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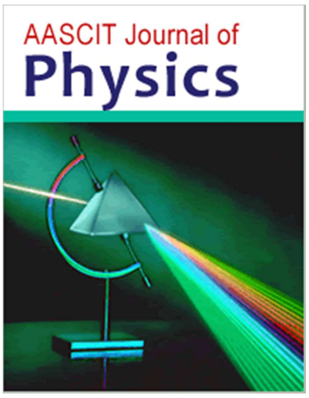

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Physics of Magnetic Field and Vector Potential

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Abstract
The carried out analysis showed that the magnetic vector potential is one of the most important concepts of classical electrodynamics, and magnetic field is only a consequence of this potential. The meaningful result is that which in them within the framework Galileo conversions is shown that the scalar potential of charge depends on its relative speed, and this fact found its experimental confirmation. This article details these ideas. The obtained results change the ideological basis of classical electrodynamics, indicating that the substantial part of the observed in the electrodynamics dynamic phenomena, this by the consequences of this dependence. Certainly, the adoption of this concept is critical step. But this step is transparent and intelligible from a physical point of view. Indeed the main parameter of charge are those energy characteristics, which it possesses and how it influences the surrounding charges not only in the static position, but also during its motion. The dependence of scalar potential on the speed leads to the fact that in its environments are generated the electric fields, to reverse fields, that accelerate charge itself. Such dynamic properties of charge allow instead of two symmetrical laws of magnetoelectric and electromagnetic induction to introduce one law of electro-electrical induction, which is the fundamental law of induction. This method gives the possibility to directly solve all problems of induction and emission, without resorting to the application of such pour on mediators as vector potential and magnetic field. This approach makes it possible to explain the origin of the forces of interaction between the current carrying systems. Up to now in the classical electrodynamics existed two not connected with each other of division. From one side this Maxwell's equation, and from which follow wave equations for the electromagnetic pour on, while from other side this of the relationships, which determine power interaction of the current carrying systems. For explaining this phenomenon the postulate about the Lorentz force was introduced. Introduction to the dependence of the scalar potential of charge on the speed mutually connects these with those not connected divisions, and classical electrodynamics takes the form of the ordered united science, which has united ideological basis.

1. Introduction

Is certain, magnetic field is one of the important concepts of contemporary electrodynamics. It determines power interaction between the moving charges, and also it enters into the majority of its equations. And, it would seem, the reality of existence of magnetic field to doubt it does not be necessary. However, if we recall those times, when magnetic field acquired official status, and introduces magnetic field Ampere law, then one cannot fail to note that the lively controversy apropos of nature of this phenomenon occurred between the ampere and the weber. If weber adhered to that point of view, that the magnetic field is the consequence of a change in the properties of charges themselves, determined by their motion, then the point of view of Ampere was reduced to the fact that the magnetic field is independent material concept. The formalization of this concept is known Ampere law about power interaction of conductors, on which move the charges. Magnetic field was introduced by ampere by phenomenological way on the basis of the observation of power interaction between the conductors, along which flows the current. The Ampere law, expressed in the vector form, determines magnetic field at the point

$$\vec{H} = \frac{1}{4\pi}\int \frac{I\left[d\vec{l}\,\vec{r}\right]}{r^3} \qquad (1.1)$$

where I is current in the element $d\vec{l}$, $\vec{r}$ is vector, directed from $d\vec{l}$ to the point.

Axiomatic way, in the form separate postulate, introduced the Lorentz force, which determines the force, which acts in the magnetic field to the moving charge.

$$\vec{F}_L = e\left[\vec{v}\times\mu\vec{H}\right] \qquad (1.2)$$

where e is magnitude of the charge, $\vec{v}$ its speed, μ is magnetic permeability of the medium, in which moves the charge.

However in this axiomatics is an essential deficiency. If force acts on the moving charge, then in accordance with third Newton's 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 is independent substance, 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.

Relationship (1.1) 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 (1.1) 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 in the existing literature there is no answer also.

Its concept consists in the fact that around any moving charge appears the magnetic field (Ampere law), whose circulation is determined by the relationship

$$\oint \vec{H}d\vec{l} = I\,, \qquad (1.3)$$

where I is conduction current. The consequence of relationship (1.3) is the Maxwell's second equation

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

if we to the conduction current add bias current. So magnetic field fell into Maxwell's equations.

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 (1.1) and (1.1) not difficult to show that with the unidirectional parallel motion of two like charges, or flows of charges, between them must appear the additional attraction. However, if we pass into the inertial system, which moves together with the charges, then there magnetic field is absent, and there is no additional attraction. This paradox does not have an explanation.

Of force with power interaction of material structures, along which flows the current, are applied not only to the moving charges, but to the lattice, but in the concept of magnetic field to this question there is no answer also, since in equations (1.1-1.3) 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.

2. Vector Potential of Magnetic Field

Long time was considered that the vector potential of magnetic field is faster the mathematical operation, than the actually existing material field, but occurs that this not thus.

Using relationship (1.1), it is possible to show that

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

and, besides the fact that

$$\left[grad\left(\frac{1}{r}\right)d\vec{l}\right] = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r}rot d\vec{l}\,.$$

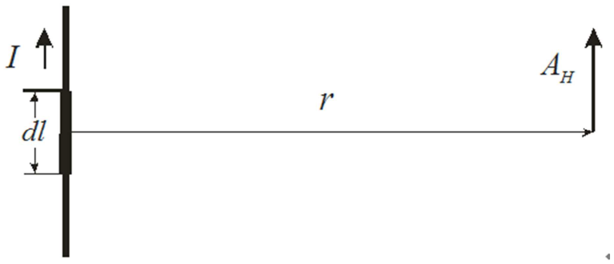

Fig. 1. *The formation of vector potential by the element of the conductor* dl*, along which flows the current* I *.*

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

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right) \tag{2.1}$$

the vector potential of magnetic field (Fig.1).

The remarkable property of this expression is the fact that the dependence of vector potential is inversely proportional to distance to the observation point, which is characteristic for the emission laws.

Since $I = gv$, where g linear charge, from relationship (2.1) we obtain:

$$\vec{A}_H = \int \frac{gv\ d\vec{l}}{4\pi r}.$$

If the size of the element $d\vec{l}$, along which flows the current, is considerably less than distance to the observation point, then the vector potential, generated by the element $d\vec{l}$, along which flows the current $I = gv$, has the form:

$$\vec{A}_H = \frac{gv\ d\vec{l}}{4\pi r}. \tag{2.2}$$

From this relationship follows interesting fact. Even on the direct current the dependence of vector potential on the distance corresponds to emission laws. And, it would seem, that, changing by jumps current in the short section of wire, and measuring the vector potential at the remote point, it is possible to transfer information into this point by the emission laws. But this interfere with the circumstance that the direct-current circuit is always locked to the local power source and therefore always there is both straight and return conductor. This special feature leads to the fact that in this situation the vector potential in the distant zone occurs inversely it is proportional to the square of distance to the observed point. This is easy to show based on the example of two parallel elements of conductor, d (Fig.2), in which flow the opposite currents.

In this case vector potential in the remote zone is defined as the sum of the vector potentials, created in the distant zone individually by each current element.

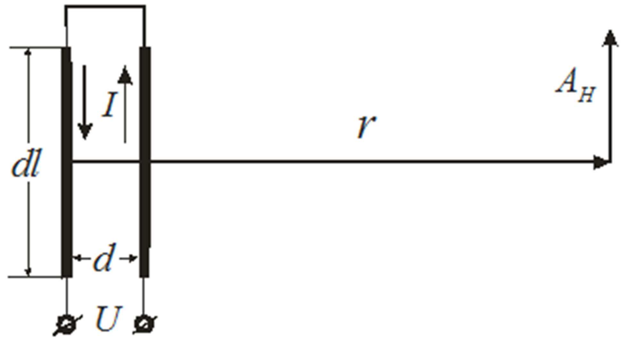

Fig. 2. *The formation of the vector potential by two parallel sections of conductors, along which flow the opposite currents.*

With satisfaction $r \gg d$ this condition we obtain

$$\vec{A}_H = \frac{gv\ d\vec{l}}{4\pi r} - \frac{gv\ d\vec{l}}{4\pi(r+d)} \cong \frac{gv\ d\vec{l}\ d}{4\pi r^2}. \tag{2.3}$$

Since

$$\vec{E} = -\mu_0 \frac{\partial \vec{A}_H}{\partial t}, \tag{2.4}$$

where μ_0 is magnetic permeability of vacuum, we find from (2.2) and (2.3):

$$\vec{E}_1 = -\frac{\mu_0 ga\ d\vec{l}}{4\pi r}, \tag{2.5}$$

$$\vec{E}_2 = -\frac{\mu_0 ga\ d\vec{l}d}{4\pi r^2}, \tag{2.6}$$

where $a = \frac{dv}{dt}$ is acceleration of charge.

Since the speed of light is determined by the relationship

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

where ε_0 is dielectric constant of vacuum, then equalities (2.5) and (2.6) can be rewritten:

$$\vec{E}_1 = -\frac{ga\ d\vec{l}}{4\pi\varepsilon_0 c^2\ r}\ \ \vec{E}_2 = -\frac{ga\ d\vec{l}d}{4\pi\varepsilon_0 c^2\ r^2}$$

If is located the point charge e, then these relationships take the form:

$$\vec{E}_1 = -\frac{e\vec{a}}{4\pi\varepsilon_0 c^2\ r},\ \vec{E}_2 = -\frac{e\vec{a}\ d}{4\pi\varepsilon_0 c^2\ r^2}.$$

The basic task of the laws of induction consists in the explanation of the reasons for appearance in the space of induction electrical pour 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 it can determine the gradient of the scalar potential $\vec{E} = -grad\ \varphi$, but acceleration or retarding of charges also leads to the appearance in the surrounding space of electrical pour on inductions.

Faraday law, who for the vacuum is written as follows, is considered as the fundamental law of induction in the classical electrodynamics:

$$\oint \vec{E}\ d\vec{l} = -\frac{\partial \Phi_B}{\partial t} = -\mu_0 \int \frac{\partial \vec{H}}{\partial t}\ d\vec{s} = -\int \frac{\partial \vec{B}}{\partial t}\ d\vec{s} \qquad (2.7)$$

where $\vec{B} = \mu_0 \vec{H}$ is magnetic induction vector, $\Phi_B = \mu_0 \int \vec{H}\ d\vec{s}$ is flow of magnetic induction

This law is integral and does not give the local connection between the magnetic and electric field. From relationship (2.7) obtain the Maxwell's first equation

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}, \qquad (2.8)$$

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

Let us introduce the vector potential $\vec{A}_H$, which satisfies the equality $\mu_0 \oint \vec{A}_H\ d\vec{l} = \Phi_B$, where the outline of the integration coincides with the outline of integration in relationship (2.6), and the vector $\vec{A}_H$ is determined in all its sections, then

$$\vec{E} = -\mu_0 \frac{\partial \vec{A}_H}{\partial t} \qquad (2.9)$$

Introduced thus vector of determines the local connection between it and by electric field, and also between the gradients this vector and the magnetic field. Consequently, knowing the derivatives of a vector $\vec{A}_H$ on the time and on the coordinates, it is possible to determine the induced electrical and magnetic fields. It is not difficult to show that introduced thus vector $\vec{A}_H$, is connected with the magnetic field with the following relationship:

$$rot\ \vec{A}_H = \vec{H}, \qquad (2.10)$$

thus, the vector of is more universal concept than the vector of magnetic field, since gives the possibility to define both magnetic and electric fields.

Until now, resolution of a question about the appearance of electrical pour on in different inertial moving systems (IS) it was possible to achieve in two ways. The first - consisted in the calculation of the Lorentz force, which acts on the moving charges, 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. 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 situation in more detail.

In order to answer the presented question, should be somewhat changed relationship (2.9), after replacing in it partial derivative by the complete:

$$\vec{E}' = -\mu_0 \frac{d\vec{A}_H}{dt} \qquad (2.11)$$

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 (2.11) can be rewritten as follows:

$$\vec{E}' = -\mu_0 \frac{\partial \vec{A}_H}{\partial t} - \mu_0 (\vec{v}\nabla)\vec{A}_H,$$

where $\vec{v}$ is speed of the prime system.

Consequently, the extra force, which acts on the charge in the moving system, will be written down

$$\vec{F}'_{v,1} = -\mu_0 e (\vec{v}\nabla)\vec{A}_H.$$

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]

$$W = -e\mu_0 \left(\vec{v}\vec{A}_H\right).$$

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

$$\vec{F}'_{v,2} = -grad\ W = e\mu_0 grad\left(\vec{v}\vec{A}_H\right).$$

Thus, the value of $\mu_0 \left(\vec{v}\vec{A}_H\right)$ 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

$$\vec{F}' = -e\mu_0 \frac{\partial \vec{A}_H}{\partial t} - e\mu_0 (\vec{v}\nabla)\vec{A}_H + e\mu_0 grad\left(\vec{v}\vec{A}_H\right) \qquad (2.12)$$

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 also determines changes of the vector potential with time, but they are connected already 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 (2.12). 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 (2.12) follows

$$\vec{E}' = -\mu_0 \frac{\partial \vec{A}_H}{\partial t} - \mu_0 \left(\vec{v}\nabla\right)\vec{A}_H + \mu_0 grad\left(\vec{v}\vec{A}_H\right) \quad (2.13)$$

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 Faraday 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. This law 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 (2.13), attempting to obtain the Maxwell's first 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

$$\mu_0 grad\left(\vec{v}\vec{A}_H\right) - \mu_0\left(\vec{v}\nabla\right)\vec{A}_H = \mu_0\left[\vec{v}\times rot\ \vec{A}_H\right],$$

that from (2.12) we will obtain

$$\vec{F}_v' = e\mu_0\left[\vec{v}\times rot\ \vec{A}_H\right] \quad (2.14)$$

and, taking into account (2.10), let us write down

$$\vec{F}_v' = e\mu_0\left[\vec{v}\times\vec{H}\right], \quad (2.15)$$

or

$$\vec{E}_v' = \mu_0\left[\vec{v}\times\vec{H}\right] \quad (2.16)$$

and it is final

$$\vec{F}' = e\vec{E} + e\vec{E}_v' = -e\frac{\partial \vec{A}_H}{\partial t} + e\mu_0\left[\vec{v}\times\vec{H}\right] \quad (2.17)$$

Can seem that relationship (2.17) 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 (2.17) to add the term

$$\vec{F}_\Sigma' = -e\ grad\ \varphi + e\vec{E} + e\mu_0\left[\vec{v}\times\vec{H}\right],$$

where φ is scalar potential, created at the observation point by the uncompensated charges.

In this case relationship (2.13) can be rewritten as follows:

$$\vec{E}' = -\mu_0 \frac{\partial \vec{A}_H}{\partial t} - \mu_0\left(\vec{v}\nabla\right)\vec{A}_H + \mu_0 grad\left(\vec{v}\vec{A}_H\right) - grad\ \varphi, \quad (2.18)$$

or, after writing down the first two members of the right side of relationship (2.18) as the derivative of vector potential on the time, and also, after introducing under the sign of gradient two last terms, we will obtain

$$\vec{E}' = -\mu_0\frac{d\vec{A}_H}{dt} + grad\left(\mu_0\left(\vec{v}\vec{A}\right) - \varphi\right). \quad (2.19)$$

If both parts of relationship (2.19) are multiplied by the magnitude of the charge, then will come out the total force, which acts on the charge. From Lorentz force it will differ in terms of the force $-e\mu_0\frac{\partial \vec{A}_H}{\partial t}$.From relationship (2.19) it is evident that the value $\left(\mu_0\vec{v}\vec{A}\right) - \varphi$ plays the role of the generalized scalar potential. If we take rotor from both parts of relationship (2.19) and to consider that $rot\ grad = 0$, then we will obtain:

$$rot\ E' = -\mu_0\frac{d\vec{H}}{dt}.$$

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 Maxwell's first equation.

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 (2.17) was only within the framework SR, after introducing two postulates of this theory. In this case all terms of relationship (2.17) are obtained from the law of induction, using the conversions of Galileo. Moreover relationship (2.17) this is a complete law of mutual induction, if it are written down in the terms of vector potential. This is the very thing rule, which gives possibility, knowing fields in one IS, to calculate fields in another inertial system, and there was no this rule, until now, in the classical electrodynamics.

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. (3) Let us select for the coordinate axis z in such a way that the axis of would be directed normal to planes, and the axis y was parallel. Then 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 of between them will be equal to the specific current of , which flows along the plates.

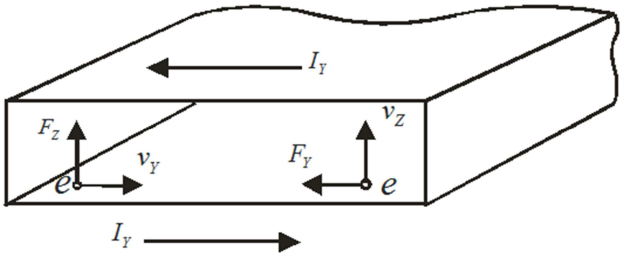

Fig. 3. *Forces, which act on the charge, which moves in the field of vector potential.*

The magnetic field H_x between them will be equal to the specific current I_y , which flows along the plates. If the vector potential on the lower plate is equal to zero, then its y is 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 (1.12) and it is equal

$$F_z = e\mu v_y I_y . \tag{2.20}$$

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 (2.12). This force in the absolute value is again equal to the force, determined by relationship (2.20), 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 (2.12).However, the summary amount of this force will be determined by relationship (2.17), and this force will be always normal to the direction of the motion of charge. Earlier was considered the presence of this force as the action of the Lorentz force, whose nature was obscure, and it was introduced as experimental postulate. It is now understandable that it is the consequence of the combined action of two forces, different in their nature, whose physical sense is now clear. However, in this case one basic problem appears. As we already spoke, from the point of view of third Newton's law, if force acts on the charge, then it must be and result ant it force and place the application of this force must be known. The concept of the magnetic field of answer to this question does not give, since the magnetic field, and vector potential come out as the independent substance, with which occurs such an interaction.

Understanding the structure of forces gives to us the possibility to look to the already known phenomena from other side. With which is connected existence of the forces, which do extend loop with the current? In this case this circumstance can be interpreted not as the action of Lorentz force, but from an energy point of view. The current, which flows through the element of annular turn is located in the field of the vector potential, created by the remaining elements of this turn, and, therefore, it has it stored up potential energy. The force, which acts on this element, is caused by the presence of the potential gradient energy of this element and is proportional to the gradient to the scalar product of the current strength to the vector potential at the particular point. Thus, it is possible to explain the origin of ponderomotive (mechanical) forces. If current broken into the separate current threads, then they all will separately create the field of vector potential. Summary field will act on each thread individually, and, in accordance with last term of the right side of relationship (2.12), this will lead to the mutual attraction.

One should emphasize that in relationship (2.14) and (2.19) all fields have induction origin, and they are connected first with of the local derivative of vector potential, then or 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 (2.14) and (2.15) 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 (2.13) 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 (2.13) participate, introducing identical contributions.

Now let us show that the relationships, obtained by the phenomenological introduction of magnetic vector potential, can be obtained and directly from the Faraday law. With conducting of experiments Faraday established that in the outline is induced the current, when in the adjacent outline direct current is switched on or is turned off or adjacent outline with the direct current moves relative to the first outline. Therefore in general form Faraday law is written as follows:

$$\oint \vec{E}'d\vec{l}' = -\frac{d\Phi_B}{dt} \tag{2.21}$$

This writing of law indicates that during the record of the circulation integral of the vector $\vec{E}$ in moving prime IS near $\vec{E}$ and $d\vec{l}$ should be placed the primes, which indicate that that the flow is determined in one IS, and field in another. 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 (2.21) must stand particular time derivative.

Complete time derivative in relationship (2.21) indicates the independence of the eventual result of appearance e.m.f. in the outline from the method of changing the flow. Flow can change both due to the local derivative of magnetic flux on the time and due to its convective component. We calculate the value of magnetic flux in relationship (2.21) with the aid of the expression:

$$\Phi_B = \int \vec{B}\, d\vec{s}' \qquad (2.22)$$

where the magnetic induction $\vec{B} = \mu_0 \vec{H}$ is determined in the fixed coordinate system, and the element $d\vec{s}'$ is determined in the moving system.

Taking into account (2.21), we obtain from (2.22)

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

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

$$\oint \vec{E}' d\vec{l}' = -\int \frac{\partial \vec{B}}{\partial t}\, d\vec{s}' - \oint \left[\vec{B}\times\vec{v}\right]\, d\vec{l}' - \int \vec{v}\ div\vec{B}\ d\vec{s}' \qquad (2.23)$$

In this case contour integral is taken on the outline $d\vec{l}'$, which covers the area $d\vec{s}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the Galileo conversions, i.e., $d\vec{l}' = dl$ and $d\vec{s}' = d\vec{s}$. Since $div\vec{B} = 0$, from (1.23) we obtain the relationship

$$\vec{E}' = \vec{E} + \left[\vec{v}\times\vec{B}\right], \qquad (2.24)$$

Let us note that this relationship is obtained not by the introduction of postulate about the Lorentz force, or from the Lorenz conversions, but directly from the Faraday law, moreover within the framework the Galileo conversions. Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

Taking into account that $\vec{H} = rot\ \vec{A}_H$, from relationship (2.23) we obtain

$$\vec{E}' = -\mu_0 \frac{\partial A_H}{\partial t} + \mu_0 \left[\vec{v}\times rot\ \vec{A}\right],$$

and further

$$\vec{E}' = -\mu_0 \frac{\partial \vec{A}_H}{\partial t} - \mu_0\left(\vec{v}\nabla\right)\vec{A}_H + \mu_0 grad\left(\vec{v}\vec{A}_H\right). \qquad (2.25)$$

Again came out relationship (2.13), 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.

3. Physical Causes for the Appearance of the Vector Potential of Magnetic Field

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions pour on upon transfer of one IS to another, and to also explain what dynamic potentials and fields can generate the moving charges. The first step, demonstrated in the works [2-5], was made in this direction a way of the introduction of the symmetrical laws of magnetoelectric and electromagnetic induction. Further development of these ideas their practical application is carried out in the works [6-13]. These laws are written as follows:

$$\oint \vec{E}' dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v}\times\vec{B}\right] dl'$$
$$\oint \vec{H}' dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v}\times\vec{D}\right] dl' \qquad (3.1)$$

or

$$rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v}\times\vec{B}\right]$$
$$rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v}\times\vec{D}\right] . \qquad (3.2)$$

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

$$\vec{E}' = \left[\vec{v}\times\vec{B}\right]$$
$$\vec{H}' = -\left[\vec{v}\times\vec{D}\right] \qquad (3.3)$$

In relationships (3.1-3.3) prime and not prime values present fields and elements in moving and fixed IS respectively. It must be noted, that conversions (3.3) earlier could be obtained only from the Lorenz conversions.

The relationships (3.1-3.3), which present the laws of induction, do not give information about how arose fields in initial fixed IS. They describe only laws governing the propagation and conversion pour on in the case of motion with respect to the already existing fields.

The relationship (3.3) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e., motion in the fields $\vec{H}$ leads to the appearance pour on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [4].Outside of a long charged rod electric field is determined from relation $E = \frac{g}{2\pi\varepsilon r}$, where g is linear charge rod, r is distance from the axis of the rod to the observation point.

If we in parallel to the axis of rod in the field of E begin to move with the speed Δv another IS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IS 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 $E'_v(r)$ in moving IS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$ .In the final analysis in moving IS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship:

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

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

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

where $v_\perp$ is 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:

$$\varphi'(r, v_\perp) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r} = \varphi(r)ch\frac{v_\perp}{c}, \quad (3.4)$$

where $\varphi(r)$ is 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.

Leading edge of the electric pulse, which is extended in the long line, is depicted in Fig. 4.

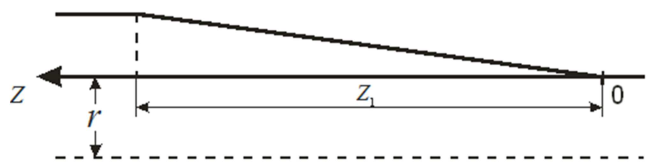

Fig. 4. *Current wave front, which is extended in the long line.*

The section z_1 represents the pulse rise time, and in this section proceeds the acceleration of charges from their zero speed (more to the right the section z_1) to the value of speed, determined by the relationship

$$v = \sqrt{\frac{2eU}{m}},$$

where e and m are charge and the mass of current carriers, and U is voltage drop across the section z_1 .Then the dependence of the speed of current carriers on the coordinate will take the form:

$$v^2(z) = \frac{2e}{m}\frac{\partial U}{\partial z}z \quad (3.5)$$

Since we accepted the linear dependence of stress from the time on incoming line, the equality occurs

$$\frac{\partial U}{\partial z} = \frac{U}{z_2} = E_z,$$

where E_z is field strength, which accelerates charges in the section z_1. Consequently, relationship (3.5) we can rewrite

$$v^2(z) = \frac{2e}{m}E_z z.$$

Using for the value of scalar- vector potential relationship (3.4), let us calculate it as the function z on a certain distance of r from the line of

$$\varphi(z) = \frac{e}{4\pi\ \varepsilon_0 r}\left(1 + \frac{1}{2}\ \frac{v^2(z)}{c^2}\right) = \frac{e}{4\pi\ \varepsilon_0 r}\left(1 + \frac{eE_z z}{mc^2}\right). \quad (3.6)$$

For the record of relationship (3.6) are used only first two members of expansion in series, functions, determined by relationship (3.4).

Using the formula $E = -grad\ \varphi$, and differentiating relationship (3.6) on z, we obtain

$$E_z' = -\frac{e^2 E_z}{4\pi\ \varepsilon_0 rmc^2} \quad (3.7)$$

where E_z' is the electric field, induced at a distance r from the conductor of line. Near E we placed prime in connection with the fact that calculated field it moves along the conductor of line with the speed of light, inducing in the conductors surrounding line the induction currents, opposite to those, which flow in the basic line. The acceleration a, tested by the charge e in the field E, is determined by the relationship $a_z = \frac{eE_z}{m}$. Taking this into account from (3.7) we obtain

$$E_z' = -\frac{ea_z}{4\pi\ \varepsilon_0 c^2\ r} \quad (3.8)$$

Thus, the charges, accelerated in the section of the line z_1, induce at a distance r from this section the electric field, determined by relationship (3.8). Direction of this field conversely to field, applied to the accelerated charges. Thus, is obtained the law of direct action, which indicates what electric fields generate around themselves the charges, accelerated in the conductor. This law can be called the law of electro-electrical induction, since it, passing fields mediators (magnetic field or vector potential), gives straight answer to what electric fields the moving electric charge generates around itself. This law gives also answer about the place of the application of force of interaction between the charges. Specifically, this relationship, but not Faraday law, we must consider as the fundamental law of induction, since. specifically, it establishes the reason for the appearance of induction electrical pour on around the moving charge. In what the difference between the proposed approach and that previously existing consists. Earlier we said that the moving charge generates vector potential, and the already changing vector potential generates electric field. Relationship (3.8) gives the possibility to exclude this intermediate operation and to pass directly from the properties of the moving charge to the induction fields. Let us show that relationship it follows from this and the introduced earlier phenomenologically vector potential, and, therefore, also magnetic field. Equality (3.8) it is possible to rewrite

$$E_z' = -\frac{e}{4\pi\ \varepsilon_0 rc^2}\frac{\partial v_z}{\partial t} = -\mu\frac{\partial A_H}{\partial t},$$

from where, integrating by the time, we obtain

$$A_H = \frac{ev_z}{4\pi r}$$

This relationship corresponds to the determination of vector potential. It is now evident that the vector potential is the direct consequence of the dependence of the scalar potential of charge on the speed. The introduction also of vector potential and of magnetic field this is the useful mathematical device, which makes it possible to simplify the solution of number of electrodynamic problems, however, one should remember that by fundamentals the introduction of these pour on it appears scalar- vector potential.

4. Conclusion

Question arises, and is it possible to generally exclude from the custom the magnetic field, which is introduced into the electrodynamics by phenomenological method. Above it was convincingly shown that entire electrodynamics can be built without the use of this concept as magnetic field. In this case as its basis must be assumed such fundamental concepts as the electric field, which is the gradient of scalar potential, and also the vector potential, by the reason for appearance of which there is dependence of the scalar potential of charge on the speed of its relative motion.

The concept of magnetic field as real vector exists since scientific they noted, how organizationally the iron shavings near the magnets or the annular currents behave. This behavior seemed by the almost obvious consequence of the presence of some force vector, which acts on them. And this vector acknowledged magnetic field. However, obvious is not always real. It occurs that this behavior of the iron shavings is connected not with existence of magnetic field as physical material field, but with the fact that currents possess potential energy according to the relation to friend to the friend, and this energy for the case of stable equilibrium is always approached the minimum. Specifically, for this reason the iron shavings, in which separate atoms present microscopic annular currents, and behave thus. But magnetic field proved to be altogether only the mathematical fabrication, without which can be built entire classical electrodynamics.

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