength of field of electric pulse composed

$$E = 3.7\times10^9 \frac{1}{r^2} \text{ V/m}$$

At a distance 100 m of the point of impact the tension of electric field there will be the wound of 3.7×10^5 V/m. However, with the explosion of trotyl charges is formed the cold plasma, in which the degree of ionization composes ~ 0.1%. The summary tension of electric field in this case will comprise 370 V/m. The importance of this method consists in the fact that by studying the topology of pulse, it is possible to judge the knocking processes and subsequent relaxation of the cloud of explosion. Obviously, electric pulse must accompany the entry of projectile into different solid obstacles, since in this case strong local warming-up to target with the formation of plasma occurs. Consequently, it is possible to draw the conclusion that in those places, where the plasma of any form is formed, must appear electric pulse.

In the scientific literature there are no communications about the appearance of electric pulse with the explosions of conventional explosives, but this can be connected with the fact that this question no one was investigated.

It is known that the electro-welding creates the strong radio reception disturbances, but these interferences very rapidly diminish with the distance. Micro-bursts it is possible to consider sparking in the poor contacts in the electrical networks, in the contact systems of electric transport means or the collectors of direct-current motors. But, since the amplitude of electric pulse rapidly diminishes with the distance, electric transport does not present special interferences for the radio reception.

The lightning also warm up plasma to the high temperature and are created the radio reception disturbances. There is an opinion that very channel of lightning serves as the antenna, which radiates the radio waves over a wide range of frequencies. But so whether this? With that length, which represents the track of lightning, this antenna must have excellent characteristics and reliably emit not only in the short-wave, but also in the long-wave radio-frequency band. But this would mean that with any lightning stroke in any place of the terrestial globe in our receivers the interferences would appear. But since they second-by-second in the world beat hundreds of lightning, entire ether would be oppressed by interferences. This it does not occur for that reason, that the plasma cylinder of lightning emits not radio waves, but electric pulses from all its sections. In this case the excess charges, which arose in different sections of the channel of lightning, see their mirror reflection under the earth's surface, forming the appropriate dipoles, whose fields diminish inversely proportional to the cube of distance.

Is that which is written in this paragraph, thus far only theoretical prerequisites. But if they will be confirmed experimentally, then will be not only just once confirmed the viability of the concept of scalar - vector potential, but also will be opened way for developing the new procedures of a study of the processes, proceeding with different explosions.

Conclusion

Fifty years since americans past already more than exploded in space above Pacific Ocean H-bomb and revealed in this case new physical phenomenon. It consists in the fact that the explosion is accompanied by the electric pulse of very large amplitude and short duration. But up to now, in spite of all efforts of physicists, was not created the theory, which could explain this phenomenon. For the author of present monograph it was possible to solve this problem. The basic prerequisite of the developed theory is the fact that the scalar potential of charge depends on speed. This approach explains not only the appearance of electric pulse with the nuclear explosions, but also a number of other physical phenomena, which earlier in the electrodynamics explanations did not have. Moreover, it turned out that this new law is the basis of all dynamic laws of electrodynamics.

One cannot fail to note and the circumstance that all started satellites must have a protection from the threat, connected with the possibility of defeat by electric pulse.

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