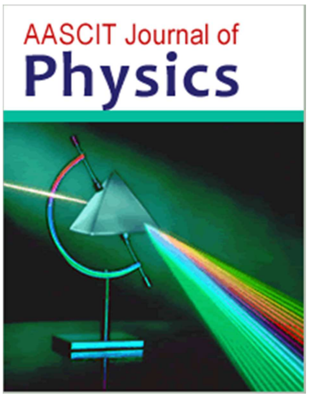
AASCIT Journal of Physics
2015; 1(3): 206-221
Published online June 20, 2015 (http://www.aascit.org/journal/physics)

AASCIT American Association for Science and Technology



Physics of Excitation and Conversion of Electrical Fields and Special Feature of the Propagation of the Wave Electrical Energy

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Keywords

Maxwell's Equation,
Substantional Derivative,
Electromagnetic Induction,
Magnetoelectric Induction,
Kinetic Wave Energy,
Rest Energy of Wave,
Speed of Wave Energy

Received: March 25, 2015
Revised: June 3, 2015
Accepted: June 4, 2015

Citation

F. F. Mende, A. V. Kukushkin, A. A. Rukhadze. Physics of Excitation and Conversion of Electrical Fields and Special Feature of the Propagation of the Wave Electrical Energy. *AASCIT Journal of Physics*. Vol. 1, No. 3, 2015, pp. 206-221.

Abstract

The fundamental equations of contemporary classical electrodynamics are Maxwell's equations. But not all know that those equations, which it is customary to assume as Maxwell's equations, not are those equations, which used itself Maxwell. During writing of its equations it used the substantional derivative, that are made themselves they invariant with respect to the conversions of Galileo. Subsequently Hertz and Heaviside excluded from the substantional derivative its convective part, after writing down Maxwell's equations in the partial derivatives. In the article are examined the conversions of electromagnetic pour on upon transfer of one inertial system to another, obtained on the basis of the equations of electromagnetic and magnetoelectric induction with the use by the substantional derivative and they are examined the consequences, which escape from such conversions. Physics of the emission of electromagnetic waves on the basis of the concept of scalar-vector potential is examined and shown that this concept assumes the clear separation between the gradient and vorticity fields. Are discussed the problems, which appear in the theory of electromagnetism because of the delivery here of the principles of relativistic mechanics for describing the motion of energy of free waves carried out in the article. It is shown that this delivery leads to the sufficiently rigid kinematic censorship. Thus, examined in the article for an example normal H_{n0} is waves hollow rectangular waveguide this censorship do not pass. Are discussed questions and consequences for the theories, connected with this fact.

1. Introduction

The laws of classical electrodynamics they reflect experimental facts they are phenomenological. Unfortunately, contemporary classical electrodynamics is not deprived of the contradictions, which did not up to now obtain their explanation. The fundamental equations of contemporary classical electrodynamics are Maxwell's equations. But not all know that the given equations, which it is customary to assume as Maxwell's equations, these are not those equations, which are given in his treatise [1]. During writing of its equations it used the substantional derivative, that are made themselves they invariant with respect to the conversions of Galileo. Subsequently Hertz and Heaviside excluded from the substantional derivative its convective part [2, 3], after writing down Maxwell's equations in the partial derivatives. In this form the equations are invariant to the conversions of Lorenz and this approach laid way to the creation of the special theory of relativity (SR). In Maxwell's equations are not contained the indications of how occurs the emission of electromagnetic waves and which physics of this process.

In the article are examined the conversions of electromagnetic pour on upon transfer of one inertial system to another, obtained on the basis of the equations of electromagnetic and magnetoelectric induction with the use by the substantional derivative and they are examined the consequences, which escape from such conversions.

Present article is dedicated to questions of practical application and refinement of the ideas, presented in the article of authors [4]. The central clause of article [4] is reduced to the following assertion. The description of the phenomena, which relate to the scope of field theory, in particular, electromagnetic, is not complete, if we do not add to it the system of *mechanical* of relativistic vector *the equations of motion* for the scalar positively determined wave function of the energy density, *W* free field and vector density function of its pulse,

$$\vec{g} = c^{-2}\vec{S}, \tag{1.1}$$

where $\vec{S}$ is Poynting vector [5], *c* is speed of light in the vacuum.

Like as Maxwell equations establish at the arbitrary moment of time the differential linkage between two vector position functions in the 3d- space between the depending on the time vectors of magnetic, $\vec{B}$, and electrical, $\vec{E}$, fields, differential the equations indicated must establish the same connection between the scalar function *W* and the vector function **S**. Such equations must be mechanical. Therefore, in contrast to the Maxwell equations they must include explicitly the 3- vector $\vec{V}_E$, which characterizes value and direction of speed for moving the energy density of field. This vector, thus, with the correct solution of general problem with the use *the complete* of system of equations must be strictly defined at the arbitrary point of space at the arbitrary moment of time (at any point of Minkowski's space). Let us note very crucial point. Namely, the complete of system of equations for determining the vectors of free electromagnetic field is now the system, which includes in itself simultaneously and system of Maxwell's equations, and the system of vector equations of motion for the energy densities and pulse of field. If this is so, that the particular solutions of Maxwell's equations for the vectors of the fields, which do not satisfy the system of vector equations of motion for the energy densities and pulse of this field, cannot then be considered as the physical solutions. Physical can be considered only such particular solutions of Maxwell's equations, which simultaneously satisfy equation of motion for the density of the energy-momentum of field or, otherwise, for which the 3- vector of the speed $\vec{V}_E$ can be accurately determined precisely from these equations of motion. In the theory of electromagnetism, thus, are included the laws of relativistic mechanics, which creates in it fundamentally new situation. Namely, for the electromagnetic waves these laws, in the first place, determine the relativistic energy-kinematics of field and, in the second place, therefore, by them imputes the role “kinematic censorship”, since far from for all particular solutions of Maxwell's equations relativistic energy-kinematics can be in principle determined. This was noted by the authors already in the first article on this problems [4].

Let us note that for the dispersion-free medium of vacuum the vector $\vec{V}_E$, if it only can be determined for this particular solution Maxwell's equations, will be also vector for the velocity of propagation of energy of field. Furthermore, essential moment is the following. If

$$\left|\vec{V}_E\right| < c, \tag{1.2}$$

that the general principles of relativistic mechanics [5, 6] conduct to the assumption that the total energy of the field of the wave, which is freely extended in the vacuum, for which *is correctly selected* the wave function, must consist in this case (1.2) of two parts: rest energy and kinetic energy, which, strictly, and characterizes the energy-kinematics of the wave, moving in the vacuum with the speed $\vec{V}_E$. Case (1.2) realizes for the surface waves (PW), which are extended in the vacuum above impedance plane [4]. It was [shown] in 1 that the function for the energy density of rest TM- polarized PW is determined by 4-scalar of the field1:

$$\eta = \frac{1}{2}\left(\vec{B}^2 - \vec{E}^2\right) = W_B - W_E. \tag{1.3}$$

Let us note that in (1.3), as it is everywhere lower in similar cases, before the bracket in the right side of the formula is omitted the coefficient $(4\pi)^{-1}$. The energy density of the rest of wave in this case is the energy density of permanent field, which, therefore, has no effect on, the displacement of kinetic wave energy. Essential is the fact that, according to the general principles of relativistic mechanics, the density of kinetic energy $W^{(k)}$ in the moving, associated wave, the prime frame of reference (FR) must become zero,

$$W'^{(k)} = 0. \tag{1.4}$$

The energy density of rest is converted to FR (with the use of Lorenz conversions) by means of the additional multiplication of expression (1.3) (undertaken with the correct sign) to the Lorenz factor γ. Rest energy of wave in some final volume in FR taking into account relationship for the elements of volume, $dV' = \gamma^{-1}dV$ (taking into account it is

1 In formula (58) of article [4] was calculated 4- scalar (3) for TM-polarized PW. For this polarization at any point of space occurs, however, that $\eta < 0$, but in the right side of formula (58) into [2] stands erroneously positive sign, but not “minus”. As it will be shown below, this error not what influences. Actually, for TM-polarized BY PW as the energy density of rest it is necessary simply to take expression for 4-scalar (1.3) with the sign “minus”. On the contrary, for Those-polarized PW the energy density of rest is determined by 4-scalar (1.3) with the positive sign.

Lorentz the decrease of lengths), after the integration for it of energy density remains, thus, the same, what it was in the fixed frame of reference (FFR). Consequently, rest energy of wave with its displacement in the space together with the wave at a velocity, which satisfies condition (1.2), remains the element, absolutely indifferent to the process of moving2. This (1.3) is connected with the fact that (the relativistic invariant of field. Hence it follows that the determination of this invariant and its properties they must play the leading part in the solution of problem regarding the density function of kinetic wave energy. Thus, if it proves to be (see it is below), that for the selected from Maxwell's equations particular solutions, $\vec{E}$ and $\vec{B}$, property of invariant (1.3) they do not make possible to identify him as "energy density" in principle, then for this wave it is not possible to determine very concept "kinetic energy". The energy-kinematics of this wave proves to be in this case absolutely indeterminate. This wave does not pass "kinematic censorship". Consequently, the corresponding particular solutions of Maxwell's equations will not satisfy the requirements, which must be presented to the physical field, although in entire rest they, it would seem, very well reflect physics of wave processes. Such solutions of Maxwell's equations, nevertheless, must be rejected; their place they must engage other solutions, which pass "kinematic censorship" in the sense that their energy-kinematics it can be accurately determined.

Case (1.2) is remarkable from that point of view, that condition (1.2) makes it possible to assert that for this wave can exist FR, in which relationship (1.4), is fulfilled, if, of course, the concept "kinetic energy" of wave can be determined in principle. We into 1 have indicated one example, which relates to the surface wave [4].

However, for the electromagnetic (and gravitational) field the case is more characteristic

$$\left|\vec{V}_E\right| = c\,. \tag{1.5}$$

The basic condition of the special theory of relativity (SR) superimpose in this case (1.5) prohibition on existence FR. For similar pour on 4-scalar (1.3) it is equal to zero,

$$\eta = 0,\ \left(W_B = W_E\right). \tag{1.6}$$

G. Beytmen in its book [7] called fields, for which is satisfied the condition $\eta \neq 0$, not selfed-adjoin, and field, for which is satisfied condition (1.6), by those by respectively self-adjoined. However, at present in the theory of electromagnetism a similar terminology is used in other sense. Therefore in order not to introduce confusion, we will call the fields, which g. Beytmen was called non-self-adjoint, longitudinal-transverse, and the fields, which satisfy condition (1.6) - by transverse, as this occurs actually.

The condition (1.6) for the transverse waves, which relates to case (1.5), speaks, that in this case the total energy of wave cannot be broken into the sum of kinetic energy and rest energy; for similar pour on it cannot be indicated FR and, therefore, they do not have rest energy, these are - mass-free fields. "Kinetic energy" in such waves is entire total energy of wave.

2 With the same success it is possible to say [4] that the density function of rest energy PW (energy of permanent field) remains on the spot, without being anywhere moved.

From a relativistic point of view the 3-vector $\vec{g} = \sum_{i=1}^{3} g_i \vec{e}_i$ and scalar W form the 4-vector of the density of the energy-momentum of the wave:

$$\vec{P} = \vec{g} - (W/c)\vec{e}_4\,. \tag{1.7}$$

If we take 4-divergence from (1.7) and to make level obtained scalar with zero, then taking into account (1.1) we will obtain the scalar equation:

$$div\vec{S} + \partial W/\partial t = 0\,, \tag{1.8}$$

which is nothing else but the law of conservation of energy in the differential form for the field of the freely extended wave. Poynting into [8] established that for the arbitrary electromagnetic field in the vacuum, the values, entering in (1.8), are expressed as the vectors of field as follows:

$$\vec{S} = c\left[\vec{E}\times\vec{B}\right], \tag{1.9}$$

$$W = \frac{1}{2}\left(\vec{B}^2 + \vec{E}^2\right) = W_B + W_E\,. \tag{1.10}$$

Has great significance that that "the equation of energy" (1.8) is by no means "the equation of continuity", which connects the input it quantities **S** and *W*. On the contrary, for the 4-vector of the electric current density,

$$\vec{J} = 4\pi\left(c^{-1}\vec{j} - \rho\vec{e}_4\right) \tag{1.11}$$

the equation, similar (1.8),

$$div\vec{j} + \partial\rho/\partial t = 0 \tag{1.12}$$

appears, as it is known [5, 6], "the equation of continuity". This regarding indicates that the fact that

$$\vec{j} = \rho\vec{V}\,, \tag{1.13}$$

where $\vec{V}$ is 3- vector, which characterizes motion FR, where $\vec{j}' = 0$, $\rho' = \gamma^{-1}\rho$, relative to FFR, in coordinates of which is recorded equation (1.12). Equation (1.12) is "the equation of continuity" because of the fact that the expression for 4-vector (1.11) is derived with the aid of the Lorenz conversions upon transfer from FR to FFR, executed for the 4-vector of current density, recorded in prime, FR, in which the three-dimensional components of 4-vector are equal to zero regarding and therefore $\vec{J}' = -4\pi\rho'\vec{e}_4'$. Nothing the similar to 4-vector (1.7) in connection with said and cannot be carried out. This means that "the Umov formula",

$$\vec{S} = \vec{V}_E W\,, \tag{1.14}$$

which Umov obtained 30 years prior to relativistic revolution in physics [9] and, and, in connection with to the motion of energy of acoustic waves in the solid body, for the electromagnetic waves, from a relativistic point of view, it was not well-off. This especially one can see well from the fact that in the case (1.5) OF FR for the electromagnetic waves there does not exist. Moreover, as it was shown in [4] in connection with PW, in the case (1.2), when for the electromagnetic wave it is possible to indicate FR, the three-dimensional components of 4-vector (1.7) in it are by no means equal to zero. Consequently, and in this case existence of the vector **S** in FFR is not explained by the convection of energy density. Nevertheless, formula (1.12) widely is used in the theory of electromagnetism [10, 11] for enumerating the module $\vec{V}_E$, but, as a rule, into somewhat different size:

$$\left|\vec{V}_E\right| = \bar{S}_z / \bar{W}, \tag{1.15}$$

where $\bar{S}_z$ is energy flow in the direction of the axis z for the unit of time through a certain area (for example, through the cross section of waveguide [10]), $\bar{W}$ is total energy of wave, accumulated in the appropriate volume for the unit of time (during the oscillatory period for the simple harmonic waves).

Since formula (1.14), as it is said above, is in drastic contradiction with principles SR, formula (1.15), which is enjoyed great success in the theory of electromagnetism [10], gives altogether only the good palliative solution of the problem of the calculation of the length of the vector $\vec{V}_E$, but not and what is more. The success of palliative formula (1.15) in the theory of electromagnetism [10] is based on what with the substitution of formula (1.14) (or (1.15)) the latter is satisfied in the equation of energy (1.8). However, to say, that this all which is required, for the correct determination of the vector $\vec{V}_E$, nevertheless what to say that for the solution of the problems of mechanics it suffices to use the scalar law of conservation of energy, but vector "equation of motion" not it is urgent. The basic leit-motif of the article of authors [4] was reduced to the refutation this of the deliberately false "idea" in connection with of the theory of electromagnetism.

In the mechanics really for the case of the rectilinear irregular motions (when the direction of the motion in advance is known) of the law of conservation of total energy for the conservative system is sufficient for determining the module of the velocity vector of material point. However, one ought not to forget that this only because energy is the integral of vector "equation of motion", whose knowledge, therefore, is and here necessary condition for the correct solution of problem. That more this is urgent for the theory of electromagnetism, since. the motion of the density field of the energy-momentum of electromagnetic wave this is not one and the same, that also the motion of material point or discrete object, which occupies in the space final volume.

In article [4] was obtained the system of vector relativistic equations of motion for the scalar- vector density field of energy-momentum, which establishes the connection between vector S and scalar $W^{(k)}$ for the waves freely extended in the vacuum. In the case of free field from this system simple relativistic formula for the vector, which characterizes the speed of the motion of the energy density of the field was brought out:

$$\vec{V}_E = \frac{\left[rot\vec{S} \times \dot{\vec{\sigma}}\right]}{\left(rot\vec{S}\right)^2}, \tag{1.16}$$

where

$$\dot{\vec{\sigma}} = \frac{\partial \vec{S}}{\partial t} + c^2 gradW^{(k)}. \tag{1.17}$$

Let us recall that in the case of transverse waves the density function of kinetic energy in (1.17) is substituted by the density of the total energy of wave, $W^{(k)} \to W$.

The purpose of present article is reduced to an attempt at the wider approval of formula (1.16) in comparison with by the fact that it was already made for this into [4]. It will be shown that from a relativistic point of view the longitudinal-transverse normal waves of hollow singly connected waveguides do not pass "kinematic censorship" for these waves it because proves to be indeterminate the concept "kinetic energy". This very "strange conclusion", nevertheless, is in the complete agreement with the analogous conclusion, made into [4] relative to the energy-kinematics of transverse uniform plane waves (OPW). Since the longitudinal-transverse waves in the rectangular waveguide can be the superposition of transverse OPW of Brillouin with the indeterminate energy-kinematics, the drawn conclusion is by no means strange, but, on the contrary, by very natural.

In [4] was shown that the transverse plane waves pass "kinematic censorship" only when transverse OPW to replace with the transverse heterogeneous plane waves (NPW). The Poynting vector of these waves at the singular points of the plane of equal phases is had logarithmic special features [12]. Because of the logarithmic nature of these special features the total flux of the energy through the cross section with the size, which covers completely the scales of the macro- and of microcosm, occurs value final [12]. Therefore the energy-kinematics of the longitudinal-transverse waves of the rectangular waveguide, probably, it can be accurately determined only when transverse OPW of Brillouin to replace with transverse NPW with the logarithmic special features, but this already exceeds the scope of present article. From a physical point of view this will indicate passage to the description of phenomena in the waveguides into the language of the photon idea of wave processes that by itself, probably, cannot cause no reaction of rejection in specialists. This reaction it can cause, however, that which into [4, 12] is indicated to the possibility of the simulation of wave functions for the particles *the classical* of field on the base of the singular solutions of Maxwell's equations, which pass "kinematic censorship". The expected reaction will be emotional the regular, since contemporary quantum field theory the role of wave functions for the photons they play transverse OPW, which, as shown into [4], do not pass "kinematic censorship" to the above-indicated sense and must be rejected as false for physicists the solutions of Maxwell's equations.

2. Physics of Excitation and Conversion of Electrical Fields and Waves

2.1. Dynamic Potentials and the Field of the Moving Charges

Gertz not only rewrote Maxwell's equations in the terms of partial derivatives. 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 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 fields on must lead to their change.

Being located in assigned IS, 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 IS 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 fields on upon transfer of one inertial system to another. This deficiency removes SR, basis of which are the covariant Lorenz conversions. With the entire mathematical validity of this approach the physical essence of such conversions up to now remains unexplained [13].

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions fields 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 [14-20], was made in this direction a way of the introduction of the symmetrical laws of magnetoelectric and electromagnetic induction. These laws are written as follows:

$$\begin{aligned} \oint \vec{E}'dl' &= -\int \frac{\partial \vec{B}}{\partial t}d\vec{s} + \oint \left[\vec{v}\times\vec{B}\right]dl' \\ \oint \vec{H}'dl' &= \int \frac{\partial \vec{D}}{\partial t}d\vec{s} - \oint \left[\vec{v}\times\vec{D}\right]dl' \end{aligned}, \qquad (2.1.1)$$

or

$$\begin{aligned} rot\vec{E}' &= -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v}\times\vec{B}\right] \\ rot\vec{H}' &= \frac{\partial \vec{D}}{dt} - rot\left[\vec{v}\times\vec{D}\right] \end{aligned}. \qquad (2.1.2)$$

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

$$\begin{aligned} \vec{E}' &= \left[\vec{v}\times\vec{B}\right] \\ \vec{H}' &= -\left[\vec{v}\times\vec{D}\right] \end{aligned}. \qquad (2.1.3)$$

In relationships (2.1.1-2.1.3), which assume the validity of the Galileo conversions, prime and not prime values present fields and elements in moving and fixed IS respectively. It must be noted, that conversions (2.1.3) earlier could be obtained only from Lorenz conversions.

The relationships (2.1.1-2.1.3), 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 fields on in the case of motion with respect to the already existing fields.

The relationship (2.1.3) 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 fields on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [16].

The electric field $E = \frac{g}{2\pi\varepsilon r}$ outside the charged long rod with a linear density g decreases as $\frac{1}{r}$, where r is distance from the central axis of the rod to the observation point.

If we in parallel to the axis of rod in the field 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:

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

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:

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c}, \tag{2.1.4}$$

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. During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp)=Hch\frac{v_\perp}{c}.$$

where $v_\perp$ is speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components fields on parallel speeds IS as $E_\uparrow$ and $H_\uparrow$, and $E_\perp$ and $H_\perp$ as components normal to it, then with the conversion fields on components, parallel to speed will not change, but components, normal to the direction of speed are converted according to the rule

$$\begin{aligned}\vec{E}'_\perp&=\vec{E}_\perp ch\frac{v}{c}+\frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},\\ \vec{B}'_\perp&=\vec{B}_\perp ch\frac{v}{c}-\frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},\end{aligned} \tag{2.1.5}$$

where c is speed of light.

Conversions fields (2.1.5) they were for the first time obtained in the work [5].

However, the iteration technique, utilized for obtaining the given relationships, it is not possible to consider strict, since its convergence is not explained

Let us give a stricter conclusion in the matrix form even let us show that the form of conversions is wholly determined by the type of the utilized law of addition of velocities - classical or relativistic.

Let us examine the totality IS of such, that IS K_1 moves with the speed Δv relative to IS K, IS K_2 moves with the same speed Δv relative to K_1, etc. If the module of the speed Δv is small (in comparison with the speed of light c), then for the transverse components fields on in IS K_1, K_2,…. we have:

$$\begin{aligned}\vec{E}_{1\perp}&=\vec{E}_\perp+\Delta\vec{v}\times\vec{B}_\perp & \vec{B}_{1\perp}&=\vec{B}_\perp-\Delta\vec{v}\times\vec{E}_\perp/c^2\\ \vec{E}_{2\perp}&=\vec{E}_{1\perp}+\Delta\vec{v}\times\vec{B}_{1\perp} & \vec{B}_{2\perp}&=\vec{B}_{1\perp}-\Delta\vec{v}\times\vec{E}_{1\perp}/c^2\end{aligned}. \tag{2.1.6}$$

Upon transfer to each following IS of field are obtained increases in $\Delta\vec{E}$ and $\Delta\vec{B}$

$$\Delta\vec{E}=\Delta\vec{v}\times\vec{B}_\perp,\qquad \Delta\vec{B}=-\Delta\vec{v}\times\vec{E}_\perp/c^2, \tag{2.1.7}$$

where of the field $\vec{E}_\perp$ and $\vec{B}_\perp$ relate to current IS. Directing Cartesian axis x along $\Delta\vec{v}$, let us rewrite (2.1.7) in the components of the vector

$$\Delta E_y=-B_z\Delta v,\qquad \Delta E=B_y\Delta v,\qquad \Delta B_y=E_z\Delta v/c^2. \tag{2.1.8}$$

Relationship (2.1.8) can be represented in the matrix form

$$\Delta U=AU\Delta v\qquad \begin{pmatrix}0&0&0&-1\\0&0&1&0\\0&1/c^2&0&0\\-1/c^2&0&0&0\end{pmatrix}\qquad U=\begin{pmatrix}E_y\\E_z\\B_y\\B_z\end{pmatrix}.$$

If one assumes that the speed of system is summarized for the classical law of addition of velocities, i.e. the speed of final IS $K'=K_N$ relative to the initial system K is $v=N\Delta v$, then we will obtain the matrix system of the differential equations

$$\frac{dU(v)}{dv}=AU(v)\ , \tag{2.1.9}$$

with the matrix of the system v independent of the speed A. The solution of system is expressed as the matrix exponential curve $\exp(vA)$:

$$U'\equiv U(v)=\exp(vA)U,\quad U=U(0), \tag{2.1.10}$$

here U is matrix column fields on in the system K, and U' is matrix column fields on in the system K'. Substituting (2.1.10) into system (2.1.9), we are convinced, that U' is actually the solution of system (2.1.9):

$$\frac{dU(v)}{dv}=\frac{d\left[\exp(vA)\right]}{dv}U=A\exp(vA)U=AU(v).$$

It remains to find this exponential curve by its expansion in the series:

$$\exp(va)=E+vA+\frac{1}{2!}v^2A^2+\frac{1}{3!}v^3A^3+\frac{1}{4!}v^4A^4+...$$

where E is unit matrix with the size 4×4. For this it is convenient to write down the matrix A in the unit type form

$$A=\begin{pmatrix}0 & -\alpha\\ \alpha/c^2 & 0\end{pmatrix},\quad \alpha=\begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix},\quad 0=\begin{pmatrix}0 & 0\\ 0 & 0\end{pmatrix},$$

then

$$A^2=\begin{pmatrix}-\alpha^2/c^2 & 0\\ 0 & -\alpha/c^2\end{pmatrix}\qquad A^3=\begin{pmatrix}0 & \alpha^3/c^2\\ -\alpha^3/c^4 & 0\end{pmatrix},$$

$$A^4=\begin{pmatrix}\alpha^4/c^4 & 0\\ 0 & \alpha^4/c^4\end{pmatrix},\qquad A^5=\begin{pmatrix}0 & -\alpha^5/c^4\\ \alpha^5/c^6 & 0\end{pmatrix}\ldots..$$

And the elements of matrix exponential curve take the form

$$\left[\exp(vA)\right]_{11}=\left[\exp(vA)\right]_{22}=I-\frac{v^2}{2!c^2}+\frac{v^4}{4!c^4}-....,$$

$$\left[\exp(vA)\right]_{21}=-c^2\left[\exp(vA)\right]_{12}=\frac{\alpha}{c}\left(\frac{v}{c}I-\frac{v^3}{3!c^3}+\frac{v^5}{5!c^5}-.....\right),$$

where I is the unit matrix 2×2. It is not difficult to see that $-\alpha^2=\alpha^4=-\alpha^6=\alpha^8=....=I$, therefore we finally obtain

$$\exp(vA)=\begin{pmatrix}Ich\ v/c & -c\alpha sh\ v/c\\ \left(\alpha sh\ v/c\right)/c & Ich\ v/c\end{pmatrix}=\begin{pmatrix}ch\ v/c & 0 & 0 & -csh\ v/c\\ 0 & ch\ v/c & csh\ v/c & 0\\ 0 & \left(ch\ v/c\right)/c & ch\ v/c & 0\\ -\left(sh\ v/c\right)/c & 0 & 0 & ch\ v/c\end{pmatrix}.$$

Now we return to (2.1.10) and substituting there $\exp(vA)$, we find

$$E'_y=E_y ch\ v/c-cB_z sh\ v/c,\qquad E'_z=E_z ch\ v/c+cB_y sh\ v/c,$$
$$B'_y=B_y ch\ v/c+\left(E_z/c\right)sh\ v/c,\quad B'_z=B_z ch\ v/c-\left(E_y/c\right)sh\ v/c\ .$$

Or in the vector record

$$\vec{E}'_\perp=\vec{E}_\perp ch\ \frac{v}{c}+\frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},\qquad \vec{B}'_\perp=\vec{B}_\perp ch\ \frac{v}{c}-\frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},\ . \qquad (2.1.11)$$

This is conversions (2.1.5)

Regular question arises, why differ the conversions examined, indeed with the low speeds $\Delta\vec{v}$ occur identical relationships (2.1.6) and (2.1.7). The fact is that according to the relativistic law of addition of velocities, are added not speeds, but rapidities. According to definition the rapidity is introduced as

$$\theta=c\ arth\frac{v}{c}. \qquad (2.1.12)$$

Precisely, if the rapidity of the systems K_1 and K, K_2 and K_1, K_3 and K_2 they are distinguished to $\Delta\theta$, then rapidity the rapidity IRS $K'=K_N$ relative to K is $\theta=N\Delta\theta$. With the low speeds $\Delta\theta\cong\Delta v$; therefore formula (2.1.7) it is possible to rewrite so

$$\Delta\vec{E}=\Delta\theta\times\vec{B}_\perp,\qquad \Delta\vec{B}=-\Delta\vec{\theta}\times\vec{E}_\perp/c^2,$$

where $\vec{\theta}=\theta\frac{\vec{v}}{v}$. System (2.1.9) taking into account the additivity of rapidity, but not speed, it is substituted by the system of equations

$$\frac{dU(\theta)}{d\theta}=AU(\theta).$$

Thus, all computations will be analogous given above, only with the difference that in the expressions instead of the speeds will figure rapidity. In particular formulas (2.1.11) take the form

$$\vec{E}'_\perp=\vec{E}_\perp ch\ \frac{\theta}{c}+\frac{\theta}{c}\vec{\theta}\times\vec{B}_\perp sh\frac{\theta}{c},\qquad \vec{B}'_\perp=\vec{B}_\perp ch\ \frac{\theta}{c}-\frac{1}{\theta c}\vec{\theta}\times\vec{E}_\perp sh\frac{\theta}{c},$$

or

$$\vec{E}'_\perp=\vec{E}_\perp ch\ \frac{\theta}{c}+\frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{\theta}{c},\qquad \vec{B}'_\perp=\vec{B}_\perp ch\ \frac{\theta}{c}-\frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{\theta}{c}\ . \qquad (2.1.13)$$

Since

$$ch\frac{\theta}{c}=\frac{1}{\sqrt{1-th^2\left(\theta/c\right)}},\qquad sh\frac{\theta}{c}=\frac{th\left(\theta/c\right)}{\sqrt{1-th^2\left(\theta/c\right)}},$$

that substitution (2.1.12) in (2.1.13) leads to the well know conversions fields on

$$\vec{E}'_\perp=\frac{1}{\sqrt{1-v^2/c^2}}\left(\vec{E}_\perp+\vec{v}\vec{B}_\perp\right),\qquad \vec{B}'_\perp=\frac{1}{\sqrt{1-v^2/c^2}}\left(\vec{B}_\perp-\frac{1}{c^2}\vec{v}\times\vec{E}_\perp\right)\ . \qquad (2.1.14)$$

With the small relative conversion rates (2.1.11) and (2.1.14) differ, beginning from the terms of the expansion of the order v^2/c^2.

2.2. Problem of Emission of Electromagnetic Wave and the 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 [18,20]:

$$\varphi(r,t) = \frac{g\ ch\dfrac{v_\perp\left(t-\frac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r}\ , \tag{2.2.1}$$

where $v_\perp\left(t-\frac{r}{c}\right)$ is component of the charge rate g, normal to

To the vector $\vec{r}$ at the moment of the time $t' = t - \frac{r}{c}$, r is distance between the charge and the point, at which is determined the field, at the moment of the time t.

Using a equation $\vec{E} = -grad\ \varphi(r,t)$, let us find field at point 1 (Fig. 1). The gradient of the numerical value of a radius of the vector of $\vec{r}$ is a scalar function of two points: the initial point of a radius of vector and its end point (in this case this point 1 on the axis of x and point 0 at the origin of coordinates). Point 1 is the point of source, while point 0 - by observation point. With the determination of gradient from the function, which contains a radius depending on the conditions of task it is necessary to distinguish two cases:

1 The point of source is fixed and is considered as the function of the position of observation point.

2 Observation point is fixed and is considered as the function of the position of the point of source.

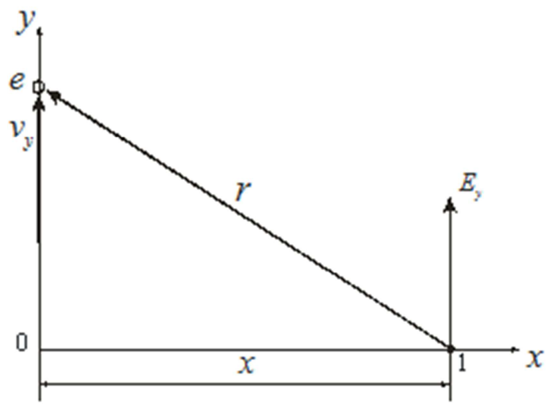

Fig 1. *Diagram of shaping of the induced electric field.*

We will consider that the charge e accomplishes fluctuating motion along the axis y, in the environment of point 0, which is observation point, and fixed point 1 is the point of source and $\vec{r}$ is considered as the function of the position of charge. Then we write down the value of electric field at point 1:

$$E_y(1) = -\frac{\partial\varphi_\perp(r,t)}{\partial y} = -\frac{\partial}{\partial y}\frac{e}{4\pi\varepsilon_0 r(y,t)}\ ch\frac{v_y\left(t-\frac{r(y,t)}{c}\right)}{c},$$

when the amplitude of the fluctuations of charge is considerably less than distance to the observation point, it is possible to consider a radius vector constant. In this case we obtain:

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 cx}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y}sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}\ , \tag{2.2.2}$$

where x is 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 (2.2.2):

$$E_y(x,t) = \frac{e}{4\pi\varepsilon_0 cx}\frac{1}{v_y\left(t-\frac{x}{c}\right)}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}. \tag{2.2.3}$$

This is a complete emission law of the moving charge.

If we take only first term of the expansion, then we will obtain from (2.2.3):

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} = -\frac{ea_y\left(t-\frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x} \tag{2.2.4}$$

where $a_y\left(t-\frac{x}{c}\right)$ is being late acceleration of charge. This equation 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 Eq. (2.2.4) takes the form:

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}. \tag{2.2.5}$$

Equation (2.2.5) determines the radiation pattern. Since in this case there is axial symmetry relative to the axis y, it is possible to calculate the complete radiation pattern of this emission. This diagram corresponds to the radiation pattern of dipole emission.

Since $\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x} = A_H\left(t-\frac{x}{c}\right)$ is being late vector potential, Eq. (2.2.5) it is possible to rewrite

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} = -\frac{1}{\varepsilon_0 c^2}\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t} = -\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}.$$

Is again obtained complete agreement with the equations of the being late vector potential, but vector potential is introduced here not by phenomenological method, but with the use of a concept of the being late scalar-vector potential. It is necessary to note one important circumstance: in Maxwell's 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 Eq. (2.2.5). It is known that in the electrodynamics there is this concept, as the electric dipole and dipole emission. Two charges with the opposite signs have the dipole moment:

$$\vec{p} = e\vec{d}\,, \qquad (2.2.6)$$

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 equation into expression (2.2.5), we obtain the emission law of the being varied dipole.

$$\vec{E} = -\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2}. \qquad (2.2.7)$$

This is also known equation [20].

In the process of fluctuating the electric dipole are created the electric fields of two forms. First, these are the electrical induction fields of emission, represented by equations (2.2.4), (1.2.5) and (2.2.6), connected with the acceleration of charge. In addition to this, around the being varied dipole are formed the electric fields of static dipole, which change in the time in connection with the fact that the distance between the charges it depends on time. These fields present the fields of the neighbor zone of dipole source. 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 fields on static dipole field on emissions.

The laws (2.2.4), (2.2.5), (2.2.7) 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 Eq. (2.2.5) it is possible to obtain the laws of reflection and scattering both for the single charges and, for any quantity of them. If any charge or group of charges undergo the action of external (strange) electric field, then such charges begin to accomplish a forced motion, and each of them emits electric fields in accordance with Eq. (2.2.5). 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 Eq. (2.2.5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2\sin\alpha}{4\pi\varepsilon_0 c^2 mx}E'_{y0}\sin\omega(t-\frac{x}{c}) = \frac{K}{x}E'_{y0}\sin\omega(t-\frac{x}{c}), \qquad (2.2.8)$$

where the coefficient $K = \frac{e^2\sin\alpha}{4\pi\varepsilon_0 c^2 m}$ can be named the coefficient of scattering (re-emission) single charge in the assigned direction, since it determines the ability of charge to re-emit the acting on it external electric field.

The current wave of the displacement accompanies the wave of electric field:

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

If charge accomplishes its motion under the action of the electric field $E' = E'_0\sin\omega t$, then bias current in the distant zone will be written down as

$$j_y(x,t) = -\frac{e^2\omega}{4\pi c^2 mx}E'_{y0}\cos\omega\left(t-\frac{x}{c}\right). \qquad (2.2.9)$$

The sum wave, which presents the propagation of electrical field on (2.2.8) and bias currents (2.2.9), can be named electrocurent wave. In this current wave of displacement lags behind the wave of electric field to the angle equal $\pi/2$. In parallel with the electrical waves it is possible to introduce magnetic waves, if we assume that

$$\vec{j} = \varepsilon_0\frac{\partial\vec{E}}{\partial t} = rot\vec{H}\,, \qquad (2.2.10)$$

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

Introduced thus magnetic field is vortex. Comparing (2.2.9) and (2.2.10) 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 equation on the coordinate, we find the value of the magnetic field

$$H_z(x,t) = \frac{e^2\sin\alpha}{4\pi cmx}E'_{y0}\sin\omega\left(t-\frac{x}{c}\right). \qquad (2.2.11)$$

Thus Eqs. (2.2.8), (2.2.9) and (2.2.11) can be named the laws of electro-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 in the role of the transformer, which ensures this reradiation. The magnetic field, which can be calculated with the aid of Eq. (2.2.11), is directed normally both toward the electric field and toward the direction of propagation, and their relation at each point of the space is equal

$$\frac{E_y(x,t)}{H_z(x,t)} = \frac{1}{\varepsilon_0 c} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z \,,$$

where Z is wave drag of free space.

The combination of electrical and magnetic wave is called the electromagnetic wave

Wave drag 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 electrocurent wave, crossing this area, transfers through it the power, determined by the data by equation, which is located in accordance with Poynting theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electrocurent 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 equations, obtained for the electrical and magnetic field, they completely satisfy Helmholtz 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 of and rotor of a certain vector function, whose divergence is equal to zero:

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

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

consequently, must exist clear separation fields 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 have gradient nature, and magnetic is vortex field.

2.3. Pulse Generator of the Radial Electric Field

Being based on the given results it is possible to propose the construction of the pulse generator of radial electric field, it is represented in Fig. 2. Generator consists of the massive metallic sphere, inside which is located the small spherical cavity, which approach two capillaries. Through the capillaries the cavity is filled up with nitroglycerine. The size of internal cavity and the thickness of the walls of sphere is selected in such a way that with the explosion nitroglycerine sphere it would not tear. The detonation of nitroglycerine is accomplished by an acoustic method by the way of sharp impact on the wall of sphere. After the detonation of charge the temperature in the internal cavity reaches value on the order of 10 thousand degrees and more, that also causes the appearance of radial electric pulse. Then, the gases emergent in the cavity slowly leave through the capillaries, and after cooling of sphere generator is again ready to work.

Let us point out that they can be recorded by a similar method and underground nuclear explosions, since the radial electric fields can without difficulty penetrate through any media.

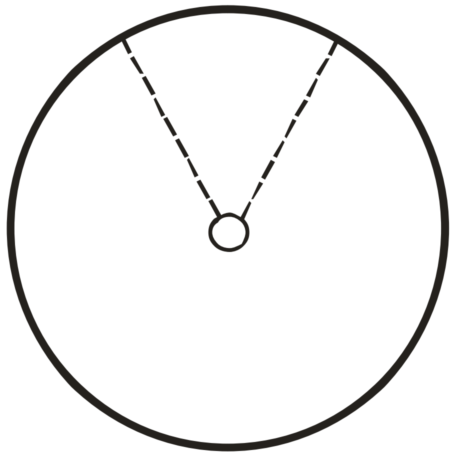

Fig 2. *Pulse generator of the radial electric field.*

It is easy to calculate the tension of electric field, generated by this generator, using the procedure, examined in the fourth division.

A generator of radial electric field can be carried out, using an electrical discharge in the ionized medium, for which should be used the charged capacitor, which they discharge through the space, connected by the thin wire (Fig. 3).

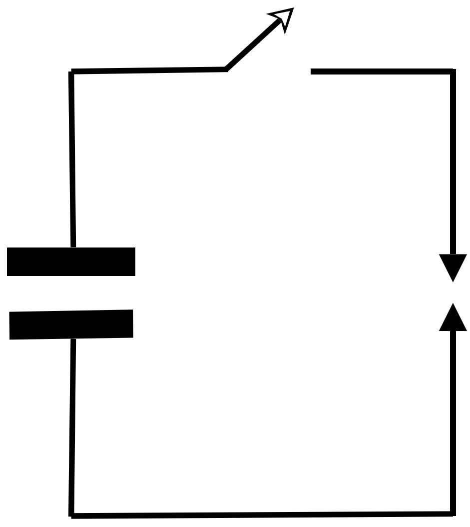

Fig 3. *Schematic of capacitor discharge.*

During the discharge wire is melted, forming the plasma, which is compressed because of the pinch effect. The compression of plasma leads to its warming-up to the high temperature. General oscillator circuit is given in Fig. 4.

In the metallic capacity, which has upper lid, is located the unit of capacitors, key and discharger. The unit of capacitors is placed in the metal casing, which with the aid of the tube is suspended to the upper lid. Cover must have a good contact with the capacity. Through the tube in the upper lid is passed the dielectric rod, with the aid of which is accomplished closing key. At the moment of closing the key in the discharger appears the plasma, which generates the electric pulse, whose electric fields through the metallic capacity penetrate outside. These fields are fixed with the aid of the dipole antenna. For the visual observation and the record of pulse is used the oscillograph, which is connected to the antenna.

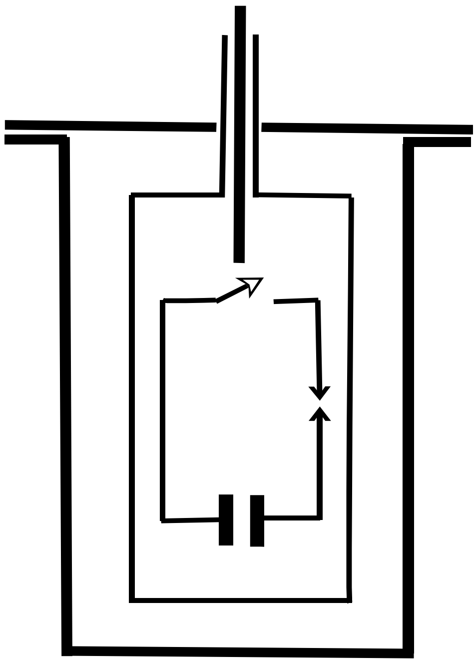

Fig 4. *General oscillator circuit of electric pulses.*

Let us examine the parameters of the separate elements of generator. The capacitance of capacitor and the potential difference, to which it should be loaded, is selected on the basis of the following considerations. Of the energy, accumulated in the capacitor must be sufficiently for the warming-up of the cloud of plasma, which is formed with the capacitor discharge to temperature on the order 10000 K.

As the wire, which is undergone melting in the discharger, let us take the copper wire with a diameter of 0.1 mm and with a length of 1 mm. The specific weight of copper is equal to 8.94 g/sm^3; therefore the mass of the section of wire indicated is equal ~7x10^{-5} g, and its volume is equal ~8x10^{-6} cm^3. The heat capacity of copper composes ~4x10^{-1} J/gK, and melting point is equal to 1350 k. Therefore in order to heat wire to the melting point it will be required ~4x10^{-2} J. Heat of fusion of copper composes ~2x10^2 J/g, therefore in order to melt wire it will be necessary ~1.4x10^{-2} J. Heat of vaporization of copper is equal ~4.8 J/g; therefore for evaporating the wire to be required still ~3.5x10^{-4} J. Therefore, in order to heat wire to the melting point, to melt it and to convert to vaporous state, to be required to spend ~5x10^{-2} J. Atom density of copper composes ~5x10^{22} 1/sm^3; therefore into the gaseous state will be transferred ~4x10^{17} of atoms. Energy of the atom of gas composes k_BT, where k_B is the Boltzmann constant. Therefore in order to heat the quantity of atoms to the temperature of 10$^{\text{of }4}$ k indicated necessary to spend ~6x10^{-2} J. Thus the total quantity of energy, necessary for the realization of the process examined, will compose 10^{-1} J.

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 is Stephan-Boltzmann constant, and S is 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

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

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

$$\varphi(r) = \frac{g\ ch\frac{v_\perp}{c}}{4\pi\ \varepsilon_0 r} \qquad (2.3.1)$$

where, r is the distance between the charge and the observation point, $v_\perp$ is the component of the charge, normal to the vector $\vec{r}$, ε_0 is 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 of the Boltzmann distribution. The most probable electron velocity in this case is determined by the relationship

$$v = \sqrt{\frac{2k_BT}{m}}, \qquad (2.3.2)$$

where T is temperature of plasma, k_B is Boltzmann constant, m is the mass of electron.

Using Eqs. (2.3.1) and (2..3.2), and taking into account with the expansion in the series of hyperbolic cosine the terms ~ $\frac{v^2}{c^2}$, we obtain the value of increase in the scalar potential at the observation point

$$\Delta\varphi \cong \frac{Nek_BT}{4\pi\varepsilon_0 rmc^2}, \qquad (2.3.3)$$

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

$$E = \frac{Nek_BT}{4\pi\varepsilon_0 r^2 mc^2} = \frac{\Delta q}{4\pi\varepsilon_0 r^2} \qquad (2.3.4)$$

where

$$\Delta q = \frac{Nek_BT}{mc^2}$$

is an equivalent charge of explosion. Using relationship (2.3.4) it is possible to calculate the tension of electric field, created by this discharge. If we consider that iron atoms are completely ionized, then at a distance 1 m of the discharger the tension of electric field will compose ~10-2 V/m. This level of the tension of electrical is completely measured by the proposed method.

The energy, stored up in the capacitor, is determined from the relationship

$$W = \frac{1}{2}CU^2$$

If we load capacitor to a potential difference 400 V, then for obtaining the energy of the discharge of ~10 -1 J is necessary capacitor with a capacity ~1 μF . The given calculation is tentative, since with its fulfillment the factors, which are yielded to calculation, were taken into account only at the same time, there is a whole series of the factors, which to consider is impossible.

3. Relativistic Mechanics in the Theory of Electromagnetism Kinematic Censorship in the Field Theory

3.1. Principles of Relativistic Mechanics in the Theory of Electromagnetism Conditions "Kinematic Censorship" for the Running Electromagnetic Waves

The made above assertion about the fact that field theory generally and the Maxwell's equations in particular must be augmented by the system of vector equations of motion for the density function of energy and pulse of field, is very strong and, therefore, it is possible not to doubt the fact that it will lead to attempts at the opposition from the side "fundamental skeptics". Before the authors, therefore, arose the task of strengthening the line of reasoning, which occurred into [4], by means of the proposal of a number of the simple computational experiments, which without the special expenditures of time will be accessible for the repetition "by skeptics" and they will, possibly, give to them food for their own analogous experiences for the purpose to refute the positions, declared by the authors into [4]. Experiments concern the determination of conditions, which must be satisfied in the field theory so that relativistic energy kinematics of the selected particular solutions of Maxwell's equations would be accurately determined by formula (16), since it is the exact solution of the system of relativistic equations of motion for the density field of the energy-momentum of electromagnetic waves 1 freely extended in [the vacuum]. Thus, everything, that it is necessary to make, is reduced to determine all those conditions, which must satisfy the field of wave for the passage of the most important mechanical tests so that it would be possible to consider this wave physical. For this it is necessary simply to explain conditions, with which formula (2.1.16) can smoothly work. Moreover, it is desirable to also explain from a systematic point of view that it will be, if some condition for the applicability of formula (2.1.16) is not satisfied, but calculations on it are possible, which actually occurs always if $rot\vec{S} \neq 0$. In this case it is interesting to explain the nature of the error, to which leads the incorrect use of formula (2.1.16); namely: this there will be error in the length of the vector $\vec{V}_E$ or, on the contrary, error in its direction? But or error will be both in the one and in the other?

It is necessary to note that there exist only two not connected with other condition for the lawfulness of using formula (1.16). It first, is required that condition (I) would be satisfied for the field of wave: $rot\vec{S} \neq 0$, and, in the second place, so that (II) relativistic invariant of field (1.3), if it is not equal to zero, it would be possible to identify as the energy density of the rest of wave. Condition (the II) is connected with the fact that only in this case it is possible to determine the entering in (1.17) density function of kinetic wave energy, which is completely necessary for the legitimate application of formula (1.16) in the case of the kinematic testing of the field of longitudinal-transverse waves.

Three such experiments were already proposed into [4]. One of them concerned the field of transverse OPW in the vacuum. BY OPW do not pass "kinematic censorship" simply because $rot\vec{S} = 0$, and condition (I) is not carried out. Let us note that in this case $\eta = 0$, and condition (the II) is not at all urgent, but kinetic energy for this wave is determined, it coincides with the total energy of wave. The second experiment was set with respect to transverse NPW with the logarithmic special features on the plane of equal phases. This wave passes "kinematic censorship", since. condition (I) is carried out, $\eta = 0$, and kinetic energy, as in OPW, it coincides with the total energy of wave. Calculations according to formula (1.16) bring in this case to the correct result: $\vec{V}_E = c\vec{e}_z$, where $\vec{e}_z$ - unit vector in the direction, perpendicular to the plane of the equal phases3.

Finally, the third experiment was executed into [4] for longitudinal-transverse NPW (for TM- polarized PW). Both applicability conditions for formula (1.16) for this wave function are carried out. Namely, condition (the II) is satisfied: function for the density of kinetic energy, $W^{(k)}$, wave taking into account interlinear footnote 1 is determined, since.

3 This experiment prove also [4], that the TEM waves in the multiconnected hollow waveguides pass "kinematic censorship".

4-scalar (1.3) gives the positively determined density function of rest energy of wave, $W^{(r)}$, (see it is below). Condition (i) also is satisfied, since. wave - heterogeneous. The calculations, executed into [4] according to formula (1.16), lead to the correct result: $\vec{V}_E = c/\beta \vec{e}_z$, where $\vec{e}_z$ is unit vector in the direction, perpendicular to the plane of equal phases, β is moderating ratio of wave, $\beta < 1$.

In this article we will place the fourth computational experiment. It will be directed toward testing of the normal waves of the rectangular waveguide. The propagated without the damping normal waves in the hollow waveguides of singly connected section as PW in the vacuum above impedance plane [4], are longitudinal-transverse modes, $\eta \neq 0$. For this case (1.2) important are the following relationships, which were not obtained into [12], but which implicitly were carried out into [4] for the calculations, executed there in connection with BY PW. Namely, if $\eta \neq 0$, then two formulas are equivalent to expression (1.3):

$$W_B = W_E + \eta ,$$

$$W_E = W_B - \eta .$$

Substituting them on the turn in (1.10), we will obtain the relationship, in one case,

$$W = 2W_E + \eta \qquad W = \vec{E}^2 + \eta \quad , \tag{3.1.1}$$

and in other respectively

$$W = 2W_B - \eta \qquad W = \vec{B}^2 - \eta . \tag{3.1.2}$$

However, for the interpretation of these formulas as mechanical,

$$W = W^{(k)} + W^{(r)} \qquad \left(W^{(k,r)} > 0\right) . \tag{3.1.3}$$

Important significance has a sign of the invariant of η computable from formula (1.3) relativistic.

In principle, is generally possible two versions: (I) η is fixed position function in Minkowski's space, (II) η is alternating function.

As shown into [4] for longitudinal-transverse NPW in the vacuum (for PW above the impedance plane) occurs situation (j). Moreover, the sign of η depends on the polarization of wave. For the TM- polarization of $\eta < 0$ (see footnote 1). Formula is immediate (3.1.2). For the Those- polarization of $\eta > 0$, aktulna formula (3.1.1). Consequently, in the first case, as this follows from formulas (3.1.1-3.1.3), we have $W^{(r)} = -\eta$, $W^{(k)} = \vec{B}^2$. Let us note that those executed into appropriate calculations, although it is implicit, completely correspond to these relationships. For Those- polarized PW, as it is possible easily to show, we will have: $W^{(r)} = \eta$, $W^{(k)} = \vec{E}^2$. In a word, both formulas, (3.1.1) and (3.1.2), in the theory are claimed, and them can be interpreted as mechanical in sense (3.1.3). This circumstance is extremely important, since. independent of polarization PW its kinetic energy is determined, which only is necessary for the heterogeneous wave (satisfying the requirements (I) automatically) so that formula (1.16) would be for it applicable and wave was past test on the kinematics.

If for the wave occurs situation (II), then to the relativistic invariant of the field of the wave η it is not possible to assign the sense of rest energy of wave. Both formulas, (3.1.1) and (3.1.2), are unfit for this. Wave will not pass “kinematic censorship” and on the strictest physical measures must be rejected. Specifically, this situation occurs for the normal waves of hollow waveguides with the singly connected cross section. Let us show this based on the example of the waveguide of rectangular cross section.

3.2. Strict Kinematic Testing of the Normal Waves of the Hollow Waveguide of the Rectangular Cross Section

As an exponential example let us examine monochromatic H_{n0} is the wave of the rectangular waveguide. The components of the field of wave, as it is possible to show, are evinced by Gaussian system of units as follows:

$$\begin{Bmatrix} E_y \\ B_x \end{Bmatrix} = A \begin{Bmatrix} 1 \\ -k_0^{-1}\gamma \end{Bmatrix} \sin\alpha\cos\beta \quad , \tag{3.2.1}$$

$$B_z = A k_0^{-1} \gamma_\perp \cos\alpha \sin\beta \quad . \tag{3.2.2}$$

In formulas (3.2.1) and (3.2.2) are introduced the following designations:

$$\alpha = \gamma_\perp x,\ \beta = \left(\gamma z - \omega t\right) \quad , \tag{3.2.3}$$

$$\gamma_\perp = n\pi/a,\ k_0 = \omega/c \,, \tag{3.2.4}$$

A is amplitude with the physical dimensionality of the field strength.

Pole H_{n0} is wave does not depend on the vertical transverse coordinate *y* (height of the waveguide *b,* therefore, does not enter into formulas for the components of field). The width of the waveguide *a* along the horizontal coordinate of *x* enters into expression (3.2.4) for the transverse wave number $\gamma_\perp$ of wave. Wave is moved in the direction of the growth of the longitudinal coordinate *z*; therefore γ in (3.2.3) plays the role of the longitudinal wave number of wave. The unit vectors of the Cartesian coordinate system form the right-handed triad of the vectors:

$$\vec{x}_0 \times \vec{y}_0 = \vec{z}_0 \quad . \tag{3.2.5}$$

In further conversions will be used calibrated to k_0 transverse, $\tilde{\gamma}_\perp$, and longitudinal, $\tilde{\gamma}$, the wave numbers, which are connected together, thus, with the usual relationship:

$$1 = \tilde{\gamma}_\perp^2 + \tilde{\gamma}^2 \quad . \tag{3.2.6}$$

For A = 1 and taking into account the aforesaid the squares of the components of the field of wave, as this follows from (3.2.1) and (3.2.2), are described by the following expressions:

$$\begin{Bmatrix} E_y^2 \\ B_x^2 \end{Bmatrix} = \begin{Bmatrix} 1 \\ \tilde{\gamma}^2 \end{Bmatrix} \sin^2\alpha\cos^2\beta, \quad (3.2.7)$$

$$B_z^2 = \tilde{\gamma}_\perp \cos^2\alpha\sin^2\beta. \quad (3.2.8)$$

Let us verify first fulfillment of conditions (I). For this it is necessary to calculate the axial vector of $rot\vec{S}$ and to be convinced of the fact that it is not equal to zero.

The wave is had two nontrivial components of Poynting's vector:

$$S_z = -cE_yB_x = c\tilde{\gamma}\sin^2\alpha\cos^2\beta, \quad (3.2.9)$$

$$S_x = cE_yB_z = \frac{c}{4}\tilde{\gamma}_\perp \sin(2\alpha)\sin(2\beta). \quad (3.2.10)$$

The required axial vector will have only one transverse component:

$$rot\vec{S} = \left(\frac{\partial S_x}{\partial z} - \frac{\partial S_z}{\partial x}\right)\vec{y}_0. \quad (3.2.11)$$

After substituting in (3.2.11) formulas (3.2.9) and (3.2.10), after differentiation and number of elementary conversions and simplifications, we find:

$$rot\vec{S} = -\frac{c}{2}\tilde{\gamma}\gamma_\perp \sin(2\alpha)\vec{y}_0. \quad (3.2.12)$$

We see that the condition (I) is satisfied. So must be, since in the cross section of waveguide the standing wave is formed; therefore the normal wave of waveguide on the plane of equal phases (z = const) is heterogeneous longitudinal-transverse plane wave. Let us verify now fulfillment of conditions (II). For this it is necessary to determine the relativistic invariant of field (1.3).

The square of the vector of magnetic field taking into account (3.2.7) and (3.2.8) is written as follows:

$$\vec{B}^2 = \tilde{\gamma}^2\sin^2\alpha\cos^2\beta + \tilde{\gamma}_\perp^2\cos^2\alpha\sin^2\beta.$$

Elementary trigonometric conversions with using of formula (3.2.6) lead this expression to the following:

$$\vec{B}^2 = \sin^2\alpha\cos^2\beta + \tilde{\gamma}_\perp^2\left(\cos^2\alpha - \cos^2\beta\right). \quad (3.2.13)$$

The square of the vector of electric field, as this follows from (3.2.7), is determined as follows:

$$\vec{E}^2 = \sin^2\alpha\cos^2\beta. \quad (3.2.14)$$

Reading according to formula (1.3) from (3.2.13) expression in right side (3.2.14), we will obtain the answer:

$$\eta = \frac{1}{2}\tilde{\gamma}_\perp^2\left(\cos^2\alpha - \cos^2\beta\right). \quad (3.2.15)$$

Taking into account relationships (3.2.3), in which are determined the variables α and β, formula (3.2.15) shows that with exception of those points of the spaces inside the waveguide, which are the points of longitudinal secants of the planes x = const, on which is satisfied the condition $\cos^2\alpha \neq 0$, function (3.2.15) is the alternating function of the longitudinal coordinate z and time t. This means that the relativistic invariant of field (3.2.15) does not satisfy condition (II): it does not befit for the idea of the density function of rest energy of the wave4, and another method to make this there does not exist. Consequently, in this case there are no bases for that, in order to one of the formulas: (3.1.1) or (3.1.2) it would be possible to consider as formula (3.1.3) for the energies in the spirit of relativistic mechanics. Hence it follows that the field of the normal waves of hollow waveguide, at least, rectangular cross section does not pass test for the relativistic kinematics and the application of formula (1.16) in this case incorrectly. As has already been spoken at the beginning, this conclusion it will completely agree with the fact that, as it was shown into [12], field transverse OPW does not pass “kinetic censorship” of relativistic mechanics, since. for it the condition is not satisfied (I). It will agree in that reason, that H_{n0} is the wave in the rectangular waveguide can be decomposed on the sum of two transverse OPW of Brillouin, which are extended inclined, at the angle θ, with respect to the longitudinal axis of waveguide [18]: (III) $\tilde{\gamma}_\perp = \sin\theta$, $\tilde{\gamma} = \cos\theta$. In view of the fact that the partial waves of Brillouin do not pass relativistic test on the kinematics of energy, negative result on this test in connection with of H_{n0} is to waves in the rectangular waveguide is completely regular. In this connection it is interesting to note the following. It is shown [18] that the wave functions of normal waves in the hollow circular waveguides also can be represented by the superposition of the continuum of transverse OPW: in the form integral from the angular parameter ψ, $\psi \in [-\pi, \pi]$. This means that the directions of propagation of partial OPW of continuum form in the space round cone with the rotational axis, which coincides with the longitudinal axis of waveguide. The aperture angle θ this cone is connected with the transverse and longitudinal wave numbers of wave with relationship (III) [18]. Hence it follows that the normal waves of hollow circular waveguide will not pass the test for the same reason indicated, on which it do not pass the normal waves of the rectangular waveguide. Most likely, this relativistic test will not pass the normal waves of the hollow waveguides of the singly connected cross section of arbitrary form.

On this it would be possible and to finish, but from a systematic point of view it is of interest to explain, as vector formula (1.16) beyond the limits of the region of its applicability works. For this we will accept the deliberately

4 the physical dimensionality of the energy density of expression (3.2.15) is restored with its additional multiplication to the lowered coefficient of A^2.

erroneous assumption that the expression for the energy density of rest (standardized value) is given by formula (3.2.15). Actually, after accumulating, according to determination (1.10), formula (3.2.13) and (3.2.14), we will obtain expression for the density of the total energy:

$$W=\frac{1}{2}\left(\vec{B}^2+\vec{E}^2\right)=\sin^2\alpha\cos^2\beta+\frac{1}{2}\tilde{\gamma}_\perp^2\left(\cos^2\alpha-\cos^2\beta\right). \quad (3.2.16)$$

After comparing (3.2.16) to formulas (3.2.13) and (3.2.14), and also keeping in mind formulas (3.1.1) and (3.1.2), we will see, that in this case of urgent appears formula (3.1.1), but not (3.1.2), as this was for TM- polarized PW. This can be explained by the fact that the longitudinal-transverse H_{n0} - the wave of the rectangular waveguide is had the one- only component of the electric field E_y , which is transverse. According to this sign this wave is similar to Those- polarized PW, for which immediate is the same formula (3.1.1), but not (3.1.2).

If we accept the erroneous conclusion that second term in right side (3.2.16) is the function $W^{(r)}$, then in accordance with formula (3.1.3) first term in (3.2.16) is the density of the kinetic wave energy,

$$W^{(k)}=\sin^2\alpha\cos^2\beta. \quad (3.2.17)$$

Let us look now, this erroneous prerequisite will lead to what.

For enumerating the velocity vector according to formula (1.16) it is necessary to determine the polar vector $\dot{\boldsymbol{\sigma}}$ according to formula (1.17). The entering in (1.17) vectors will calculate. Namely, keeping in mind formulas (3.2.17) and (3.2.3), we will obtain:

$$c^2 gradW^{(k)}=c^2\left[(\gamma_\perp/2)\left(1+\cos 2\beta\right)\sin(2\alpha)\vec{x}_0-\gamma\sin^2\alpha\sin(2\beta)\vec{z}_0\right]. \quad (3.2.18)$$

Differentiating expressions (3.2.9) and (3.2.10) on the time, we will obtain also that

$$\partial\vec{S}/\partial t=c^2\left[-(\gamma_\perp/2)\sin 2\alpha\cos(2\beta)\vec{x}_0+\gamma\sin^2\alpha\sin(2\beta)\vec{z}_0\right]. \quad (3.2.19)$$

After accumulating vectors (3.2.18) and (3.2.19), we find:

$$\dot{\vec{\sigma}}=c^2\,(\gamma_\perp/2)\sin(2\alpha)\vec{x}_0. \quad (3.2.20)$$

Taking into account formulas (3.2.5), (3.2.12) and (3.2.20) we obtain:

$$\left[rot\vec{S}\times\dot{\vec{\sigma}}\right]=\frac{c^3}{4}\tilde{\gamma}\gamma_\perp^2\sin^2(2\alpha)\mathbf{z}_0. \quad (3.2.21)$$

From (3.2.12) we determine the square of the length of the axial vector:

$$\left(rot\vec{S}\right)^2=\frac{c^2}{4}\tilde{\gamma}^2\gamma_\perp^2\sin^2(2\alpha). \quad (3.2.22)$$

After substituting (3.2.21) and (3.2.22) in (1.16), we obtain the answer:

$$\vec{V}_E=\frac{c}{\tilde{\gamma}}\vec{z}_0=\frac{\omega}{\gamma}\vec{z}_0=V_{ph}\vec{z}_0,\ \left|\vec{V}_E\right|=V_{ph}>c.$$

As it was expected, the incorrect (in the given circumstances) use of relativistic formula (1.16) leads to the erroneous result for the module of velocity vector, but for the direction of vector formula gives correct answer.

4. Conclusion

The laws of classical electrodynamics they reflect experimental facts they are phenomenological. Unfortunately, contemporary classical electrodynamics is not deprived of the contradictions, which did not up to now obtain their explanation. The fundamental equations of contemporary classical electrodynamics are Maxwell's equation. But not all know that those equations, which it is customary to assume as Maxwell's equations, not are those equations, which used itself Maxwell. During writing of its equations it used the substantional derivative, that are made themselves they invariant with respect to the Galileo conversions. Subsequently Hertz and Heaviside excluded from the substantional derivative its convective part, after writing down Maxwell's equations in the partial derivatives. In this form the equations are invariant to the conversions of Lorenz and this approach laid way to the creation of the special theory of relativity In the article are examined the conversions of electromagnetic pour on upon transfer of one inertial system to another, obtained on the basis of the equations of electromagnetic and magnetoelectric induction with the use by the substantional derivative and they are examined the consequences, which escape from such conversions. Physics of the emission of electromagnetic waves on the basis of the concept of scalar- vector potential is examined and shown that this concept assumes the clear separation between the gradient and vorticity fields. From the point of view of this separation the electric fields are gradient, and magnetic field presents vorticity fields.

Regular connection to the theory of the electromagnetism of the system of equations of motion for the density of the energy-momentum of field introduces into the theory the substantial limitations, which are manifested in the form sufficiently rigid censorship for the selection of the physically significant solutions Maxwell's equations. It is shown based on the example of the waveguides of rectangular cross section in the article that the normal waves of the hollow waveguides of singly connected section do not pass relativistic test on the energy-kinematics. The scalar density field of energy of these waves does not satisfy the requirements of relativistic mechanics. Namely, the velocity of propagation of energy of the normal longitudinal-transverse waves, such as are the normal waves of the hollow waveguides of singly connected section, must be less than the speed of light. This indicates existence of the associating wave frame of reference. In connection with energies of normal H_{n0} is the waves of the rectangular waveguide the executed in the article studies showed the impossibility of determining for them the energy density of rest, which for the physically significant solutions, according to the principles of relativistic mechanics, the speed of wave energy of less than the speed of light must be accurately determined when. On the strictest physical measures such wave functions must be rejected and substituted with others, which would pass relativistic test on the energy-kinematics of field. As it was shown in the first article of the authors this problems [4], mathematical prerequisites for this exist, but this already exceeds the scope of this work.

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